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RESEARCH ARTICLE 9

Effects of *Acacia Senegal* (L) Seeds on Germination of *Striga Hermonthica* (Del.) Benth Seeds' and on Yield of *Sorghum Bicolor* (L.) Moench in Sudan

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***Abstract*— *Striga hermonthica* is a root hemi-parasite of several cereals in sub-Saharan Africa. Despite many control methods have been already proposed, but the infestation by this parasitic continue. Two fields and pot experiments were carried out in Sinnar state, Sudan during the period (2009-2010) to assess the capacity of *Acacia Senegal* seeds to control the germination of *Striga* infection seeds on sorghum. The field experiment was aimed at determining, the effectiveness of *A. Senegal* seed powder on suppression of seed germination and increasing sorghum yield. The pot study was conducted also to assess the *A. Senegal* seeds (powder and suspension) effects on seed germination of *Striga*. *A. Senegal* seeds powder when used, as a pre-plant treatment with sorghum, inhibited the emergence in the field by 99 % -100% and increased the yield of sorghum by 181% compared to the one affected by *Striga* and by 125% compared with sole sorghum. The results also indicated that, using the same treated plots, in the second season without any new treatment, in plots treated with *A. Senegal* powder in the first season was suppressed by almost 100%. And it has resulted in the highest sorghum yield increase compared to plots planted with and sole sorghum in the first season. The pot experiment showed that *A. Senegal* powder and suspension could suppress the germination of seeds, by as much as 100% compared with untreated sorghum pots. This results reflect, the importance of *A. Senegal* as meritorious tree, for eradication of *Striga* beside its production of gum Arabic as a commercial crop.**

Index Terms*— Sorghum, *Striga hermonthica*, *Acacia Senegal

I. INTRODUCTION

Witchweed (*Striga sp.*) is a harmful hemi-parasite, of many cereals causing a considerable damage, for agricultural crops. The main destructive *Striga* species, which belongs to the family Orobanchaceae, are *Striga hermonthica*, *S. asiantica* and *S. gesnenode* that have a wide range of distribution, from Africa through southern and eastern Asia to Australia [1]. *Striga sp*. are considered as the most limiting biotic factor in the production of sorghum [*Sorghum bicolor* (L) Moench] in semiarid areas [2] and [3] including sub-Saharan Africa [4]. It also attacks other crops such as millet (*Pennisetum glaucum* L.) and maize (*Zea mays* L.) [5].

In Africa, *S. hermonthica* (Del.) Benth, giant Witchweed has a negative impact on grain production; production, twenty one million hectares, of arable land in Africa sub Saharan was estimated to be infested with *Striga*, resulting in annual grain yield loss of 1.4 million tons [7]. Forty percentages of average infested land is estimated now while. West Africa *Striga* has infested 17 million ha of arable land; 3million ha is reported in eastern and 1.6 million ha in southern Africa [6]

S. hermonthica is not particular to soil type or pH and can be abundant in lighter soils in West Africa as well as on heavy clay soils in East Africa [2]. It is reported that up to 45 million ha of arable land is threatened by these weeds in Africa [7]. [4] Noted that two-thirds of the area devoted to cereal production in East and Central Africa are seriously affected by *Striga*. That designate it as a serious pest, of the food crops [sorghum, maize, millet, rice] along the Sahel of Africa and in parts of the Sahel, it causes more damage to millet and sorghum than any other factor, with the possible exception of birds [2].

In Sudan, *S. hermonthica* is an important growth-reducing factor in agricultural crops, especially sorghum, in vast areas of traditional and mechanized farming, and of all *Striga* species, it is the most economically important parasitic in Sudan [8]. Indicated that the parasite is spreading rapidly in Sudan and the infested area was estimated to be 7.4 million hectares [9].

A *Striga* plant can produce tens of thousands of tiny seeds and can remain dormant in the soil for many years [10]. Studies indicate that *S. asiatica* seeds may remain viable in the soil for

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14 years or more [11]. Many control measures were developed including breeding crops that are attacked by *Striga* [12]. [13] Reported that *Striga* was controlled in the United State through the use of several management strategies including quarantines imposed on affected areas, control of movement of farm equipments between infected and not infected areas and herbicide application. Another control measure is imposed suicidal germination in the field; before planting the crops, *Striga* seeds present in the soil are induced to germinate by injecting ethylene gas, which mimics the natural physiological response tied to host recognition and because no host roots are available the seedlings die [13]. *Striga* problems are compounded by the plant productive capacity, where a huge amount of seeds produces (50000 seeds/plant), which remain a viable in the soil for 12-20 years [14, 15]. Control of ethylene injection is an expensive method and not generally available to many farmers in developing nations of Africa and Asia beside that the method does not remove all seeds from the soil. Other studies showed that ethylene derived from soil-borne pathogens could be used to induce suicidal germination of the parasite and thus deplete the seed reserves [13, 16]. Some practices like trap-crops use legume plant to stimulate suicidal germination of *Striga* seeds to reduce the seed bank and improve soil fertility [17]. Legume-maize rotation is another type of control used to reduce seeds germination of *Striga* and hence *Striga* infestation as [18] reported 35% reduction of *Striga* infestation in first year of legumes in the rotation and by 76% a after two years of legumes in the rotation.

The use of plant products for the control of *Striga* and other parasitic weeds is very limited, although the effect of plant materials especially Neem tree [*Azadiractha indica*] products have been reported, to significantly control some organisms such as insects and fungi [19, 20]. The use of powder from the fruits of *Parkia biglobosa* was found to inhibit the germination of *S. Hermonthica* seeds and be beneficial to the soil agrochemical properties in Burkina Faso [21]. When Parkia products were used in Nigeria, 29.1% and 38.8% less emergence of *strife* was reported in the field and greenhouse, respectively [22].

Approaches to control of *Striga* in Sudan are based on cultural control, such as the addition of appropriate rates of fertilizer and suitable herbicide application, hand pulling and host plant resistance [8]. [12] noted that germination stimulant production is the sole resistance mechanism in sorghum that has been extensively studied and exploited for breeding purposes; other resistance mechanisms have not been effectively characterized and used. Despite many control methods have been already proposed, the infestation by this parasitic weed continues [23]. *Striga* seeds germination can be stimulated by using of ethylene producing bacteria, successful control depends on eliminating the seed reserves of *Striga* spp. in soil and preventing parasitism. Biological control can be done by bacteria *Pseudomonas syringae* by stimulating germination seeds [24]. There is a great need to develop simple methods for *Striga* control.

Objective

The present study focuses on the assessment of the effect of *A. Senegal* seed products, as a pre-planting treatment. This research was started as a result of field observations, on the existence of *Striga*, in sorghum fields adjacent to areas forested with *A. Senegal*. It was observed that the number of *Striga* plants, decrease towards these forests and they disappear and absent completely within a distance of about 20 m from the forest. The objective of this paper was to investigate the effect of *A. Senegal* seed powder and extract/suspension on nullify the germination of *S. hermonthica* seeds on sorghum roots and increase corn yield.

II. MATERIALS AND METHODS

Nursery experiment

The nursery experiment was carried out at the FNC nursery, in Singa in 2009 and 2010, to investigate the effect of *A.Senegal* seed powder and extract/suspension on the germination of *S. hermonthica* seeds. The experiment was arranged in a completely randomized design with four replicates. A total of 16 pots [20 cm in diameter x 22 cm in height] were used. Each pot was filled with heavy clay soil, collected from a field in Singa area, which had been under sorghum, for the last two years and was observed and marked as free from *S. hermonthica*. Loss of *Striga* seeds, through drainage was avoided by using a filter paper, at the bottom of each container.

Striga seeds were collected, from mature healthy *Striga* plants in Gedarif and Dali areas. Two types of sequential experiments were conducted, four replicates were used for each treatment and each replicate represented four pots i.e. 16 pots were used. The preparation of suspension was done first used 150 g of milled powder of *A. Senegal* seeds, added to 500 ml of distill water and boiled for ten minutes and air cooled. The solution was stained into a pot. The seeds of four recent healthy plants of *Striga* [approximately 40 000 seeds] were collected in a cloth bag well tied and submerged in *A. Senegal* seeds/suspended for two days, then the treated *Striga* seeds were used for the experiment after divided into four parts, to be used into four pots, each pot contain about 10000 seeds of *Striga* approximately. While the same process was done for other parts where 800 g of *A. Senegal* powder was added to 800 g of clean soil well mixed and divided into four parts 400 g for each pot. Four treatments were applied as follows: [i] *Striga* seeds treated with *A. The Senegal seed suspension* was planted with sorghum

in four parts, [ii] *Striga* seeds treated with *A. Senegal* seed powder planted with sorghum in four pots too, [iii] untreated *Striga* seeds planted with sorghum in four plots, and [iv] only sorghum grown in four pots [control]. In each pot, 5 seeds of sorghum and approximately 10000 seeds of *Striga* were sown, except control which was sown with sorghum only. The pots were watered every three days and weeding was done by hand. The number of *Striga* plants emerging per pot was monitored for two months. Another minor experiment was conducted where five leaves of recent green *Caltropis procera* were collected, and sub emerged with a pot filled with *A.Senegal* suspension, for twenty four hours, to determine the effect of suspension, on color (chlorophyll) of the tested leave and observations were recorded. This experiment was conducted as confirmatory test, to determine that the emergence white *Striga* observed in the first experiment is not natural albino.

Field experiment

The field experiment was conducted in Singa area, where the soil is heavy clay with a pH 8.5. The trial site had been under sorghum, for the previous two years and it was observed and marked as free from *S. hermonthica*. I.e. it is an uninfected area Within this site an area of 646 m^2 was selected. The land was ploughed twice and then divided into nine plots with an area of 60 m^2 each [12 x 5m]. As it was in the nursery experiment, *Striga* seeds were obtained from Gedarif and Dali areas. The local variety of *Sorghum bicolor* was used as a *Striga* host. *A. Senegal* seeds were milled into powder using a mill machine and 20 kg/plot (12x 5 m) was used to amend the soil in the treatment plots, where the powder was dispersed and mixed with soil. Three treatments were applied as follows: [i] *Striga* planted with sorghum in untreated soil, [ii] *Striga* planted with sorghum in soil treated with *A. Senegal* seeds powder and [iii] sorghum in untreated soil. The experimental design was a completely randomized design with three replicates (**Figure 1**).

Thereafter, the experimental units were weeded twice where weeds other than *Striga* were removed by hand. Data on the number of emerging *Striga* plants and mean sorghum yield [grain per corn] were collected and weighed per plot. The experiment was conducted for two seasons [2009 and 2010]. In the second season sorghum was planted in all plots of the last season, without any treatment. Data were collected after two months on the number of emerging *Striga* and after three months on sorghum yield per plot.

Statistical analysis

The data collected were subjected to analysis of variance [ANOVA] and means were compared using Least Significant Difference [LSD] at the 5 % level of probability.

12m	12m	12m	
3 *Striga* + sorghum	6 Pure sorghum	9 Sorghum + *Striga*+ powder	5m
2 Pure sorghum	5 Powder+ sorghum + *Striga*	8 Pure sorghum	5m
1 *Striga* + sorghum+ Powder	4 *Striga* + sorghum	7 *Striga* + sorghum	5m

Figure 1. layout of field experiment

III. RESULTS AND DISCUSSIONS

Nursery experiment

The results of nursery studies indicated that, *Striga* seeds treated with extract/suspension of *A. Senegal* seeds for two days resulted in no germination of *Striga* seeds on sorghum roots. In four replicate containers, only one *Striga* plant was observed emerging in one container after 73 days of sowing, but the plant had white leaves i.e. without chlorophyll (**Figure 2**) and died after three days. The half immersed leaves of *Calotropis procera* were changed from green to yellow color, in the four pots filled with suspension, while the other four submerged in distill water, remain without change, indicating that chlorophyll is disappeared in the half emerged leaves due to an effect of suspension (**Figure 3**). This confirmed that, the single discolored immerged *Striga* is not albino as described by [9] but due to *A. Senegal* effect that act on chlorophyll. The results also showed that there was no germination of *Striga* seeds in all containers, where the soil was treated with *A. Senegal* seed powder. These results suggested that *A. Senegal* seeds, can be used to hinder the germination of *Striga* seeds, on sorghum roots, without apparent negative effect on sorghum growth and chlorophyll. The result showed that *A. The Senegal powder / suspension* has marked effect on germination of *Strigia* seeds on sorghum roots in a pot experiment (Table 1), where the germination was suppressed in treated pots in both season and high infection was observed on untreated pots, in which high number of *Striga* plants were germinated.

Figure (2).An emerged white *Striga* plant

Figure (3). an obvious de-coloration of chlorophyll on *Caltropis Procera* due to effect of *A. Senegal* seed solution

Table 1
Effect of *A. senegal* seed powder and extract/suspension on *Striga* seed germination

Season	Treatment	Mean number of *Striga* plants per pot
2009	Sorghum + *Striga* + Suspension	0.25
	Sorghum + *Striga* + Powder	0
	Sorghum + *Striga*	2591
	Sorghum	0
2010	Sorghum + *Striga* + Suspension	0
	Sorghum + *Striga* + Powder	0
	Sorghum + *Striga*	2666
	Sorghum	0

Field experiment

Results from the field experiment [**Table 2**] showed that, the number of emerging *Striga* plants, in the plots treated with *Acacia Senegal* seeds powder was significantly lower, compared to the untreated plots. No significant variation was found, in the number of *Striga* plants, between the plots treated with *Acacia Senegal* seeds powder [sorghum + *Striga* + powder] and those planted only with sorghum [control]. *A. Senegal* seeds powder ,when used as a pre-planting treatment with sorghum, reduced *Striga* emergence by an average of 99% in the field; this result is in line with that reported by [21] in Burkina Faso using *Parkia biglobora* powder as biological control, he reported germination inhibition of 97-100%. While [22] reported 29.1 and 38.8% less *Striga* emergence in the field and greenhouse, when Parkia products were used, It also coincided with that reported by [17] on trap-crops use legumes, and [18] on legumes –maize rotation to reduce *Striga* infestation as biological control. Our result is also in agreement with that stated by [24] in successful biological control by eliminating the seed reserve of *Striga* in soil.

The results also showed that, there were significant differences, in sorghum yield, between the treated and untreated plots. During the first season, sorghum yield in untreated plots was significantly lower, than in the control and plots treated with *Acacia Senegal* seed powder, which had comparable yields.

In the second season, significant differences were found, in sorghum yield, between the control and treated plots; the highest average yield was obtained, from plots treated with *A. Senegal* seeds powder. In both seasons, the use of *A. Senegal* powder, increased the yield of sorghum by 181%, compared to the one affected by *Striga*. While the yield of the treated sorghum and control was comparable in the first season, the yield of the former was about 125% of the latter, in the second season. These results indicate that *A. Senegal* powder, has the ability to amend *Striga*-infested land and make it suitable for sorghum farming.

Table 2

Effect of *A. Senegal* seeds powder on the mean number of *Striga* plants /m^2 and sorghum Yield per corn during seasons 2009 and 2010

Season	Treatment	Mean number of *Striga* plants /plot	The mean yield of Sorghum [g/corn]
2009	Sorghum +*Striga*	121 A	16 B
	Sorghum+*Striga*+powder	0.9 B	45 A
	Sorghum	0 B	47 A
2010	Sorghum +*Striga*	134 A	36 C
	Sorghum+*Striga*+powder	0.02 B	101 A
	Sorghum	0 B	81 B

Means in the same column followed by the same letter [s] are not significantly different at 0.05 level of significance using LSD

There is an increasing interest, in discovering new natural products, for use in *Striga* control. The results revealed that *A. senegal* seeds [powder or suspension] is a natural product, that has strong ability to suppress, the germination of *Striga hermonthica* seeds on sorghum and can be considered as, an effective biological method, to control the negative impact of *Striga*. Moreover, the treatment of soil with *A. Senegal* seeds appear to be a natural soil amendment method that might increase sorghum yield. [20] Noted that natural products or derivatives therefore, could have a number of advantages, over the current synthetic products, including reduced environmental persistence and accumulation, greater target selectivity and enhanced activity. The current results also suggest the introduction of *A. Senegal* agro forestry practice and its expansion as a suitable farming system, in *Striga*-infested sites. The focus of our ongoing research work is to design practical and efficient method of application, determine the effective components of *A. Senegal* seeds that, suppress the germination of *Striga* seeds and evaluate the effect of this product on soil properties. However, the result revealed that *A. Senegal* suspension has the ability, to remove the green color of chlorophyll, from the leaves of *Colotropus perocera* this result confirmed that, there is a substance that has an effect on the removal of chlorophyll, which what was happening, on removal chlorophyll from *Striga* in pot experiment.

IV. CONCLUSION

The results of this study reflect the importance of *Acacia Senegal* seeds, as a herbicide substance, that suppresses or impairs germination of *Striga hermonthica*, among Sorghum plants. These results encourage the farmers, to plant *A. Senegal*, instead of cutting it due to decline of gum Arabic prose. The result also paves the way, for more investigation on *A. Senegal* seeds, to identify the effective gradients of the seed, that have the ability to nullify *Striga* germination , amelioration of agricultural land and help in increasing Sorghum yield per unit area, beside its contribution to generating income, for farmers perhaps the national economy in Sudan.

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