

Influence of Cowpea and Soybean Intercropping Pattern in Sorghum on Striga (striga hermonthica) Infestation and System Productivity at Mechara, Eastern Ethiopia

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Abstract
Striga is a serious constraint to sorghum, millet, rice and maize production in the dry land zones of Africa Field experiment was conducted at Mechara Agricultural Research Center during ; to determine the effect of cowpea and soybean intercropping pattern on Striga hermonthica infestation in sorghum and to assess the effect of S. hermonthica and intercropping on system productivity. The treatments included two legume crops (soybean and cowpea), their planting time (simultaneously and at first weeding of sorghum),three planting patterns of legumes (double alternate plants within sorghum plants, two rows in between two rows of sorghum and both double alternate plants and two rows in between two rows of sorghum) along with sole crops (sorghum, soybean and cowpea). The experiment was conducted in randomized complete block design with three replications. The results showed that cowpea proved significantly superior to soybean in reducing striga infestation. Though simultaneous planting of soybean with sorghum in double alternate plants and two rows in between two rows of sorghum had minimum Striga infestation, but it was statistically at par with cowpea planted simultaneously with sorghum under all the planting patterns and planting with first weeding in sorghum under double alternate plants and two rows in between two rows of sorghum. Interaction of legumes with planting pattern significantly influenced sorghum plant height and aboveground dry biomass yield, while legumes and their time of planting and time of planting and planting pattern had significant effect on crop stand count and kernel weight per head, respectively.
Keywords: Cowpea, infestation level, intercropping, planting pattern, productivity, sorghum, soybean, Striga

Introduction

Agriculture plays an important role in the Ethiopian economy and livelihood of the people. CSA (2012) reported that cereals are the major food crops both in terms the area they are planted and volume of production. They are produced in larger volume than with other crops because they are the main principal crops. Sorghum [*Sorghum bicolor* (L.) Moench] is the third most important cereal crop in terms of area of production next to tef [*Eragrostis tef* (Zucc.) Trotter] and maize (*Zea mays* L.). Sorghum is one of the most important cereal crops of the tropics grown extensively over wider areas with altitude range from 1400 to 2100 meters above sea level (m.a.s.l). Its ability to adapt to adverse environmental conditions has made sorghum a popular crop worldwide. Sorghum is the major source of energy and protein for millions of people living in the arid and semi-arid regions of the world. It occupied third position in Africa after maize and wheat and fifth in the world after maize, rice, wheat and barley (FAO, 2009). In Ethiopia, sorghum was cultivated on 1.78 million ha with a production of 3.47 million metric tons and the average yield of 1.95 ton ha^{-1} during 2010-11 (CSA, 2012). The livelihood of millions of Ethiopians depends on a staple food crop. It remains to be the primary source of food in Ethiopia (Asfaw, 2007). Besides, it has tremendous uses for the Ethiopian farmers and no parts of this plant are ignored. The leaf and stalks of sorghum are used for animal feed and the stalks are used for construction of houses and fences and as fuel. Sorghum grows in a wide range of agro ecologies, most importantly in the moisture, stressed parts where other crops can least survive and food insecurity is rampant.

At present, *Striga* is a serious constraint to sorghum, millet, rice and maize production in the dry land zones of Africa. It is also a problem in sub-humid to humid African regions (Rao and Musselman, 1987; Gebisa, 2007). The main constraints for achieving higher crop productivity in those areas are lack of *Striga* resistant varieties, erratic rainfall, and low soil fertility due to monoculture, insect pests and diseases as well as poor transfer of improved production technologies. With erratic rainfall, encroaching desert, intensive land use and free movement of farm produce, the spread of *Striga* has increased with a consequent decrease in food production in many countries (Fasil, 2002). In traditional African cropping, prolonged fallow, crop rotation and intercropping were the common practices that kept *Striga* infestation in tolerable level.

In Ethiopia, where sorghum is one of most important staple food crops for most rural community, *Striga* causes serious yield reductions. This parasitic weed cause estimated yield losses that range from 40 to 100% when the infestation is very serious, especially in northern, north western and western parts of the country where sorghum cropping is the most suitable choice for farmers. Sorghum is a major food crop grown in western Hararghe, accounting for 59.3%, followed by maize 32.8%, and tef 4.15% of the total cultivated areas (CSA, 2012). Farming systems in the West Hararghe Zone of Ethiopia constitute complex production units involving a diversity of interdependent mixed cropping and livestock activities. The area predominantly is cereal producing with sorghum and maize as staple crops; the major annual crops grown include sorghum, maize, groundnuts, sweet potato, wheat, common beans and barley. In addition, the major cash crops like chat and coffee have a long-standing tradition in the district.

In most areas, parasitic weeds are problematic in agricultural production systems. The two species that are found in Hararghe are *S. hermonthica*, which has pink flowers and is relatively tall (0.5m) and *S. asiatica*, which has bright red or orange flowers and is relatively short (0.2m). The weeds compete with crops for nutrients, water and food. Striga compensate for lack of their own root system by penetrating the roots of host plants and thus depriving the essential nutrients for plant growth. This brings about stagnation of the host plants resulting in low yield.

There are several suggestions for the control of striga. However, only a few seem to be technically feasible and cost effective for small-scale holding. The long list of control measures includes the use of resistance varieties, hand pulling, adequate land preparation, hoe weeding, herbicide spray, high rate of inorganic and organic nitrogen fertilizer, trap and catch crops, the use of germination stimulants and biological control (Lagoke *et al*., 1988).

The adoption of intercropping of sorghum with legumes such as green gram, cowpea, and groundnut may help to suppress striga through suicidal germination while producing higher value pulse intercrops. Cereal legume intercropping is a predominant cropping system in Sub-Sahara African countries where it is used for maximizing use of limited farmlands, food security and improving soil fertility. Use of legume trap crops is an important low cost method for depletion of striga seed bank in the soil. Legume crops like Desmodium, cowpea and soybeans have been found to release exudates that induce germination of striga but are themselves not parasitized (Aliyu and Emechebe, 2006). Integrating these crops into cropping systems could reduce the striga seed bank and improve soil fertility and livelihood of farmers. In addition, preliminary works shows that some soybean accessions induce germination of *S. hermonthica* but are themselves not parasitized (Carsky *et al*., 2000). According Odhiambo *et al*. (2011) growing maize in association with soybean in the field resulted in lower striga incidences , hence better growth and yield of associated maize. Less number of striga per net plot area are observed when sorghum is intercropped with cowpea (Aliyu and Emechebe, 2006). Apart from this when plants are grown in association (intercropping), interaction between the components crops species may occur. This interaction is essentially a response of one species to the environment as modified by the presence of another species. Intercropping with legumes also improves soil fertility through fixation of atmospheric nitrogen.

In West Hararghe the infestation of *S. hermonthica* discourages farmers from sorghum cultivation. The hand pulling and crop rotation, which are practiced by farmers of the area, could not bring significant change in reducing its infestation. Research on the control of *S. hermonthica* in sorghum using legume under different planting pattern of intercropping has not been carried out in west Hararghe, which may be an effective and economical means of reducing its infestation. Thus, apart from finding an easy and economical measure of controlling and/or reducing the infestation of *S. hermonthica*, intercropping may also result in higher productivity per unit area per unit time with stability in production. Therefore, the study was conducted with the following objectives; to determine the effect of cowpea and soybean intercropping patterns on *S. hermonthica* infestation in sorghum

Materials and Methods

Description of the Study Area

The field experiment was conducted at Mechara Agricultural Research Center (MeARC) during the 2013 cropping season. MeARC is found in altitude 1700 M.a.s.l and (40^{o} 19' N latitude and 08^{o} 35' E longitude). It is located 434 km east of Addis Ababa in West Hararghe, eastern at Ethiopia. The major soil type of the Center is sandy loam with reddish color (MeARC, 2010). MeARC is found Daro Lebu, which is one of the districts of West Hararghe zone, and 12% of its area lies in the high land, 44% in the mid-high land and 44% in the low land agro ecological zones. The rainfall in this area is usually erratic; there is also rainfall variability in the onset and cessation of the main rainfall. Farming systems of Daro Lebu district constitute complex production units involving a diversity of interdependent mixed cropping and livestock activities. The area is predominantly cereal producing with sorghum and maize as staple food crops; the major annual crops grown include sorghum, maize, groundnuts, sweet potato, wheat, common beans and barley. In addition, the major cash crops, like chat and coffee, have a long-standing tradition in the district. Monthly data of total rainfall, maximum and minimum temperatures during the experimental season showed a total rainfall of 757.6 mm out of which 35.1% was received during the month of August (Table 1).

Table 2. Total rainfall (mm), mean maximum and minimum temperatures (°C) at Mechara Agricultural Research Center during June- October 2013 cropping season

		Air temperature (⁰C)		
Month	Rain fall (mm)	Maximum	Minimum	Average
June	96.7	26.46	14.95	20.71
July	133.0	25.06	15.22	20.14
August	266.1	24.88	15.19	20.07
September	135.9	26.68	15.35	20.30
October	125.9	25.48	15.06	21.04
Total	**757.6**	**-**	**-**	**-**
Monthly Mean	**151.52**	**25.7**	**15.15**	**20.45**

Mean monthly maximum and minimum temperatures of the experimental season varied between 24.88 and 26.68 °C and 14.95 to 15.35 °C, respectively while the average temperature during the cropping season was 20.45 °C. In general, the average monthly maximum and minimum temperatures and rainfall distribution were suitable for sorghum production.

Experimental Materials

Sorghum variety Girana-1, cowpea variety ILRI11114-accession number and soybean variety Crowford were used for the study. Girana-1 was released by Sirnka Agricultural Research Center in 2007. It requires 600-900 mm rainfall and takes 75 days to heading and 122 days to physiological maturity. Crowford is early maturing soybean variety, with determinate growth habit and takes 90-120 days to reach physiological maturity. It grows on soils free from excessive rainfall and at altitude ranges from 1300-1700 m. Cowpea ILRI11114-accession number was introduced by International Livestock Research Institute.

Treatments and Experimental Design

Cowpea and soybean were intercropped with sorghum in three planting patterns, i.e. inter rows (two rows each of cowpea and soybean in between two rows of sorghum) and intra-rows (two plants each of soybean and cowpea in between two sorghum plants) and the combination of both inter and intra rows. The legume intercrops were planted as per their planting pattern simultaneously with sorghum and at the time of first hand weeding sorghum. Thus, there were 12 treatment combinations (two legume crops x three planting patterns x two time of planting). Apart from these treatments, sole sorghum, sole cowpea and soybean were used for the study. Thus, there were 15 treatments as below:

T 1= Sorghum + Cowpea (2:2) planted simultaneously
T 2= Sorghum + Cowpea (Two plants in intra rows or double alternate plants) planted simultaneously
T 3= Sorghum + Cowpea (2:2) (Combination of both inter and intra rows of cowpea) planted simultaneously
T 4= Sorghum + Cowpea (2:2) and cowpea planted with first weeding of sorghum
T 5= Sorghum + Cowpea (Two plants in intra rows or double alternate plants) and cowpea planted with first weeding of sorghum
T 6= Sorghum + Cowpea (2:2) (Combination of both inter and intra rows of cowpea) and cowpea planted with first weeding of sorghum
T 7= Sorghum + Soybean (2:2) planted simultaneously
T 8= Sorghum + Soybean (Two plants in intra rows or double alternate plants) planted simultaneously
T 9= Sorghum + Soybean (2:2) (Combination of both inter and intra rows of soybean) planted simultaneously
T 10= Sorghum + Soybean (2:2) and soybean planted with first weeding of sorghum
T 11= Sorghum + Soybean (Two plants in intra rows or double alternate plants) and soybean planted with first weeding of sorghum
T 12= Sorghum + Soybean (2:2) (Combination of both inter and intra rows of soybean) and soybean planted with first weeding of sorghum
T 13= Sole sorghum
T 14= Sole cowpea
T 15= Sole soybean

The experiment was conducted on a hot spot field that has been under natural *Striga* infestation for the last several years. The experiment was laid out in a randomized complete block design (RCBD) in a factorial arrangement with three replications. Each plot was separated by 1 m and each block with 1.5 m. The plot size was 4.5 m x 3.0 m = 13.5 m^2. The net plot size was 3.0 m x1.8 m. The sole and intercropped sorghum were planted in spacing of 75 cm x 30 cm with a population density of 44,444 ha^{-1}. Sorghum seed was drilled in the rows and thinned to the recommended spacing at 30 cm between plants. Other agronomic management practices were followed as per the recommendation for the crop. Both cowpea and soybean were spaced at 18.75 cm from the sorghum rows with intra-row spacing of 10 cm and 5 cm for cowpea and soybean, respectively. The inter row spacing of 37.5 cm was between the rows of legume crops. The populations of cowpea and soybean were 2, 66, 666 and 5, 33,333 ha^{-1}, respectively. In intra, rows of sorghum two seeds of both soybean and cowpea were spaced 10 cm from each sorghum plant. The population of sole cowpea and soybean in combined inter-and intra-row planting pattern 33, 3332 and 59, 9999 ha^{-1}, respectively. The sole soybean and cowpea were planted at recommended spacing of 60 cm x 5 cm and 60 cm x 10 cm with a population of 3, 33,333 and 1, 66,666 ha^{-1}, respectively.

Management of the Experiment

The land was ploughed, disked and harrowed by tractor before planting. Simultaneously planting of sorghum and legume crops was made on 24 June 2013 and the sowing of legume crop at first weeding of sorghum was done on 28 July 2013. After the crop emerged, thinning was carried out according to recommended population and spacing for all crops. Selective hand weeding was practiced to keep the plots weed free other than *S. hermonthica.* Each crop was harvested at physiological maturity; threshing was done manually. Grain moisture content of sorghum was adjusted to 12.5 % where as for soybean and cowpea it was adjusted to 10% moisture content.

Soil Sampling and Analysis

An initial soil sample was collected at a depth of 0 - 30 cm from randomly selected spots diagonally across the experimental field and a composite soil sample was prepared. Then the collected soil sample was air-dried by spreading on a plastic sheet at room temperature. The dried soil sample was ground with mortar and pestle to pass through a 2 mm sieve and then packed in a polythene bag, labeled and sent to the laboratory for analysis (Sahilemendhin and Taye, 2000). Soil samples were analyzed for textural classes, pH, organic matter, total nitrogen, and available phosphorus and Cation exchange capacity (CEC), at the Ziway Soil Laboratory using standard laboratory procedures.

Data Collection

Weed parameters

***Striga* counts ha^{-1}:-** *Striga* counts ha^{-1} was taken at physiologically maturity of sorghum. Because of the high variability observed for the actual *Striga* counts, both with and among the treatments, square root transformation of the original data was performed to stabilize the variance analysis.

***Striga* infestation: -** To estimate the *Striga* infestation levels at sorghum harvest the calculation was made by using the formula below;

$$Striga\ infestation\ (\%) = \frac{\text{Total } Striga \text{ count per plot}}{\text{Crop stand per plot}} \times 100$$

The reduction in *Striga* infestation level (RIL) among the cowpea and soybean were calculated as fallows

$$RIL = \frac{Striga \text{ count in sole sorghum } - Striga \text{ count in intercrop}}{Striga \text{ count in sole sorghum}} \times 100$$

Data Analysis

The analysis of variance (ANOVA) was carried out using statistical packages and procedures out lined by Gomez and Gomez (1984) appropriate to Randomized Complete Block Deign using GenStat Computer Software version 13.3. Mean separations was carried out using least significant difference (LSD) at 5% probability level.

Results and Discussion

Soil analysis

The soil analysis data indicated that the soil of the study area had high (1.4%) level of total nitrogen, (2.73%) medium level of organic carbon, (3.46-ppm) low level of available phosphorus, and medium CEC (21.6). The pH (H_2O) of the soil was 5.63 showing moderately acidic nature of the soil. Thus, the pH of the experimental soil was within the range for productive soils. Soil textural analysis results indicated that the textural class of the experimental site was sandy clay (Table 2).

Table 3. Selected physicochemical properties of experimental field soil at Mechara before planting

Soil characteristic	Values
pH (1:2.5 H_2O)	5.63
Organic carbon (%)	2.73
Total nitrogen (%)	1.4
Available phosphorus (ppm)	3.46
Cation exchange capacity (meq/100g)	21.6

Weed parameters

***Striga* count ha^{-1}** : The analysis of variance (ANOVA) revealed that *Striga* count per hectare was highly and significantly (P < 0.01) different due to main effect of legume crops, time of planting and planting pattern. However, no significant difference was recorded except due to interactions the interaction effect of legume crops with time of planting. Higher *Striga* population was recorded when soybean was intercropped with sorghum than in the cowpea intercropped with sorghum (Table 3). This was in agreement with the findings of Fasil and Verkleij (2007) who found that higher *Striga* shoots per plant were recorded in soybean-sorghum intercropping than in cowpea intercropped with sorghum. Furthermore, even some varieties were more effective than others and effectiveness is known to vary across *S. hermonthica* populations (Fasil and Wondimu, 2001). The results on the effect of time of legume planting in sorghum revealed that when legume was planted at the time of first weeding of sorghum *Striga* population was 32.1% more than that of simultaneous planting of legumes (Table 3). Similarly, Khan *et al.* (2011) reported lower number of the weed population when maize and mungbean were planted simultaneously. In contrast, Fasil and Verkleij (2007) reported that time of cowpea; soybean and haricot bean planting in sorghum did not significantly influence *Striga* count per plant. The contrasting results might be due to varietal and environmental differences at the locations. Higher *Striga* count was recorded in 2R planting pattern and the lowest was recorded DAPs+2R planting pattern (Table 3). In two rows of legume in between the two rows of sorghum (DAPs) the proximity of legume roots might not be near (18.75 cm) to sorghum compared to double alternate plants (DAPs) where the legume plants were 10 cm away from sorghum plants within the rows. On the other hand, in 2R+DAPs planting pattern of legumes, the sorghum plants were surrounded by legumes, thereby it might have created condition conducive to decreased *Striga* population. It could also be the result of significantly higher plant stand per unit area and dense cover might have more suppressing and shading effect, thereby reduced soil temperature and hence reduced seed germination and emergence of *S. hermonthica* (Parker and Riches, 1993; Berner *et al*., 1996). Shading especially with more than 60% light interception can reduce *S. hermonthica* infestation but not underground attachment of the parasite to maize (Oswald, 2005). In contrast, Khan *et al.* (2011) reported lower number of weeds when maize was intercropped with two rows of mungbean. However, it might be due to different set of treatments as two rows were compared with one row of mungbean. Nevertheless, it confirmed the role of higher plant stand per unit area in reducing the *Striga* infestation.

Table 4. The effect of legume crops, time of planting and planting pattern on weed parameters in sorghum, cowpea and soybean intercropping systems at Mechara

Treatments	Striga count (ha^{-1})	Striga infestation percentage (%)	Reduction infestation level (%)
Legume			
Soybean	15.67a (267)	4.28	65.0
Cowpea	11.36b (137)	2.05	84.9
LSD (5%)	1.80	0.837	7.08
Time of planting			
Simultaneously	11.42b (141)	1.88	83.3
First weeding	15.61a (263)	4.45	66.6
LSD (5%)	1.80	0.837	7.08
Planting pattern			
Double alternate planting (DAPs)	13.55b (196)	4.47	75.3
Two rows of inter crops (2R)	15.82a (273)	3.95	63.9
Two rows of inter crops (2R) + DAPs	11.77c (139)	1.09	85.5
LSD (5%)	2.16	1.026	8.67
CV (%)	18.90	38.20	13.70

Means followed by the same letter(s) within columns are not significantly different at P ≤ 0.05 level of significance, LSD= Least significant difference, CV= Coefficient of variation. The figures in the parenthesis are the original values for *striga* count per hectare

Sole sorghum showed higher *Striga* count than sole cowpea, sole soybean and legume intercropping systems (Fig. 1). This is in agreement with the findings of Aliyu and Emechebe (2006) who reported higher number of *Striga* in sole sorghum as compared to sorghum was intercropped with cowpea. Similarly, by Fasil and Verkleij (2007) indicated higher *Striga* count in sole sorghum than sole soybean, sole cowpea and sole haricot bean. Khan *et al.* (2011) also reported that weed population was significantly affected by intercropping both mungbean and soybean in one-one and two-two rows simultaneously seeded or delayed seeded by three weeks. Zeyaur *et al.* (2006) reported that *S. hermonthica* counts were significantly lower in the sorghum/*Desmodium intortum* intercropping, than in sorghum monocrops, they are also significantly lower in the intercrops than monocrops plots.

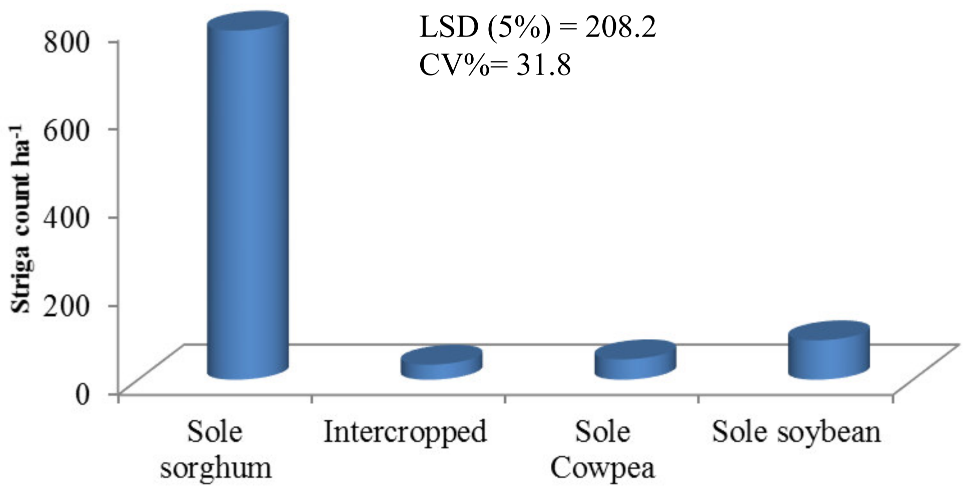

Figure 1. The effect cropping system on Striga count ha^{-1}

Lower *Striga* population in intercropped plots indicated that sole sorghum could not suppress the growth and development of *S. hermonthica* as compared to intercropped plots. This implies that intercropping suppressed the growth and development of *S. hermonthica*, which might be due to exudates released from both the cowpea and soybean. Aliyu and Emechebe (2006) reported that cowpea and soybean released exudates that induced germination of *Strig*a but they were not parasitized served as trap crops. This was in agreement with the findings of Kureh *et al*. (2006) who indicated that intercropping maize with cowpea reduced emerged *Striga* density. This reduction may also be due to shading effects from the cowpea canopy. However, the *Striga* population in this experiment was low, which might have been below the damage and economic threshold.

Striga infestation percentage

The infestation level of *S. hermonthica* was highly significant ($P < 0.01$) due to main effect of legume crops, time of planting and planting pattern. All main factors interaction were also found significant ($P < 0.0 5$). The planting of soybean in two rows (2R) at first weeding in sorghum resulted in significantly higher *Striga* infestation level than the other interactions. The lowest *Striga* infestation level was observed because of soybean intercropping using 2R+DAPs planting pattern at the time of sorghum planting .

Table 5. Interaction effect of the legume crops, time of planting and planting pattern on *S. hermonthica* percent infestation in sorghum intercropped with cowpea and
soybean at Mechara 2013 cropping season

		Striga infestation percentage		
Legume crops	**Time of planting**	DAPs	2R	2R+DAPs
Soybean	Simultaneously	4.31	1.18	0.3
	First weeding	7.53	9.94	2.44
Cowpea	Simultaneously	2.28	2.28	0.95
	First weeding	3.76	2.39	0.66
LSD (5%)			2.051	
CV (%)			38.20	

Means followed by the same letter(s) within rows are not significantly different at $P \leq 0.05$ level of significance, LSD= Least significant difference, CV= Coefficient of variation

However, it was statistically at parity with soybean in 2R pattern planted simultaneously, cowpea planted simultaneously under all the planting patterns and at first weeding of sorghum in 2R+DAPs. The result also demonstrated that *Striga* infestation level was significantly reduced when soybean was planted simultaneously with sorghum under the entire planting pattern compared to soybean planting with the first weeding in sorghum. On the other hand, there was no as such a significant difference when cowpea was intercropped with sorghum. This might be due to the difference in growth habit of the legumes. However, planting of soybean with first weeding of sorghum in 2R pattern resulted in significantly higher *Striga* infestation percent than the other interactions. The soybean plants might have been very small at the time of *Striga* emergence when planted with the first weeding of sorghum that did not hampered the germination of

Striga. Further, in 2R and DAPs patterns planted plots, the roots of soybean might have not developed and may not be in proximity to the roots of sorghum compared to 2R+DAPs planting pattern, thus resulted considerably increase *Striga* infestation percentage (Table 4).

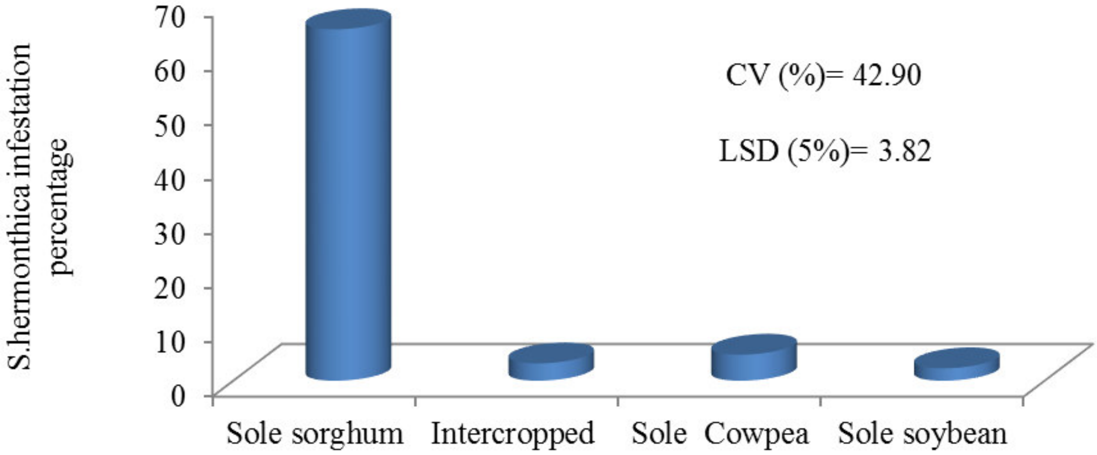

Figure 2. Effect of cropping system on *S. hermonthica* infestation percentage

Cropping system significantly influenced *Striga* infestation percentage. Sole sorghum had significantly higher *Striga* infestation percentage than intercropped legume as well as sole soybean and cowpea (Fig 2). This is because sorghum is the main host crop for *S. hermonthica* infestation. *Striga* infestation percentage in sole cowpea, sole soybean and the intercropping systems was not significant. Kureh et al. (2006) who indicated that Striga infestation and incidence were lower when maize was intercropped with cowpea than planted sole reported similar finding. Hence, intercropping sorghum with cowpea and soybean is a good agronomic practice for *Striga* management due to reduced *Striga* infestation.

Reduction infestation level

The reduction in infestation level of *S. hermonthica* showed highly significant ($P < 0.01$) difference due to main effect of legume crops, time of planting and planting pattern. The interaction effect of legume crops with time of planting was highly significant. However, all other interactions were not significant. Cowpea and soybean reduced the infestation level of *S. hermonthica* in sorghum; one of the advantages of intercropping in weed suppression.

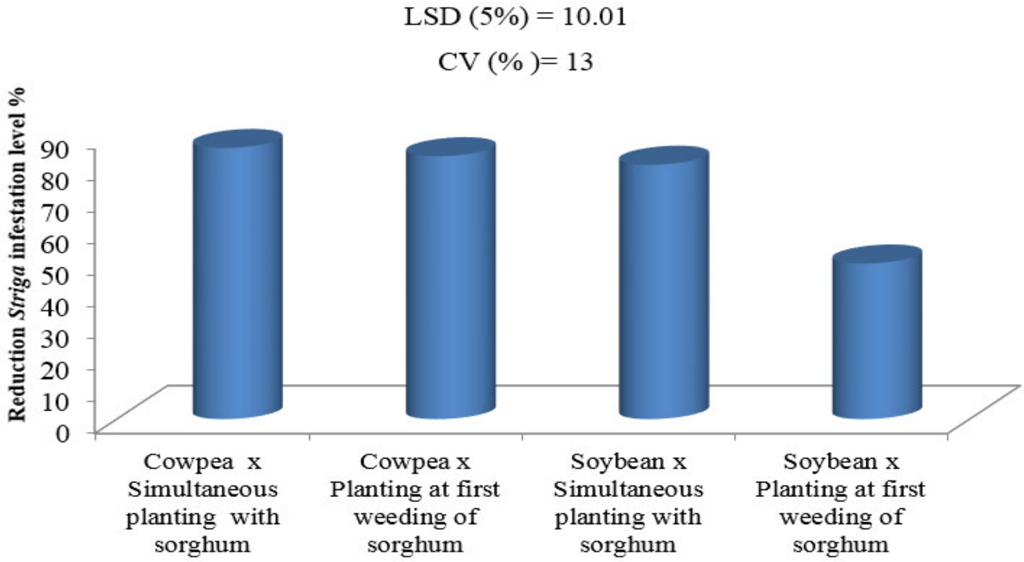

Figure 3. The interaction effect of legume crops with time of planting on reduction of *Striga hermonthica* infestation level

Cowpea planted simultaneously with sorghum and first weeding of sorghum as well as soybean planted simultaneously with sorghum did not show significant difference among themselves, but all these interactions gave significantly higher reduction in infestation level of *S. hermonthica* than soybean planted during the first weeding of sorghum (Fig 3). This might be because of difference in morphological growth and the competitive ability of cowpea for nutrients, light and space. The ground cover of cowpea was also more than that of soybean; which might have limited the growth, development and survival of *S. hermonthica*.

Table 1. Mean square of ANOVA for yield components and yield of sorghum as influenced by legume crops, time of planting and planting patterns in cowpea and soybean intercrop at Mechara.

		Mean Squares					
Source of variation	**DF**	Head weight per plant(g)	Above ground dry biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Grain yield per plant (g)	Harvest index (%)	Thousand grain weight (g)
Replication	2	4.1	746323	17562	16.11	47.32	27.7
Legumes(L)	1	445.2	2224040*	1336290*	1059.07**	193.35*	91.58*
TP	1	1162.8*	1546993*	902722*	129.96	135.06*	287.89*
PP	2	16.8	2857798**	237150*	33.17	65.16*	20.72
L x PP	2	200.9	2050046**	309938*	98.17	52.01	14.5
L x TP	1	31	737220	8007	45.65	26.79	23.8
PP x TP	2	167.7	4813312**	1135596*	468.16**	73.64*	23.78
L x TP x PP	2	22.2	51269	52748*	5.78	26.86	1.9
Residual	22	105.2	204360	12688	38.46	19.58	14.98
CV (%)		20.1	11.7	7.1	14.1	10.7	12.9

DF= degree of freedom *= significant at ($P \leq 0.05$) **= significant ($P \leq 0.01$).

Grain yield

The analysis of variance (ANOVA) showed that grain yield of sorghum was significantly influenced due to main effect of legume crops, time of planting, planting pattern and all interaction effects; except the interaction of legume crops with time of planting . The interaction of three factors revealed that soybean DAPs at the time of sorghum first weeding resulted in the highest grain yield of sorghum; however, it did not show significant difference with soybean planted in 2R in between two sorghum rows at first weeding . It was also noticed that the latter interaction was statistically at parity with cowpea intercropped with sorghum in 2R pattern at the first weeding of sorghum. The (911.8 kg ha $^{-1}$) lowest grain yield of sorghum was obtained when cowpea was intercropped in DAPs simultaneously with sorghum. It was also revealed that soybean intercropped with sorghum resulted in significantly lower grain yield when planted simultaneously with sorghum than planting at first weeding of sorghum under all the planting patterns. On the other hand, cowpea- sorghum intercropping showed, a similar trend except cowpea planted with first weeding in sorghum in 2R+DAPs pattern, where in simultaneous planting in 2R+DAPs pattern gave significantly higher grain yield. Myaka and Kabbissa (1996) and Champion *et al.* (1998) reported that variation in planting pattern could cause variation in nutrient uptake and the general performance of intercropping system. Addo-Quaye (2011) found that time of introduction of soybean significantly affected maize grain yield and delayed soybean planting increased maize grain yield in maize/soybean cropping system. It was also reported that maize planted in alternate rows 28 days after soybean gave significantly higher grain yield than those planted in double rows of soybean. Similarly, Chemeda (1997) reported that delayed bean planting increased maize grain yield in maize / bean cropping systems.

Sorghum/soybean cropping system reduced sorghum grain yield by 23.9%, where as sorghum/cowpea reduced the grain yield by 40.31% . Although in this experiment, the *Striga* infestation was significantly high in sole sorghum than the sole soybean and cowpea and intercropped sorghum and legume (Fig.1), the density of *Striga* seemed to be below the threshold level thus failed to inflict loss in sorghum yield. As reported by Mbwaga *et al*. (2001) the effectiveness of cereal-legume intercropping to influence *Striga* germination depends on the effectiveness of produced stimulants, root development, fertility improvement, shading effect and its compatibility to *Striga* species as the management option is *Striga* specific. As reported by Khan *et al*. (2002) the effectiveness of cereal-legume intercropping to influence *Striga* germination depends on the effectiveness of produced stimulants, root development, fertility improvement, shading effect and its compatibility to *Striga* species as the management option is *Striga* specific. Fasil and Verkleij (2007) also reported that sorghum/ soybean-cropping system reduced sorghum yield by 27.5% while in system the magnitude of sorghum yield reduction was 55.6% sorghum/cowpea intercropping. Similarly, Oseni and Aliyu (2010) obtained a reduction of 69.7% in sorghum yield due to sorghum/cowpea intercropping. Further, they found that grain yield of sorghum was higher in sole cropping than intercropping mixtures. This was in agreement with the findings of Langat *et al*. (2006) who indicated that intercropping significantly affected the yield of sorghum in sorghum/ groundnut intercropping. Other studies revealed higher sorghum (Tamado and Eshetu, 2000) and maize (Chemeda, 1997) grain yield in sole cropping than intercropping. This was is in agreement with the findings of Addo-Quaye (2011) who reported that maize planted in alternate rows with maize planted 28 days after soybean gave significantly higher grain yield than those planted in double rows of soybean.

The interaction effect of legume, their planting time and planting pattern showed that planting of soybean in double alternate plants in between sorghum plants at the first weeding of sorghum resulted in a significant increase in sorghum yield over other interaction except the interaction of two soybean rows planted at the first weeding of sorghum in between two sorghum rows. Further, the latter interaction was statistically in parity with the interaction of two rows of cowpea planted at first weeding in sorghum. Simultaneous planting of double plants of cowpea in between the sorghum plants resulted in significant decrease in sorghum yield over other interactions.

Conclusions

The result indicated that *Striga* count ha^{-1} was significantly different due to main effects of legume crops, time of planting and planting patterns. The results on the effect of time of legume planting in sorghum revealed that when planting of a legume crops was done at the time of first weeding of sorghum the *Striga* population was 32.1% more than that of simultaneous planting of legumes with sorghum. Sole sorghum showed higher *Striga* count per hectare than sole cowpea, sole soybean and intercropping systems. The planting of soybean in two rows (2R) at first weeding in sorghum resulted in significantly higher *Striga* population than the other interactions. The lowest *Striga* population occurred in soybean intercropped with sorghum in 2R+DAPs planting pattern when planted simultaneously with sorghum. However, it was not considerably different from soybean in 2R pattern planted simultaneously, cowpea planted simultaneously under all the planting patterns and at first weeding of sorghum in 2R+DAPs. Sole sorghum had higher *Striga* infestation percentage than intercropped legume crops as well as sole soybean and cowpea. The result clearly depicted that the role of legumes in increasing production per unit area and reduced striga infestation.

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