Advances in Crop Science and Technology
ISSN: 2329-8863

Dereje et al., Adv Crop Sci Tech 2016, 4:5
DOI: 10.4172/2329-8863.1000238

Research Article Open Access

The Influence of Intercropping Sorghum with Legumes for Management and Control of Striga in Sorghum at Assosa Zone, Benshangul Gumuz Region, Western Ethiopia, East Africa

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Abstract

Sorghum is an important cereal crop and occupies third place in production after Maize and Tef in Ethiopia. *Striga hermonthica* reduces sorghum yields by competing for water, nutrients, space, light and photosynthates with the host plants. Information on the influence of intercropping sorghum with legumes for management and control of striga in sorghum in the Assosa Zone is scanty. On farm experiments were they are conducted at three locations, for three years, to investigate the effect of eleven treatments (Intercrop ground nut with Sorghum 1:1 and Simultaneous planting, Intercrop ground nut with sorghum 1:1 and Relay planting, Intercrop ground nut with Sorghum 2:1 and Simultaneous planting, Intercrop ground nut with Sorghum 2:1 and Relay planting, Intercrop soybean with sorghum 1:1 and Simultaneous planting, Intercrop soybean with sorghum 1:1 and Relay planting, Intercrop soybean with sorghum 2:1 and Simultaneous planting, Intercrop soybean with sorghum 2:1 and Relay planting, Sole soybean, Sole Sorghum and Sole Ground nut.) and was laid out in a randomised complete block design (RCBD) with three replication. Significant influence on the grain yield of sorghum due to treatment application was recorded. During the all season, the sorghum/legume intercrop had the highest sorghum yield. The sorghum/Ground nut intercrop out yielded than the sorghum/soybean intercrop at all growing season. The gross income and Land equivalent ratio indicates greater economic benefit with this intercropping groundnut in 1:1 proportion and simultaneous planting than sole planting. As a result, intercropping groundnut in 1:1 proportion and simultaneous planting for the control striga is essential, ideal and useful to small-scale farmers, in order to achieve sustainable crop production.

Keywords: Sorghum; *Striga hermonthica*; Intercropping; Yield; Land equivalent ratio

Introduction

Striga hermonthica reduces yields by competing for water, nutrients, space, light and photosynthates with the host plants El-Halmouch et al. [1]. In Africa, crop yield losses associated with Striga related activities is about 40% and represents an annual loss of cereals worth US$7 to 13 billion Khan et al. [2]. In East Africa, *S. hermonthica* is the most important species causing an estimated 20-100% total loss for maize, sorghum and millet Emechebe and Ahonsi [3]. *Striga hermonthica* (Del.) Benth (*Scrophulariacae*) is one of the major production constraints in the subsistence sorghum producing farmers in Ethiopia. This problem is further aggravated by the inherent low soil fertility, recurrent drought and overall natural resource degradation because of decades of continuous cereal monoculture and deforestation Fasil [4]. Many environmental factors including soil temperature and moisture status, may affect the growth and development of Striga species either acting directly on the weed or by mediation through the host Oryokot [5]. In sub-Sharan Africa, Striga is exasperated by its exquisite adaptation to the climatic conditions of the semi-arid tropics, its high fecundity, and longevity of its seed reserves in tropical soils Gebisa [6], Gebisa et al. [7]. This is, therefore, reducing the seed bank from the infested field must be considered as one strategy for effective control of Striga.

Controlling *Striga* like other root parasites is such a challenge because the weed can do much damage to the host crop before emerging above the ground. Cultural, mechanical, chemical and biological control measures are available to regulate the parasite population. However, few of these techniques can provide complete Striga eradication and it is usually necessary to use a combination of these methods most relevant to the farming system Parker and Riches [8], Bebawi [9].

Similarly, in Benishangule-Gumuze region, for instance, where *striga* resistant varieties and chemical controls are not possible and affordable, the loss is still occurred and becoming devastating. Although sorghum yield loss due to striga has not been well documented in the region, it could reach up to total failure of the crop depend on the severity of infestation in the region (personal observation). Hence, farmers have no option rather to shift to other crops even though sorghum is their staple food and major crops. Sorghum covers about 25.9% of total area cultivated in the region (CSA, 2014/15). Moreover, these area do not have recommended and effective control methods against striga to their site. On the other hand, even if there has been a released resistant sorghum variety, they didn't adapt well in this region. Hence, looking for cost effective and applicable control measure against this serious weed is of a paramount importance for the resource poor farmers in the region. An effective Striga management program should include a reduction in the number of *Striga* seed from the heavily infested soils and prevention of further seed multiplication [10]. Soil active herbicides have been identified which give partial control of *S. hermonthica* before it emerges from the soil. Dicamba has been used to effectively control *S. asiatica* in the USA Eplee and Norris [11]. In Kenya, Odhiambo and Ransom [12] found Dicamba to be effective

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Received June 27, 2016; **Accepted** September 06, 2016; **Published** September 08, 2016

Citation: Dereje G, Adisu T, Mengesha M, Bogale T (2016) The Influence of Intercropping Sorghum with Legumes for Management and Control of Striga in Sorghum at Assosa Zone, Benshangul Gumuz Region, Western Ethiopia, East Africa. Adv Crop Sci Tech 4: 238. doi: 10.4172/2329-8863.1000238

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only when applied at the peak of *Striga* germination and attachment. Rotating or intercropping Sorghum with trap crops such as Soy beans (*Glycine max* L.), groundnut (*Arachis hypogea* L.), Bambara nut (*Vigna subterranea* (L.)Walp), sunflower (*Helianthus annus* L.) and cowpea (*Vigna unguiculata* (L.) Walp) may help to reduce the number of *S. hermonthica* seed in the soil Ejeta and Butler [13], Odhiambo and Ransom [12].

Carson [14] showed that intercropping of sorghum (*Sorghum bicolor* (L.) Moench) and groundnut significantly reduced *Striga hermonthica* (Del) Benth emergence. This was associated with a decrease in soil temperature in the intercropped plots. In Gambia, alternating sorghum or millet (*Pennisetum americanum* (L.) K. Schum) with groundnut resulted in a low *S. hermonthica* infestation Lagoke et al. [15]. Soybeans (*Glycine max* L.), cotton (*Gossypium hirsutum* L.) and bambara nut when grown as intercrops with maize or sorghum, are known to induce abortive germination of *S. hermonthica* seeds, with a consequent reduction in infestation Ejeta and Butler [13]. This has advantages of depleting the seed bank and ensuring that no new seed is added to the soil Sauerborn [16].

Therefore, this research activity was initiated with the objective of determine the best intercrop legume with sorghum by its control ability of striga and yield advantage and to determine appropriate spatial and temporal arrangements on legume and sorghum intercropping.

Materials and Methods

Description of the study area

This experiment was conducted at Assosa Zone, on three woreda's s at Bambasi, Assosa, and Homosha in western Ethiopia during the main rainy season of 2012, 2013 and 2014. They are found at an altitude ranging between 1300-1470 masl with the minimum and maximum temperatures of 14.5 and 28.8°C, respectively. The average annual rainfall of 1358 mm of which 1128.5 mm were received between May and October during the cropping season.

Experimental details

The experimental land was well prepared. Initially, seed were planted in drilling methods and latter thinned to one plant per hill. The spacing was 0.75 m and 0.25 m between rows and plants, respectively. A total of eight rows were kept on each plot. Each plot and block was separated by 0.75 m and 1.5 m, respectively. Local Sorghum variety those farmers practices was used for the experiment. Important agronomic practices like hoeing and weeding were uniformly applied to all experimental plots as often as required.

The experiment was conducted on farmer's fields where striga infestations have been relatively higher. The study was involving three factors: two legumes (soybean and ground nut), two spatial arrangements of sorghum to legume rows ratio (1:1 and 2:1), and two temporal arrangements (Simultaneous and relay planting, planting legumes 3-4 weeks after sorghum planting). In addition sole stand of all crops as the legumes and the sorghum were included as a treatment in all replications. All the treatments were laid down in RCBD with three replications. In all intercropping treatments where the legumes' rows are beside sorghum rows half the recommended row spacing of sorghum was maintained i.e., 37.5 cm. Each plot area was 4 m × 6 m space between blocks and plots was 1.5 m and 1 m, respectively.

The treatments are intercropped groundnut in 1:1 and simultaneous, and relay planting; intercropped groundnut in 2:1 and simultaneous, and relay planting; intercropped soybean in 1:1 and simultaneous planting, and relay planting; intercropped soybean in 2:1 and simultaneous and relay planting; Sole soybean, sorghum and Groundnut making a total treatment of eleven treatments.

Data collection and analysis

Prior to the field experimentation, ten to fifteen per sites random samples (0-30 cm depth) were collected and a composite soil sample was made. Similarly, post crop harvest soil samples were collected from each plot receiving different treatments for selected soil physical and chemical analysis (pH, OC, N, P, K, CEC, texture and bulk density). Striga count will be recorded in all physiological stages of the main crop phenology. Yield and yield determinant factors of both crops (sorghum and the intercrop) were also taken from all plots. Land equivalent ration and economic advantage of the cropping system was computed and Farmer's assessment were done by inviting equal number of female and male farmers to evaluate and share their opinions at mid grain filling stages of the crop.

Analysis of variance was carried out for the yield studied following statistical procedures appropriate for the experimental design using SAS computer software. Whenever treatment effects will be significant, the means will be separated using the least significant difference (LSD) procedures test at 5% level of significance.

Results and Discussion

Soil physico-chemical properties

The soil pH of the study site ranges from very strongly acidic (4.78) to neutral (7.4). At Amba 14, where the soil pH is very strongly acidic at a pH of 4.78, there is possibility of Al toxicity and deficiency of certain plant nutrients while at Amba 5 is neutral.

The total nitrogen ranges from 0.15 to 0.18 and characterized by low according to Landon [17]. Similarly, the available P ranges from 0.15 to 11.05 characterized by low and marginally medium, respectively. The organic carbon (OC) of these soils varies from 1.68 to 3.12 and fall in the ranges of very low to low Landon [17]. The exchangeable K of the soil ranges from 0.13 $cmol^{(+)}\ kg^{-1}$ to 0.42 $cmol^{(+)}\ kg^{-1}$, indicating that these soils has had deficient to adequate ranges respectively. The very low OC and associated low N and available P indicated that the soils in the study area are poor in nutrient supplying power to the growing crops. This could be due to continuous cultivation and lack of incorporation of organic materials.

Population density of *Striga hermonthica*, Sorghum yields and Land Equivalent Ratio (LER)

Population density of striga: Generally, the highest number of *S. hermonthica* were recorded in sole sorghum ($777/m^2$) while the sorghum/legume intercrop repress the presence of striga and resulting lower its density at all sites during the growing season. Intercropping sorghum with ground nut able to reduce the emergence of striga by 11.98-70.24% while with soya bean it varies from 2.95 to 54.21% with 2:1 and 1:1 spatial arrangements, respectively. In ground nut, however, increasing the temporal arrangement from simultaneously to relay helps to suppress the emergence of striga while for soya bean it favors. On the contrary, spatial arrangements do have similar effect on the emergence of striga for both crops as intercropped with 1:1 suppress striga significantly than 2:1 (Table 2).

The lower number of *S. hermonthica* plants that emerged in the intercrops during the growing season indicated a reduced potential for overall flower and capsule production and, consequently, a reduced

capacity of increasing the *S. hermonthica* seed bank in the soil. It is, however, important to note that the number of *S. hermonthica* plants that emerged represents an unknown and often variable percentage of the total number of *S. hermonthica* plants that actually parasitize the host's roots. The decreased number of *S. hermonthica* plants in the Sorghum/legume intercrop may be attributed to the suicidal germination caused by the germination stimulant produced by the legume roots. In addition to being a trap crop, Ground nut provides shade which smothers the witch weed thereby reducing its vigor. These two factors are detrimental to the growth and development of *S. hermonthica* plants. Striga transpires less when shaded, thereby reducing the amount of nutrients and water drawn from the maize Stewart and Press [18].

Therefore, it can be concluded that in order to control striga emergence if the intercropped is ground nut, it is better to go for relay cropping and if the crop is soya bean simultaneous planting with 1:1 spatial arrangement helps to suppress the emergence of striga.

Sorghum grain yields: During the all season, the sorghum/legume intercrop had the highest sorghum yield. The sorghum/Ground nut intercrop out yielded than the sorghum/soybean intercrop at all growing season. Sorghum grain yields during the growing season were significantly different ($P<0.05$) in all treatments at all sites. The highest grain yield was obtained from the intercropped when compare to the sole. Sorghum grain yields were almost similar in the intercrops during the 2013 and 2014 growing season and this may indicate that in a good season, the type of legume intercropped with sorghum does not affect sorghum grain yields. However, there may be differences in the beneficial effects on sorghum yields in subsequent seasons due to residual nitrogen, which would have been fixed by the particular legume.

Partial Land Equivalent Ratios (PLER): Summarizes the PLER of Sorghum from the various intercrops for the all season. Intercropping sorghum and legumes at all sites resulted in greater than unit (above 1) PLER's for Sorghum (Tables 1-4).

Conclusions and Recommendations

The Sorghum/ground nut intercrop exhibited a higher potential for suppressing *S. hermonthica* emergence as compared to the other

No.	Districts	pH	CEC	OC (%)	N (%)	P	K
1	Amba 14	4.78	17.2	1.68	0.15	3.4	0.192
2	Homosha	7.02	35.53	3.12	0.179	11.05	0.2
3	Amba-5	7.4	25.84	2.48	0.168	7.5	0.13

Table 1: Soil physico-Chemical analysis of some parameters of soil prior to cropping.

Treatments	*Striga* Emergence plants /24 m²	Grain Yield (kg/ha)			LER	Gross Income (ETB)
		Sorghum	Soybean	Ground nut		
S+GN (1:1) & SP	295.10	1213	-	828	2.12	17214
S+GN (1:1) & RP	231.20	1433	-	515	2.23	14778
S+GN (2:1) & SP	683.90	934	-	502	1.55	11628
S+GN (2:1) & RP	615.10	863	-	243	1.30	8094
S+SB (1:1) & SP	355.80	423	897	-	1.11	9714
S+SB (1:1) & RP	395.10	1072	175	-	1.54	7832
S+SB (2:1) & SP	659.30	945	418	-	1.52	9014
S+SB (2:1) & RP	754.10	1155	134	-	1.63	8002
SSB	-	-	1661	-	-	13288
SS	777.00	747	-	-	-	4482
SGN	-	-	-	1663	-	19956
LSD	493.45	737	306	235	-	-
Sign (0.05)	**	**	**	**	-	-
CV	121.51	98.52	109.35	73.47	-	-
SE	69.91	97.18	285.36	246.32	-	-

Table 2: The influence of intercropping on *striga* emergence, yield, LER and income in 2012.

No.	Treatments	*Striga* Emergence plants /24 m²	Grain Yield (kg/ha)			LER	Gross Income (ETB)
			Sorghum	Soybean	Ground nut		
1	S+GN (1:1) & SP	69	2890.3	-	695.8	2.1	25691.4
2	S+GN(1:1) & RP	86.7	2629.2	-	332.6	1.67	19766.4
3	S+GN (2:1) & SP	311	1988.9	-	339.9	1.34	16012.2
4	S+GN (2:1) & RP	231	2398.6	-	134.9	1.39	16010.4
5	S+SB (1:1) & SP	202.3	2202.8	855.6	-	1.54	20061.6
6	S+SB (1:1) & RP	317.7	2222	328.5	-	1.33	15960
7	S+SB (2:1) & SP	284.7	2318	425	-	1.42	17308
8	S+SB (2:1) & RP	211	2390	526	-	1.5	18548
9	SSB	-	-	2420	-	-	19360
10	SS	575.3	1863.9	-	-	-	11183.4

11	SGN	-	-	-	1257.7	-	15092.4
12	LSD	372	1230	630.4	241.6	-	-
13	Sign(0.05)	*	NS	**	**	-	-
14	CV	62	29.6	43	23	-	-
15	SE	14.38	103.61	387.55	198.22	-	-

Table 3: The influence of intercropping on striga emergence, yield, LER and income in 2013.

No.	Treatments	*Striga* Emergence plants /24 m²	Grain Yield (kg/ha)			LER	Gross Income (ETB)
			Sorghum	Soybean	Ground nut		
1	S+GN (1:1) & SP	25.3	2126.7	-	557.5	2.05	19450.2
2	S+GN (1:1) & RP	73.7	2087.9	-	318.7	1.82	16351.8
3	S+GN (2:1) & SP	158.7	1873.6	-	305.4	1.39	14906.4
4	S+GN (2:1) & RP	152	2476.1	-	142.9	1.96	16570.8
5	S+SB (1:1) & SP	58.7	1826.5	669.6	-	1.68	16318.2
6	S+SB (1:1) & RP	120.7	2124.9	205.9	-	1.67	14396.6
7	S+SB (2:1) & SP	167	2120.4	199.7	-	1.66	14320
8	S+SB (2:1) & RP	219.3	1874.7	88.3	-	1.43	11954.6
9	SSB	-	-	2040.5	-	-	16324
10	SS	479.7	1351.8	-	-	-	8110.8
11	SGN	-	-	-	1147.5	-	13770
12	LSD	173	897.7	72	215	-	-
13	Sign(0.05)	*	NS	**	**	-	-
14	CV	77.9	25	14.3	48.7	-	-
15	SE	44.6	348.4	363.96	176.16	-	-

Note:
*=Significant, **=Highly significant
S+GN (1:1): SP=Intercrop ground nut with Sorghum 1:1; Simultaneous planting.
S+GN (1:1): RP=Intercrop ground nut with sorghum 1:1; Relay planting.
S+GN (2:1): SP=Intercrop ground nut with Sorghum 2:1; Simultaneous planting.
S+GN (2:1): RP=Intercrop ground nut with Sorghum 2:1; Relay planting.
S+SB (1:1): SP=Intercrop soybean with sorghum 1:1; Simultaneous planting.
S+SB (1:1): RP=Intercrop soybean with sorghum 1:1; Relay planting,
S+SB (2:1): SP=Intercrop soybean with sorghum 2:1; Simultaneous planting.
S+SB (2:1): RP=Intercrop soybean with sorghum 2:1; Relay planting, SSB=Sole soybean, SS=Sole Sorghum; SGN=Sole Ground nut. For calculated the gross income: price of sorghum=6 birr/Kg, Price of Ground nut=12 birr/kg and Price of soybean 8 birr/kg.

Table 4: The influence of intercropping on *striga* emergence, yield, LER and income in 2014.

intercrops. Therefore, intercropping groundnut in 1:1 proportion and simultaneous planting for the control striga is essential, ideal and useful to small-scale farmers, in order to achieve sustainable crop production.

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Citation: Dereje G, Adisu T, Mengesha M, Bogale T (2016) The Influence of Intercropping Sorghum with Legumes for Management and Control of Striga in Sorghum at Assosa Zone, Benshangul Gumuz Region, Western Ethiopia, East Africa. Adv Crop Sci Tech 4: 238. doi: 10.4172/2329-8863.1000238

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