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Full Length Research Paper

Assessment of the resistance of sorghum (*Sorghum bicolor*) varieties to the parasitic weed (*Striga hermonthica*) in Cameroon

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Sorghum is a food product which ensures food safety in Cameroon. However, the production yields remain low because of the many parasitic constraints due particularly to *Striga hermonthica*, plant parasite that can cause up to 100 % of losses if no protective measures are taken. Generally, the level of resistance of various local varieties of sorghum to *S. hermonthica*, remains unknown; which results in very low yields, despites the techniques employed to fight. This constitutes a risk to their diffusion in rural community. The farmers and biological control methods of cultivation generally used in rural areas remain very binding and give unsatisfactory results. Concerning chemical control, it is polluting and expensive. In the search for alternatives to these methods of struggles mentioned above, this work was undertaken to determine the level of resistance in 13 varieties of sorghum to *S. hermonthica*. To this end, after planting S. *hermonthica* in the various pots, its influence on the 13 varieties of sorghum has been measured through the evaluation of their parameters of growth, the rate of emergence and the number of foot of *S. hermonthica* fixed on the roots of varieties of sorghum tested and finally the fresh and dry weight of seedlings of sorghum. The variety CK-60B deemed very sensitive to *S. hermonthica* has been used as a witness of reference. In view of the results obtained, it reveals that compared to the reference variety CK-60B, the varieties CS-54, S-35, CS-95, CS-130, Zouaye, Mabassi, CS-233, IRMA-Bp, CS-61, CS-154, SSD-35 seems to be resistant or at least tolerant to *S. hermonthica*. By against the varieties Damougari and Gueling have been proved susceptibles.

Key words: *Sorghum bicolor*; resistance; tolerance; sensitive; *Striga hermonthica.*

Abbreviations: IRAD_Agricultural Institute of Research for Development ; CRRAM_Regional Center for Agronomic research of Maroua; DAS_Day After Sowing

INTRODUCTION

Sorghum (*Sorghum bicolor* [L.] Moench.) is a food-producing crop that participates in the food security in the North Cameroon (Ngamo and Hance, 2007; Lawane et al., 2009; Noubissié et al., 2012). It constitutes the basis of the daily food of the farmers and contributes in the strategic manner to the food security of the poorest population. With an estimated output to about 525 083 tons on a surface of about 445 666 hectares, the production is very weak. One of the main factors responsible for these weak outputs are the presence of the weed parasitizes *Striga hermonthica* (Del.) Benth. (Olivier, 1995; Ayongwa and Ngoumou, 2002; Lawane et al., 2009; Yonli et al., 2010; Noubissié et al., 2012). *S. hermonthica* is a bad weed harmful to cereals, a hemi parasite weed with chlorophyll partially unable to absorb water and minerals of soil. On the sorghum, the yearly losses of production due to the *S. hermonthica* have been estimated to 70% if any protective measure is undertaken (Doggett, 1988; Olivier et al., 1992). Moreover the losses of 100% due to the neglected field have been observed (Olivier, 1995; Toukourou et al., 2004; Brink and Belay, 2006). Some researches have been done to improve the agricultural production, but the devastating effects of these adventitious of the crop continue to strongly decrease yield (Olivier, 1995; Randrianjafizanaka, 2010). Indeed, the parasitic plants

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are characterized by the setting up, in the host's tissue, of a particular absorption device named sucker or haustoria (Olivier et al., 1991; Olivier, 1996). The suckers or real structural bridge and physiological joins the parasite to the host, able to control the flow of sap finely (Olivier et al., 1991; Olivier, 1996; Lepoivre, 2003). So whatever is the considered parasitic plant, it diverts to its profit, through the sucker, a part of water and the nourishing substances normally intended to her host-plant (Olivier et al., 1991; Olivier, 1996; Lepoivre, 2003).

Various strategies of struggle namely the cultural struggle, the struggle biologic and the chemical struggle have been considered to fight against *S. hermonthica* (Ramaiah et al., 1983; Bashir, 1987; Olivier, 1995; Carsky et al., 1994; Traoré, 1999; Ayongwa and Ngoumou, 2002). Unfortunately, the methods of cultural and biologic struggle respectively based on the manual extraction of *S. hermonthica*, the rotation with non hosts plants and the parasitism generally used in farmer's environment remains very coercive and give some results with little satisfaction (Olivier, 1995). As regards the chemical struggle that consists in treating soil and the cultures by means of the herbicides, it essentially remains for reasons of economic order and easiness of setting in work; the most used method. However despite of their efficiency, the regular use of the herbicides presents some limitations. A part their relatively elevated cost of application, they disrupt the ecological balances of the surroundings treated, pollute the environment and the food commodities, lead to the harmful effects on the health of the human and animals, and cause the development of the resistant stumps.

Facing this situation, the use of the resistant varieties causes a lot of hopes. The existence of differences between varieties for the sensitivity of sorghum to the *S. hermonthica* has been put in evidence several years ago. In Cameroon, the setting of a program in order to value the level of resistances of the sorghum varieties in relation *to S. hermonthica* by the Regional Center of Agricultural Research for the Development (IRAD) of Maroua, is a track of hope. It will not only permit to reduce the harmfuls effects of the agricultural intensification, which make the object of chemicals, but also to be able to produce sufficiently in order to make possible the food for all. The main objective of this work is to value the level of resistance of 13 varieties of sorghum opposite the bad grass parasitizes *S. hermonthica* in Cameroon.

MATERIALS AND METHODS

Plant material

The test has been achieved in pot, to the greenhouse of the Regional Center of the Agricultural Research institute for the Development (IRAD) of Maroua, to Cameroon in 2012. In this survey, 13 varieties of 7 month old sorghum namely Zouaye, CS-54, CS-95, IRMA-Bp, S-35, Damougari, CS-154, SSD-35, CS-130, Gueling, CS-233, Mabassi, CS-61, well stocked by the Agricultural Research institute for the Development (IRAD) of Maroua, have been used for the assessment *in vivo* of their resistance to *S. hermonthica*. The CK-60B variety, well-known to be very sensitive to *S. hermonthica* (Ramaiah et al., 1983; Lendzmo, 2004) has been used like reference. This last was provided also by the Agricultural Research Institute for the Development (IRAD) of Maroua. The choice of these varieties has been made on the basis of their food, economic importance and the necessity to determine their level of resistance opposite *S. hermonthica*.

Four months before the test of the seeds of *S. hermonthica* (about 200 mg), have been harvested in Maroua and kept in a bag made of jute to ambient conditions of the laboratory.

Preparation of the pots and the soil

The used pots have been cleaned previously with the help of tap water and the toilet paper, to avoid possible contaminations. Thereafter, 5 holes of about 20 mm of diameters uniformly left to the bottom of the pots have been pierced. The hygienic paper cut and well doubled has served to block the different holes before the ground deposits, this in order to avoid that the ground as well as seeds did not meet to soil. With the help of a hoe, some ground has been dug, crumbled, and then transported to the laboratory. After sterilization, the last one has been weighed so that each of her has a mass of 4 kg that corresponds to a replenishment of 90% each. Finally the pots have been arranged in the greenhouse.

Experimental device

A device with completely randomized blocks including 4 repetitions has been used in every test (Table 1). To the total of 56 pots; constituted of 4 repetitions of 14 pots each has been used. These different pots received the seeds of *S. hermonthica*.

Seedling and plants removal

The experience has been led in greenhouse in pots of 22 cm of diameter containing a mixture of 2 kg of clayey soil, 1 kg of sand and 1 kg of manure (equal mixuture and representative of the texture of sorghum fields" and the pH is 6.4). Seven month old seeds of *S. hermonthica* (about 200 mg) were mixed to the first five centimeter of the soil of every pot before the seedling. Sorghum has been sowed at the rate of five seeds per pot. It was

Table 1. Experimental disposition of the test (number of pots in which seeds of *Sorghum bicolor* and *Striga hermonthica* were sown)

Variety	Repetition 1	Repetition 2	Repetition 3	Repetition 4
Zouaye	101	207	308	4010
CS-54	102	201	3013	405
CS-95	103	204	304	408
IRMA-Bp	104	203	3011	4012
S-35	105	2012	303	403
Damougari	106	2011	3014	407
CS-154	107	2014	306	404
SSD-35	108	208	305	4013
CS-130	109	202	301	406
Gueling	1010	206	3010	402
CS-233	1011	205	3012	409
Mabassi	1012	209	302	4011
CS-61	1013	2010	307	4014
CK-60B	1014	2013	309	401

reduced to two, then to one plant per pot, 2 weeks after the seedling and irrigated every day.

Collection of the data

The parameters of growth of the aerial parts measured on every plant and to the intervals of time of 7 days from the 2nd week after seedling, include: the number of functional leaves of every sorghum plant, that has been done by simple observation and counting; the size of the plants determined in cm has been measured with the help of a rule and the diameter to the collar of the plants, determined in cm has been measured with the help of a slide rule.

The number of plants of *Striga* emerged in every pot was determined 27 days after the seedling. Since their emergence, the number of *S. hermonthica* has been counted and noted every two days until the end of the test.

43rd DAS (can be written the first time clearly) , the plants of sorghum have been carefully dug up from the pots and the number of plants of *S. hermonthica* fixed to the roots of the varieties tested has been valued by simple counting.

At the end of the test, the fresh and dry weights of the different plants of sorghum tested have also been evaluated. So 43rd DAS, every plant of fresh sorghum has been weighed, before being wrapped in the newspapers to be dried in the oven at 60 °C during 48 hours and reweighed a second time.

Analysis of the data

The data recorded (size, fresh and dry weight) have been submitted to an analysis of the variance (ANOVA) with the help of the software R at the critical level of 5%. The averages presenting meaningful differences have been classified by the method of Newman and Keuls.

RESULTS

Assessment of the parameters of growths of the aerial parts

Table 2 shows the averages values of the height, the diameter of the collar and the number of functional leaves of the sorghum plants varieties tested. Analysis of variance achieved on the averages values of the height of the plants tested show that the 13 varieties of sorghum tested were meaningfully different ($P< 0.05$) and superior to the reference variety CK-60B. Concerning the diameter of the collar of the plants tested, the Zouaye, CS-54 and CS-95 varieties proved to be meaningfully different ($P< 0.05$) and superior to all other tested varieties. Finally concerning the number of leaves, only the four varieties namely IRMA-Bp; Damougari; Were Mabassi and CS-61

Table 2. Evaluation of the parameters of growths of the aerial parts Values in a column followed by the same letter do not differ at P= 0.05.

	Growths parameters		
Varieties	**height (cm)**	**Collar diameter (cm)**	**Number of leaf**
Zouaye	21.50 ± 3.70a	13.50 ± 1.92a	10.75 ± 1.26b
CS-54	21.50 ± 5.20a	13.75 ± 0.96a	9.25 ± 0.50b
CS-95	25.00 ± 8.29a	13.75 ± 2.87 a	8.75 ± 0.50b
IRMA-Bp	21.75 ± 3.59a	12.75 ± 2.22b	8.50 ± 1.29a
S-35	22.75 ± 2.06a	12.00 ± 1.15b	9.00 ± 0.82b
Damougari	19.50 ± 1.91a	11.25 ± 1.26b	8.25 ± 0.96a
CS-154	22.25 ± 1.71a	11.00 ± 1.15b	9.00 ± 0.82b
SSD-35	25.50 ± 5.20a	11.75 ± 1.50b	9.00 ± 0.00b
CS-130	22.50 ± 2.38a	13.00 ± 0.82b	9.25 ± 0.96b
Gueling	21.75 ± 4.57a	12.25 ±1.26b	9.50 ± 1.29b
CS-233	23.75 ± 2.87a	12.50 ± 1.29b	9.50 ± 0.58b
Mabassi	21.75 ± 2.87a	12.50 ± 1.29b	8.50 ± 1.00a
CS-61	21.50 ± 2.08a	12.75 ± 0.50b	8.00 ± 1.00a
CK-60B	15.75 ± 0.96b	11.25 ± 0.50b	10.00 ± 0.82b

Table 3. Median number of seedlings of *S. hermonthica* emerged per pots of sorghum Values in a column followed by the same letter do not differ at P= 0.05. DAS: Days after sowing

	Number of *S. hermonthica* emerged from pots	
Varieties	**27 DAS**	**43 DAS**
Zouaye	0.00± 0.00a	2.50 ± 0.58b
CS-54	0.00± 0.00a	3.00 ± 1.41b
CS-95	0.00± 0.00a	1.50 ± 0.58a
IRMA-Bp	0.00± 0.00a	2.50 ± 0.96b
S-35	0.00± 0.00a	2.75 ± 1.71b
Damougari	0.50 ± 1.00b	2.75 ± 0.96b
CS-154	0.00± 0.00a	4.50 ± 1.29b
SSD-35	0.00± 0.00a	2.75 ± 0.96b
CS-130	0.00± 0.00a	4.00 ± 1.15b
Gueling	0.00± 0.00a	3.75 ± 4.19b
CS-233	0.00± 0.00a	3.00 ± 0.82b
Mabassi	0.00± 0.00a	3.25 ± 1.26b
CS-61	0.00± 0.00a	3.25 ± 2.99b
CK-60B	0.00± 0.00a	4.00 ± 1.26b

meaningfully different (P< 0.05) and lower to the others tested varieties.

Assessment of the number of *Striga hermonthica* appeared in the pots

Table 3, show the average number of plants of *S. hermonthica* emerged in the pots containing the different varieties of Sorghum tested. So 27 days after seedling, only the pots containing the Damougari variety had recorded plants of *S. hermonthica* with a average value of 0.50 ± 1.00. However 43rd days after seedling, only the pots containing the CS-95 variety (1.50 ± 0.58) was meaningfully different (P<0.05) and had a average number of the plants of *S. hermonthica* lower to the than

Table 4. Many feet of *S .hermonthica* fixed at the roots of the seedlings of sorghum Values in a column followed by the same letter do not differ at P= 0.05.

Varieties	*S. hermonthica* attached to the roots of the varieties
Zouaye	3.50 ± 0.58a
CS-54	3.75 ± 1.71a
CS-95	9.25 ± 2.63b
IRMA-Bp	8.50 ± 1.29b
S-35	2.50 ± 0.58a
Damougari	9.00 ± 0.82b
CS-154	8.50 ± 2.38b
SSD-35	5.25 ± 1.71a
CS-130	8.75 ± 1.71b
Gueling	8.75 ± 1.26b
CS-233	8.50 ± 1.29b
Mabassi	10.00 ± 2.16b
CS-61	9.50 ± 1.29b
CK-60B	10.50 ± 1.29b

that of the pots containing the other varieties tested including the variety of reference.

Assessment of the number of feet of *S. hermonthica* fixed to the roots of the sorghum varieties

Table 4, shows the averages numbers of feet of *S. hermonthica* fixed to the roots of the different varieties of Sorghum tested at the end of the test. So 43rd days after seedling, the feet of *S. hermonthica* were fixed on the roots of all sorghum varieties tested. The analysis of variance achieved on the averages values of the number of feet of *S. hermonthica* fixed on the roots of the four varieties namely Zouaye; CS-54, S-35 and SSD-35 were meaningfully different (P<0.05) and lower to those obtained on the others varieties tested including CK-60B, the variety of reference.

Assessment of the fresh and dry weights of the varieties of sorghum tested

Table 5 shows the averages values of the weight of fresh and dry of the plants of the sorghum varieties tested at the end of the test. The analysis of variance achieved on the averages values of the fresh weight showed that the fresh weights of the Damougari varieties (12.50 ± 3.00); CS-154 (13.00 ± 2.58); SSD-35 (12.00 ± 2.83); CS-233 (15.25 ± 1.89) and CK-60B were meaningfully different (P< 0.05) and lower to those obtained on the others tested varieties. On the other hand concerning dry weights, the CS-54 varieties (9.46 ± 2.12); CS-130 (9.24 ± 1.53); Gueling (11.27 ± 1.74); Mabassi (9.40 ± 2.01); CS-61 (9.24 ± 1.53) and CK-60B (6.82 ± 0.38), had recorded average value meaningfully superior to the other tested varieties.

DISCUSSION

Sorghum is a food product that participates in the food security in Cameroon, particularly in the northern part of the country. However, the parasitizes plants *S. hermonthica*, constitute one of the main constraint to its production (Lendzemo, 2004; Kengué et al., 2008). The present work reveals the degree of resistance of 13 varieties of sorghum opposite *S. hermonthica*. The regression of the growth parameters (the number of the leaves, the size and the diameter of the collar of the plants), observed on some varieties of sorghum tested consecutive to the infection of the plants by the seeds of *S. hermonthica*, is bound to the insufficiency or deficiency in water and/or in element essential minerals observed at the level of soils. These same results have already been observed by Lepoivre (2003), that had shown that the plant parasitizes *S. hermonthica*, once in presence of the sorghum plants diverts the water and mineral substances first of all be having to used by the plant host for its growth and development. Otherwise, it is important to recall that water and the mineral elements of soil are essential for the growth and the development of the plants and their deficiencies lead to a reduction of the growth parameters (the number of the leaves, the size and the diameter of the collar of the plant s). So, the

Table 5. Fresh and dry weight of varieties of sorghum collected 43^{éme} DAS Values in a column followed by the same letter do not differ at P= 0.05

Varieties	Fresh weight of plants	Dry weight of plants
Zouaye	16.00 ± 4.32a	8.68 ± 1.73b
CS-54	19.00 ±3.83a	9.46 ± 2.12a
CS-95	18.50 ± 8.00a	8.60 ± 2.96b
IRMA-Bp	16.00 ± 4.00a	8.33 ± 0.46b
S-35	16.25 ± 1.71a	8.45 ± 0.87b
Damougari	12.50 ± 3.00b	7.76 ±0.75b
CS-154	13.00 ± 2.58b	8.26 ± 1.81b
SSD-35	12.00 ± 2.83b	7.66 ± 1.00b
CS-130	18.00 ± 4.62a	9.24 ± 1.53a
Gueling	19.25 ± 2.50a	11.27 ± 1.74a
CS-233	15.25 ± 1.89b	8.38 ± 1.10b
Mabassi	15.75 ± 2.63a	9.40 ± 2.01a
CS-61	17.50 ± 1.00a	9.24 ± 1.53a
CK-60B	10.75 ± 0.96b	6.82 ± 0.38b

averages values of growth parameters relatively low gotten at the CK-60B, SSD-35, CS-61, IRMA-Bp, Gueling, Mabassi and Damougari varieties are due to the deficiency in water and in mineral elements essentially provoked by the plant parasitize *S. hermonthica* that once in pot, has provoked a competition with the plant host (sorghum). These results, also corroborate with those gotten by several authors namely Ramaiah et al. (1983); Lendzemo (2004), that had shown respectively that in presence of the parasite *S. hermonthica*, signs of insufficiencies and deficiencies in essential elements appear. Otherwise, according to Traoré (1999) and Lepoivre (2003), the competition between the varieties of sorghum and the plant parasitizes *S. hermonthica* for water and the nutrients of soil can according to the severity of the attack, lead in the regions where the water problems are important (Sahel) a decrease of the yield of the crop capable to drive to the abandonment of the fields and to the clearing of new earths. Besides, since the underground phase, the parasite *S. hermonthica* fixed to the roots of sorghum is more harmful to this plant and it more than thereafter because being holoparasitic to become hemiparasitic after germination (Hoffman et al., 1997; Ayongwa and Ngoumou, 2002).

During all periods of observations, the number of *S. hermonthica* emerged in the different pots varies from a variety to another. However globally, the pots containing the different varieties of sorghum tested contain less *S. hermonthica* compared to the number recorded in the pots containing the reference variety CK-60B. This variation of the number of *S. hermonthica* in the different pots can be either due to the variation in wealth of fertilizing element in the soil used either to the personal statute of every variety to inhibit the emergence of the parasitic plant. Indeed, several authors namely Hoffmann et al. (1997); Doumbia and Thomas (2007) and Randrianjafizanaka (2010) had shown respectively in their works of research that on a fertile soil, the plant parasitizes *S. hermonthica* doesn't have a lot of influence on the development and the production of sorghum. In our survey, the level of fertilization of the soil used has been valued; it could contribute or could explain variations observed on the number of *S. hermonthica* in the different pots containing the varieties of sorghum tested.

The number of *S. hermonthica* fixed on the roots of the Zouaye varieties, CS-54, S-35 and SSD-35 are reduced considerably in relation to those recorded to the level of the roots of the other varieties tested including the variety sensitive CK-60B. This result corroborates in party with the one obtained by Arnaud and al. (1999) because according to this last, the seeds of *S. hermonthica* set less on the S-35 variety. In the same way according to Kengue et al. (2008) the S-35 varieties, CS-54, Zouayes, Damougaris, CS-95 and CS-61 are recognized resistant until a certain level to the plant parasitizes *S. hermonthica.* During our survey the plant parasitizes *S. hermonthica* is developed itself well and fixed on the roots of Damougari. Besides, taken place in 1990 had shown that when the plant parasitizes *S. hermonthica* reproduced at the end of season, it appeared less in the level on the S-35 varieties and CS-54 than that to the level of the local variety and popular Djigari and the Damougari variety (Carsky et al., 1996). So concerning the resistance of the different varieties of sorghum to the plant parasitizes *S. hermonthica*, one notes to the look of the previous results gotten by several authors that the resistance of the varieties is not definitive, it evolves with time because in the literature one notes that the varieties that proved to be resistant became today sensitive and vice-versa.

The fresh weight of the Damougari varieties, CS-154, SSD-35 and CS-233 was low in relation to the one recorded at the other varieties of sorghum tested. The plant parasitizes *S. hermonthica* had more effects certainly on the Damougari varieties, CS-154, SSD-35 and CS-233, what results in their smaller fresh weight, and it is the temperature of the steam room that would have permitted that we have less plants of dry important weight. We notice that largely these are varieties known of superior genetic nature that had a more important weight.

CONCLUSION

The main objective of our work is to determine the level of resistance of 13 varieties of sorghum present to the IRAD of Maroua, compared to the variety sensitive CK-60B. The test has been done *in vivo* in the greenhouse of the IRAD of Maroua. The gotten results allow us today to affirm that the parameters of growths (height of the plants, diameter of the collar, number of leaves) of the tested varieties develop themselves according to their resistance opposite the *S. hermonthica*. In general, the frequency of emergences of the plants of *S. hermonthica* is not the same at the different tested varieties. It seems to vary according to the sensitivity of these varieties opposite to *S. hermonthica*. The number of feet of *S. hermonthica* fixed on the roots so the fresh and dry weights of the different varieties of sorghums tested would follow the same logic than that one of the plants parasite *S. hermonthica* emerged in the different pots.

Finally, we notice that for the set of the studied parameters, the different tested varieties don't generally behave of the same way, because some in occurrence the majority behaved better than sensitive CK-60B variety with CS-54first, S-35 and CS-95 whereas Damougari and gueling appeared below it. We can therefore in this logic think that the eleven varieties having dominated the sensitive variety CK-60B for the studied parameters can be classify as being resistant varieties or of least tolerant to the plant parasitizes *S. hermonthica* in the order decreasing CS-54, S-35, CS-95, CS-130, Zouaye, Mabassi, CS-233, IRMA-Bp, CS-61, CS-154, SSD-35. However the Gueling and Damougaris varieties appear respectively more sensitive opposite to *S. hermonthica* that the sensitive variety CK-60B. Globally, we notice that the resistance or the tolerance of the sorghum varieties opposite to the plant parasitize *S. hermonthica* and that has been estimated through the assessment of the set of these parameters studied doesn't appear precisely in general of the same way at all different varieties. We want to say more clearly that three tolerant varieties for example treated in the same conditions, we have noticed that the first dominates in height, the second tends to dominate in obvious symptoms of the illness and the third in reduced number of seeds of the *S. hermonthica* fixed to the roots and so on. It will remain therefore appropriate, to better judge the level of tolerance of these varieties, while putting all the parameters together susceptible to intervene, to be able to discover the differences in general.

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