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Effect of Soil Sterility on Soil Chemical Properties and Sorghum Performance under *Striga* Infestation

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Abstract: Soil samples were collected from *Striga* endemic areas, bulked and half subjected to steam sterilization while the other half non-sterilized. After sterilization, soils were separately infested with 3000 germinable *Striga hermonthica* seeds per pot and planted to sorghum in a randomized complete block design of two treatments (steam sterilized and non-sterilized soils) replicated four times. Soil samples were taken from the soils, bulked and divided into four subsamples and subjected to chemical analysis. Data on *Striga* count were transformed using the square-root transformation. Data were subjected to statistical analysis using GLM procedures and means separated with LSD. Across sampling periods Sterile soil had significantly higher maximum *Striga* emergence than non-sterile soils. sorghum root weight, *Striga* weight per pot and striga plant height were significntly higher in sterile than non-sterlie soils. Non-sterile soil, delayed First date of *Striga* emergence. Only Copper and exchangeable K were significantly different between treatments. Results suggests that the direct effect of the soil nutrients on the host, parasite or interaction between the two may not have been responsible for the differences observed between sterile and non-sterile soils and implicates microbial activity in inhibiting *Striga* seed germination in non-sterile soil as against sterile soils. This study suggests microbial inundation of soils in *Striga* endemic areas which could enhance microbial activities to reduce *Striga* seed bank. Microbial inundation could destroy *Striga* seed prior to germination or kill germinated and developing seedlings.

Keywords: *Striga* · soil-sterility · soil-nutrients · microbe · sorghum

INTRODUCTION

Striga parasitism is one of the serious constraints to cereal production in Africa. Oikeh *et al.* [1] estimated yield loss due to *Striga* ranging from zero to 46% and averaging 10% for 66 fields. Sauerborn [2] estimated that yield loss from all *Striga* spp. is 24% in six West African studies from which data were available. Yield losses averaged 24% (10-31%) but in areas of heavy infestation, losses reached 90-100% in some years [3]. The Food and Agricultural Organisation (FAO) estimated an annual loss due to *Striga* spp. parasitism to be approximately US$7 billion which is detrimental to the lives of over 100 million African people [4]. Population pressure has resulted in the increase of land use and more intensive agriculture. *Striga* has become not only a biological constraint to food production in sub-saharan Africa but also a socio-economic problem to resource poor farmers. These farmers are forced to abandon their farms under high infestation conditions [5]. Controlling *Striga* spp. becomes an enormous task considering the seed production rate of 10,000-100,000 seeds/plant which remains viable in the soil for 20 years [6, 7]. There is therefore a need to solve the *Striga* problem in order to achieve the sustainable food production goal. Most effective control technologies involve high input agriculture and there is the need to look for simple techniques as components of an integrated *Striga* control package which is adaptable to the African situation [8]. Crops that are non-hosts to *Striga* but produce germination stimulants for *Striga* seeds (which die in the absence of a host) have been termed Trap crops [9].

The use of legume as a trap crop for *Striga hermonthica* control has been suggested by several authors [9-11]. Planting soybean before maize crop has

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been shown to reduce *Striga* seedbank in the soil depending on the variety and duration of rotation [8, 10, 12-14]. Legume rotation operates through two major mechanisms (1) suicidal germination of *Striga hermonthica* seeds in the soil and (2) soil suppressiveness. Suppressive soils are those soils in which disease development is suppressed even though the pathogen is introduced in the presence of a susceptible host [15]. Rotation cropping with a selected legume a year, has been shown to be effective in *Striga hermonthica* control [8]. Eplee and Norris [16] also reported 90% reduction in *S. asiatica* using cotton in a single season. However reports from many researchers show that at least three years of rotation are likely to be needed for benefits in *Striga* control to be seen Doggett, 1965 and Robinson & Dowler, 1966 cited by Parker and Riches [7].

A system that would improve soil condition to increase yield as well as reduce *Striga* infestation will be of double advantage. Since soil suppressiveness is biotic, the simple means of maximizing suppressiveness is to improve soil conditions to encourage the growth of biotic agents. Good soil management practices involving the use of crop residues and organic manure have been reported effective control measure against *Striga* [18, 19]. Vogt *et al.* [20] observed that *Striga* infestation decreased with increasing organic matter of the soil and that organic matter content seemed to be the most important factor which preserved the soil fertility. Since soil microbial biomass flourishes better in a medium rich in organic matter, organic or inorganic soil amendments may increase soil suppressiveness to *Striga hermonthica* and also improve soil conditions to increase yield of subsequent cereal.

Natural biotic suppressiveness is widespread in Nigeria, including soils from *Striga hermonthica* infested areas [8]. Soils collected from farmers fields in 11 locations in Nigeria, showed a highly significant overall reduction in numbers of attached parasite (43%) in non sterilized compared to sterilized soils, attributable to soil suppressiveness of microbial origin [8]. Inspite of this natural suppressiveness, cereals planted in these soils still suffer very low yields following *Striga* infestation.

Since steam sterilization eliminated soil microbes, any significant increase in emerged *Striga hermonthica* on the host plant could also be attributed to the direct effect of the soil nutrients on the host, parasite or interaction between the two. This study therefore sets to investigate the effect of soil sterility on soil nutrient, *Striga* emergence and sorghum performance.

METHODS

The experiment was conducted in a Randomized Complete Block Design with two treatments (steam sterilized and non sterilized soil), replicated four times in screen house at IITA Ibadan.

Soil samples were collected from *Striga* endemic areas, bulked and filled into 3 L pots with half the number of pots subjected to steam sterilization for 4 h at 15 psi and 121°C using a steam sterilizer and the other half was not subjected to sterilization. After the sterilization, the pots containing sterilized soils were left to cool and the sterile and non sterile soils were separately infested with 3000 germinable *Striga hermonthica* seeds per pot. Infestation was effected by removing half of the soil content in each pot and mixing thoroughly with the 3000 germinable *S. hermonthica* seeds. Pots were watered to field capacity every other day and left for 4 weeks prior to sowing with sorghum.

Data on first *Striga* emergence, emerged *Striga* seeds per pot on weekly basis, sorghum plant height, sorghum stover weight, sorghum root weight, *Striga* weight per pot, *Striga* plant height and *Striga* rating were taken.

Four soil samples were taken from each of the sterized soils and non sterile soils and subjected to chemical analysis in the IITA Ibadan soil analytical laboratory.

Nitrogen was determined by Kjeldahl digestion and colorimetrimeric determination on Technicon Autoanalyser. Phosphorus was determined by Bray -1- P in soil. Exchangeable Ca, Mg, K, Na and Mn were determined in 1 N, pH 7 Ammonium Acetate extract. Soil micronutrients (Fe, Cu, Zn) were determined by Dilute HCl (0.1 N) extraction method. Exchangeable acidity was determined by titration method after extraction with 1 N KCl. Organic Carbon was by acid digestion method and Soil pH was determined in water on 1:1 soil / water ratio.

Data on Striga count were transformed using the square-root transformation $(X+0.05)^{1/2}$

Where; "X" is *Striga* count. Transformation was done to improve the homogeneity of variance before analysis of variance. Data were subjected to statistical analysis using GLM procedure of SAS [21].

RESULTS AND DISCUSSION

Sterile soil had significantly higher *Striga* emergence than non-sterile soils across sampling periods (Table 1). Sterile soil was significantly higher than non-sterile soil in respect to Maximum *Striga* emergence (Fig. 1). However

Table 1: Emerged *Striga hermonthica* per pot as affected by sterile and non-sterile soil treatment

	WAP									
Treatments	3	4	5	6	7	8	9	10	11	12
ST	0.80	1.32	2.29	2.93	3.43	3.77	3.88	3.82	3.82	3.31
NS	0.83	1.21	1.75	2.14	2.44	2.78	2.90	2.75	2.71	2.42
LSD	0.04	0.10	0.15	0.18	0.18	0.18	0.18	0.17	0.19	0.15

ST = Steam sterilized soil; NS = Non-sterilized soil; WAP = Weeks after planting

Table 2: Effect soil sterility on *Striga* height, weight and sorghum stover and root weight

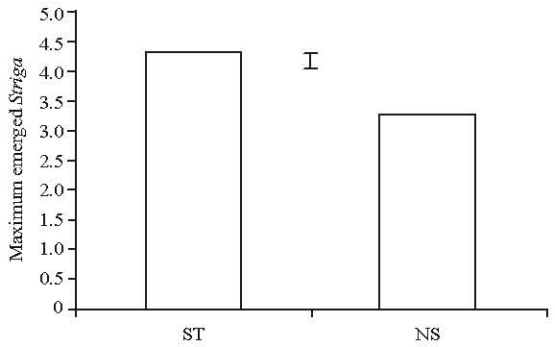
	Striga		Sorghum	
Treatments	Height (cm)	Weight (g/pot)	Stover weight (g)	Root weight (g)
ST	19.20	1.88	5.96	7.88
NS	17.54	0.99	5.96	4.96
LSD	1.41	0.24	0.60	0.85

ST = Steam sterilized soil; NS = Non- sterilized soil

Table 3: Effect of Soil sterility on soil chemical properties

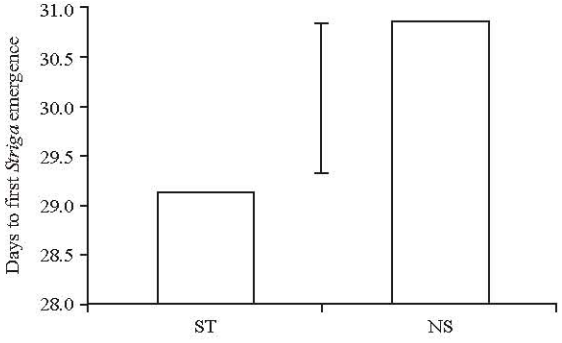
	N	P	K	pH	Cu	Zn	Fe	C	Ca	Mg	Na	Exch Mn
Treatments	%	mg kg^{-1}	ppm	1:1	ppm	ppm	ppm	%		cmol kg^{-1}		
ST	0.02	34.77	0.11	3.92	0.55	1.83	9.11	0.23	2.92	0.57	0.31	0.40
NS	0.03	39.56	0.07	4.52	1.57	2.29	11.66	0.21	2.40	0.48	0.40	0.35
LSD	0.006	33.09	0.03	0.71	0.66	1.28	5.48	0.47	0.96	0.17	0.11	0.09

ST = Steam sterilized soil; NS = Non- sterilized soil



ST=Steam sterilized soil; NS=Non sterilized; Bars represent LSD at p=0.05

Fig. 1: Effect of Sterile and non-sterile soils on maximum emerged *Striga*



ST=Steam sterilized soil; NS=Non sterilized; Bars represent LSD at p=0.05

Fig. 2: Effect of sterile and non-sterile soil treatments on days to first *Striga* emergence

non-sterile soil delayed first date of *Striga* emergence (Fig. 2). Sterile soil had significantly higher sorghum root weight, *Striga* weight per pot and *Striga* plant height than non-sterile soil. There was no significant difference between the treatments (sterile and non-sterile soil) on plant height at harvest and stover weight (Table 2).

The significantly higher sorghum root weight on sterile soil compared to non-sterile soil may be a result of the attached un-emerged *Striga* which were more on the root of sorghum on sterile soil following higher infection. The significantly higher *Striga* weight per pot and *Striga* plant height in sterile soil compared to non-sterile soil may be due to the inhibition on *Striga* germination and development conferred by micro-organisms in the non-sterile soil.

The significantly higher *Striga* emergence in sterile soil compared to non-sterile soil may be connected with microbial activity which inhibited *Striga* seed germination in the non-sterile soil. Berner *et al.* [8] found a similar reaction and implicated microbial activity inhibiting *Striga* seed germination.

Chemical analysis of the soils showed that Copper was significantly lower and exchangeable K significantly higher ($p \leq 0.05$) in sterile than in non-sterile soils whereas organic C, N, P, Ca, Mg, Na, Zn, Fe, were not significantly different in these soils (Table 3).

That K is significantly higher in sterile than non-sterile soil may not be surprising since alternate wetting/drying and freezing has been shown to enhance both the fixation of K in non exchangeable forms and release the previously fixed K to the soil solution. Although the practical importance of this is recognized, its mechanism is not well understood [22]. Since there was no significant difference between N levels in both treatments, K could not have enhanced stimulant activity and increased number of emerged *S.hermonthica* or maximum emerged *S. hermonthica* between treatments. K promotes stimulant activity only in the absence of N, the presence or absence of P in the growth medium did not affect *Striga* seed germination, probably due to the inability of this element to interfere with the production or activity of the stimulating substance from the host plants [23].

The significant difference in Cu between Sterile and nonsterile soil appear inexplicable. Copper ions are held tightly by cation exchange sites [24]. Copper is important as a coenzyme that is needed to activate several plant enzymes and it is involved in chlorophyll formation [24]. The coenzyme and chlorophyll formation properties of Copper may not have been same in this regard as it did not enhance the stimulation of germination nor improve the performance of sorghum in the non-sterile soil where it was higher and therefore could not have been responsible for the increase in emerged *Striga hermonthica* plants on the host plant in the sterile soil.

Since steam sterilization eliminated soil microbes any significant increase in emerged *Striga hermonthica* on the host plant would have been attributed to the direct effect of the soil nutrients on the host, parasite or interaction between the two but this study has shown that the soil nutrient could not have been responsible for the increase in emerged Striga hermonthica in the sterile soil nor inhibited the performance of the host plant (sorghum) in the nonsterile soil.

This study suggests that the direct effect of the soil nutrients on the host, parasite or interaction between the two may not have been responsible for the differences observed between sterile and non-sterile soils and agrees with the findings of Berner *et al.* [8] implicating microbial activity in inhibiting *Striga* seed germination in nonsterile soil as against sterile soils where the micro-organisms had been eliminated.

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