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Effect of cropping system, seed treatment and planting date on *Striga hermonthica* infetstaion and growth and yield of sorghum

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Striga hermonthica **is a serious biotic constraint to sorghum production in sub-Saharan Africa but the use of cropping system, seed treatment and appropriate planting dates might help to control the weed. Two years trial was conducted at the Federal University of Technology Minna research farm. The objective was to evaluate the effect of intercropping system, seed treatment, and planting date in integrated management of** ***S. hermonthica*** **in sorghum. Treatments comprised two varieties of sorghum (resistance ICSV 1002 and susceptible Gwari Local variety), three different concentrations of** ***parkia*** **pulp powder (0, 66 and 100 g/L), soyabean variety TGX 1448-2E and two sowing dates (15 June and 21 July) in two cropping season (2012 and 2013). These were evaluated in a randomized complete block of three replicates. Data in both years were collected on days to first** ***Striga*** **emergence and** ***Striga*** **count per stand of sorghum plant and per plot of sorghum plant, severity score, sorghum plant height and grain yield were collected in both years. The results show that** ***Striga*** **emergence was significantly delayed in sorghum variety ICSV1002, sorghum intercropped with soyabean and sorghum soaked with 66g/L** ***Parkia*** **concentrations compared to other treatments.** ***Striga*** **count was fewer in sorghum variety ICSV1002, sorghum intercropped with soyabean and sorghum soaked with 66 g/L** ***Parkia*** **concentrations compared to other treatment. Severity score, plant height and grain yield showed the same trend as** ***Striga*** **emergence and** ***Striga*** **count. In conclusion, program of integrated** ***Striga*** **control could provide sustainable** ***Striga*** **control**

Key words: Sorghum, *Striga hermonthica,* integrated management.

INTRODUCTION

An estimated cereal production area of 50 million hectare shows different levels of *Striga* infestation in Africa (Westwood et al., 2010). In total, 25 African countries reported *Striga* infestations in 2005 (De Groote et al., 2008). The socioeconomic consequences are difficult to measure, but a few estimations have suggested that

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Striga affects the life of more than 100 million people in Africa and causes economic damage (Labrada, 2008; Waruru, 2013). Controlling the production of new *Striga* seeds is therefore an important component of a long-term control program. Farmers in Africa have limited resources to invest in *Striga* control practices and longer term, low-input approaches are needed. Cropping systems remain traditional and the methods mostly used in controlling *Striga* are hand-pulling, land fallowing, crop rotation, crop seeds treatment with the powder of *Parkia biglobosa* (African locust bean tree) peels before the planting (Traoré and Yonli, 2001). Unfortunately, these cultural practices do not lead to significant reduction of the density of *S. hermonthica* in affected-fields (Traoré and Yonli, 2001). Besides, some of these control methods are labour intensive to the capital deficient farmers (Mashark et al., 2006). The land fallowing method is less used because of the reduction of arable land due to the population growth. Regarding crop cultivars, the national programme of cereal breeding has attempted to identify *Striga* resistant varieties of sorghum, based on the number of emerged *Striga* plants in cultivation plot. Long-term *Striga* control focus approaches on controlling the production of new *Striga* seeds and on reducing the number of seeds in the soil. Several seasons of hand weeding are required before the beneficial effect on the cereal crop can be observed. Intercropping with trap crops can reduce *Striga* seed banks but selection of a trap crop should be based on their ability to stimulate *Striga* seeds to germinate. The use of plant products for the control of *S. hermonthica* is limited, though the effect of plant materials especially neem (*Azadiracthaindica)* products have been reported to significantly control some organisms e.g insects, fungi and to some extent nematodes (Gahukar, 2002; Agbenin, 2002; Abdel-Razek and Gowen, 2002).The use of powder from the fruit of *P. biglobosa* has been reported to improve the soil agrochemical properties and to inhibit the germination of *S. hermonthica* seed. In Nigeria, Marley et al. (2004) reported 29.1% less *Striga* emergence under field conditions when *Parkia* products were used. Integrating yield protecting technologies like the seed dressing technology with practices that provide returns in the longer term may be one way to longer-term approach. The objective of this study is to evaluate the effect of intercropping system, seed treatment, and planting date in integrated management of *S. hermonthica* in sorghum;

MATERIALS AND METHODS

Experimental area

Field experiment was conducted at the Federal University of Technology Minna, (09° 39' N and 06° 28' E) in the Southern Guinea Savannah ecological zone of Nigeria with mean annual rainfall of 1300 mm. The experiment was carried out on sandy clay loamy in a field with a history of high *Striga hermonthica* infestation. The soil was characterized as an acidic (pH 5.2) sandy clay loamy (640 g/kg sandy 100 g/kg silt and 260 g/kg clay) with organic matter content of 8.9 g/kg. Total nitrogen was 0.5 g/kg, phosphorus of 4.2 mg/kg and cation exchange capacity of 6.09 cmol/kg.

Preparation of *parkia* pulp powder

Parkia fruits were obtained from Bosso town in Bosso local government area, Minna. The pulp was separated from the seeds by pounding in mortar with pestle and sieved. A weighing scale was used to measure 5 g of the pulp powder put in containers and diluted with distilled water at different volumes.

Experimental design, treatments and agronomic practice

The treatment design was a randomized complete block with three replicates. Three concentrations of *P. biglobosa* pulp powder at 0, 66 and 100 g/L was used to prime two sorghum cultivars (resistance ICSV1002 and Gwarri local varieties) and two sowing dates (15 June and 21 July) was assigned to main plot and sowing in July was considered late. Planting distance was 75 cm between rows and 30 cm between plants. Seed were socked for 16 h and sown two to three seeds of sorghum per hill on the chosen dates and stands with excess seedling were thinned to two plants per hill at two weeks after sowing. Hand pulling of weeds other than *S. hermonthca* seedling was done at four weeks and second weeding was carried out at 8 weeks after sowing. Harvesting of sorghum panicles was done at 22 and 23 weeks after sowing for June and July dates respectively; panicles were dried threshed and grain yield determined.

Data analysis

Data collection and analysis include days to first *Striga* emergence, *Striga* count per stand and per plot, severity score of maize using a scale of 1-5, where 1 indicates no *Striga* damage and 5 indicating a very high severely level, plant height from tagged stand using tape rule and measuring from the soil surface to neck of last leaf, grain yield per plot using weighing balance. Data were statistically treated with analysis of variance (ANOVA) using the computer software Genstat (2010). Statistical differences between variables means were compared using least significant difference ($P < 0.05$).

RESULTS

Striga emergence and count

Sorghum variety ICSV 1002 intercropped with soyabean at 66 g/L *Parkia* concentration significantly ($P < 0.05$) delayed *Striga* emergence (63.33 days) compared to other treatment combinations. In the local sorghum variety, intercropped with soyabean at 66 and 100 g/L *Parkia* concentration delayed *Striga* emergence (58.67 days) compared to other treatment combinations in 2012 (Table 1). In 2013, ICSV1002 variety intercropped with soyabean at 100 g/L *Parkia* concentration significantly ($P < 0.05$) delayed S*triga* emergence (66.00 days) compared to other treatment combinations. Delayed infestation was observed in the local sorghum variety intercropped with soyabean at 66 g/L *Parkia* concentration compared to other treatment combinations

Table 1. Interaction effect of sorghum, soyabean and *Parkia* concentration on days to first *Striga* emergence, *Striga* shoots count per stand and per plot.

Sorghum	Soyabean	*Parkia* concentration (g/l)	2012							2013						
			DFE	SCS (WAS)			SCP (WAS)			DFE	SCS (WAS)			SCP (WAS)		
				10	14	18	10	14	18		10	14	18	10	14	18
ICSV 1002	Sole	0	59.83	3.50	5.67	6.67	5.67	9.83	10.67	60.50	2.17	4.33	6.67	4.50	7.17	8.17
ICSV 1002	Sole	66	61.83	2.00	3.50	4.67	3.33	7.17	8.17	63.00	1.40	2.50	4.00	2.50	4.50	5.83
ICSV 1002	Sole	100	62.00	3.17	5.17	5.67	4.50	8.00	9.67	62.50	2.00	3.83	4.67	3.83	5.67	7.00
ICSV 1002	Soyabean	0	60.67	2.00	3.00	4.17	3.17	6.33	6.83	62.00	2.19	2.83	4.83	2.67	4.83	6.00
ICSV 1002	Soyabean	66	65.33	1.67	2.83	3.00	2.30	4.17	5.17	65.83	1.93	1.45	3.00	0.12	2.17	3.00
ICSV 1002	Soyabean	100	63.67	1.83	3.00	3.00	2.33	4.67	5.67	66.00	3.09	3.67	5.17	3.94	4.83	8.17
Local variety	Sole	0	55.33	10.00	15.17	16.00	14.83	22.33	23.67	59.00	7.50	9.50	11.67	11.00	13.33	14.83
Local variety	Sole	66	57.67	4.83	7.67	9.00	8.33	13.17	14.30	59.00	4.33	5.83	8.67	6.33	8.50	10.83
Local variety	Sole	100	57.40	5.50	9.17	10.00	9.67	13.83	14.83	59.67	4.33	6.83	8.50	6.67	8.50	10.83
Local variety	Soyabean	0	57.50	5.10	8.83	10.33	8.67	13.67	13.17	59.83	5.50	3.83	6.17	5.83	7.50	9.17
Local variety	Soyabean	66	58.67	2.83	4.83	5.50	5.17	7.83	9.33	59.83	2.00	4.17	5.57	3.83	5.83	7.50
Local variety	Soyabean	100	58.67	4.67	8.67	8.50	8.33	11.00	13.67	59.17	3.00	4.67	6.50	5.00	7.00	8.67
Mean			59.97	3.92	6.45	7.21	6.36	10.17	11.26	61.36	3.29	4.45	6.29	4.69	6.65	8.33
$LSD_{(0.05)}$			0.82	1.22	1.46	1.64	1.72	2.26	2.35	1.16	NS	1.40	NS	1.23	NS	NS

DFE, Day to first *Striga* emergence; SCS, *Striga* shoot count per stand; SCP, *Striga* shoot count per plot; NS, Non-significant; LSD, probability level at 0>.05; WAS, weeks after sowing.

Table 1). Irrespective of year of planting and in all the sampling periods, priming at 66 g/L *Parkia* concentration significantly ($P < 0.05$) supported fewer *Striga* count per stand and per plot compared to other treatment combinations (Table 1).

There were significant ($p < 0.05$) differences in sorghum intercropped with soyabean and treated with 66 g/L *Parkia* concentrate, as the treatment significantly suffered less *Striga* damage (2.17 and 2.00 in 2012 and 2013 respectively) compared to other treatment combinations. The Local variety showed same trend with ICSV 1002 variety (Table 2). In 2013 the interaction effect of sorghum, soyabean and *Parkia* concentration on plant height was significantly affected ($p<0.05$) at 10 WAS but not at 14 WAS. Intercropped sorghum at 66 g/L *Parkia* concentration produced taller plants (56.83 cm) in the ICSV 1002 variety compared to 100 and 0 g/l treatments. In the Local sorghum variety, the intercropped at 66 g/L *Parkia* concentration significantly ($p<0.05$) produced tallest plant height (45.17 cm) compared to 100 and 0 g/L *Parkia* treatments, 2012 which were not significantly different. There was no significant ($P <0.05$) differences in grain yield among the cropping system and *Parkia* treatments.

Sorghum variety ICSV1002 intercropped with soyabean and planting in July delayed *Striga* emergence (66.44 days) compared to most treatment combinations in 2012, while in local sorghum variety, soyabean intercropped and planting in June and July delayed *Striga* emergence (58.33 days and 58.33 days) compared to other treatments (Table 3). There were no significant differences in 2013. *Striga* count per stand was not significantly ($P < 0.05$) different in all cases where sorghum varieties were combined with soyabean and sowing date in 2012 and 2013 (Table 3). *Striga* counts per plot were not significant on number of *Striga* shoots ($P < 0.05$) in 2012; however, in 2013, fewer *Striga* count per plots were recorded in July planting compared to planting in June at 10 and 14 WAS irrespective of sorghum varieties and cropping system.

The interaction effect of sorghum varieties,

Table 2. Interaction effect of sorghum, soyabean and *Parkia* concentration on severity score, plant height (cm) and grain yield (kg/ha) of sorghum.

Sorghum	Soya bean	*Parkia* concentration (g/l)	2012				2013			
			SC	PH (cm) (WAS)		GY(k/ha)	SC	PH (cm) (WAS)		GY (k/ha)
				10	14			10	14	
ICSV 1002	Sole	0	3.17	37.33	47.33	1385.30	2.83	44.83	53.00	1572.90
ICSV 1002	Sole	66	2.83	46.33	55.00	1535.00	2.00	50.83	56.67	1623.30
ICSV 1002	Sole	100	2.50	41.67	50.83	1514.00	2.33	45.50	54.33	1599.00
ICSV 1002	Soyabean	0	3.00	49.50	58.33	1507.80	2.67	48.50	59.17	1630.80
ICSV 1002	Soyabean	66	2.17	56.67	65.00	1702.70	2.00	56.83	63.33	1833.90
ICSV 1002	Soyabean	100	2.27	56.17	64.33	1613.90	2.50	52.67	59.33	1615.50
Local variety	Sole	0	5.00	23.67	31.83	965.80	5.00	36.17	39.50	1088.10
Local variety	Sole	66	5.00	35.33	43.50	1183.40	5.00	40.33	43.00	1169.40
Local variety	Sole	100	4.83	32.33	43.33	1294.80	5.00	40.33	46.33	1161.40
Local variety	Soyabean	0	4.83	28.83	38.00	1152.70	4.83	42.17	47.00	1220.10
Local variety	Soyabean	66	3.50	40.17	49.00	1329.60	4.67	45.17	50.50	1351.10
Local variety	Soyabean	100	3.67	38.83	48.00	1336.70	5.00	40.50	47.83	1288.10
Mean			3.82	40.57	49.54	1376.80	4.00	45.32	51.67	1429.47
LSD(0.05)			0.42	NS	NS	NS	0.70	3.23	NS	NS

SC, Severity Score; PH**,** Plant height (cm), GY**,** Grain yield (k/ha); NS**,** Non-significant; LSD**,** Probability level at 0> 05; WAS, Weeks After Sowing.

Table 3. Interaction effect of sorghum, soyabean and sowing date in days to first *Striga* shoot emergence, shoot count per stand and per plot.

Sorghum	Soya bean	Sowing date	2012							2013						
			DFE	SCS (WAS)			SCP (WAS)			DFE	SCS (WAS)			SCP (WAS)		
				10	14	18	10	14	18		10	14	18	10	14	18
ICSV 1002	Sole	June	59.22	3.78	5.78	6.67	5.00	9.00	10.33	60.50	2.50	4.89	6.78	4.56	6.44	8.00
ICSV 1002	Sole	July	63.22	2.00	3.78	4.67	4.00	7.67	8.67	63.44	1.22	2.22	3.44	2.67	5.11	6.00
ICSV 1002	Soyabean	June	60.00	2.22	3.11	3.67	2.67	5.00	5.89	61.67	3.66	3.37	5.56	4.11	5.44	7.00
ICSV 1002	Soyabean	July	66.44	1.44	2.78	3.11	2.56	5.11	5.89	67.56	1.14	1.93	3.11	0.37	2.44	4.44
Local variety	Sole	June	57.11	8.00	11.67	12.78	11.56	16.22	16.56	59.78	6.89	1.11	11.22	9.44	11.56	13.56
Local variety	Sole	July	57.22	5.56	9.67	10.56	10.33	16.67	18.67	59.33	3.89	5.67	8.00	5.78	7.67	9.89
Local variety	Soyabean	June	58.33	4.89	8.44	9.11	7.44	10.67	11.22	59.33	3.67	5.22	7.00	5.78	7.67	9.89
Local variety	Soyabean	July	58.33	3.56	6.44	7.11	7.33	11.00	12.89	59.89	2.00	3.22	5.11	4.00	5.89	7.00
Mean			59.98	3.93	6.46	7.21	6.36	10.17	11.26	61.44	3.12	3.45	6.28	4.59	6.53	8.22
LSD(0.05)			0.67	NS	NS	NS	NS	NS	NS	NS	0.90	NS	NS	1.00	1.30	NS

DFE, Day to first *Striga* emergence; SCS, *Striga* shoot count per stand; SCP, *Striga* shoot count per plot; NS, Non-significant; LSD, probability level at 0>.05; WAS, weeks after sowing.

Table 4. Interaction effect of sorghum, soyabean and sowing date on severity score, plant height and grain yield (k/ha) of sorghum.

Sorghum	Soya bean	Sowing date	2012				2013			
			SC	PH (WAS)		GY (k/ha)	SC	PH (WAS)		GY(k/ha)
				10	14			10	14	
ICSV 1002	Sole	June	3.22	40.56	49.33	1396.60	2.44	47.44	58.11	1577.10
ICSV 1002	Sole	July	2.44	43.00	52.78	1559.60	2.33	46.67	51.22	1619.80
ICSV 1002	Soyabean	June	2.67	53.44	62.33	1497.70	2.52	54.00	61.89	1648.80
ICSV 1002	Soyabean	July	2.22	54.78	62.78	1718.60	2.26	51.33	59.33	1738.00
Local variety	Sole	June	5.00	26.44	35.89	1057.70	5.00	37.22	41.11	984.30
Local variety	Sole	July	5.00	34.44	43.22	1238.30	5.00	40.67	44.78	1295.00
Local variety	Soyabean	June	4.56	33.56	42.44	1203.20	5.00	44.67	49.89	12.73
Local variety	Soyabean	July	3.44	38.33	47.56	1342.90	4.56	40.56	47.00	1355.50
Mean			3.82	40.57	49.54	1376.83	4.00	45.32	51.67	1278.90
LSD(0.05)			NS	NS	NS	NS	0.57	2.64	2.05	55.46

SC, Severity Score; PH, Plant height (cm); GY, Grain yield (k/ha); NS, Non, significant; LSD, Probability level at 0>0.05; WAS, Weeks After Sowing.

cropping system and sowing date on severity score did not attain any level of statistical significance in 2012, but did in 2013 (Table 4).

Intercropping resistant ICSV 1002 sorghum variety and planting in July significantly ($P < 0.05$) suffered less *Striga* damage compared to other treatments; same trend was observed in the local sorghum variety (Table 4). There were no significant ($P < 0.05$) differences in interaction effect of sorghum varieties, cropping system and sowing date on plant height in all the sampling periods in 2012 (Table 4) . Generally intercropping the sorghum varieties with soya bean in June produced significantly higher plant height than planting in July in 2013. In 2013, ICSV1002 sorghum variety intercropped with soyabean and sowing in July produced highest grain yield of sorghum compared to other treatment combinations. The local variety showed the same trend with ICSV 1002 variety.

DISCUSSION

Striga emergence

The observed difference in the days to first *Striga* shoot emergence between varieties ICSV 1002 (resistant) and local sorghum variety (susceptible) could be due to low germination stimulant production commonly found in *Striga* resistant sorghum genotypes, as observed by Matuasova et al*.* (2005). The delayed *Striga* emergence in sorghum intercropped with soyabean relative to sole sorghum could be due to the ability of soyabean to increase soil moisture and reduce soil temperature needed for the *Striga* seed to germinate. A similar observation was made by Oswald et al*.* (2002) that intercropping maize with cowpea and sweet potato can significantly affect *Striga* germination. The delayed *Striga* emergence following the priming of sorghum with 66 g/L *Parkia* concentration compared to 100 and 0 g/L in 2012 and 2013 might be due to allele chemical in the *Parkia* pulp which inhibited Striga development at that concentration or level. A similar observation was made by Kolo and Mamudu (2008) that dressing of maize seed with *P*. *biglobosa* pulp gave better maize development both vegetative and in grain yield especially with the resistant varieties

Sorghum planted in July delayed *Striga* emergence compared to those planted in June could probably be due to high soil moisture which is caused by *Striga* seeds to undergo wet dormancy. This is also in agreement with work of Dugje et al. (2008) that sowing maize in mid-July reduced Striga infestation compared to sowing in mid-May or mid-June in parts of the Northern and Southern Guinea Savanna of Nigeria.

Striga count

The significance of sorghum and soyabean intercropping in reducing Striga count compared to those sown without soyabean in 2012 and 2013 could be attributed to the effect of soyabean cover with lowering soil temperature and increasing relative humidity which are unfavorable for Striga seed germination. This is in agreement with the findings of Teasdale and Daughtry (1993) that cover crop absorbs red-light and reduces red: far-red ratio sufficiently to inhibit phytochrome mediated seed germination. Also, Dembele and Kayentao (2002) in Mali found a reduction of Striga biomass by 92% in the intercropped plot of sorghum with cowpea.

Fewer Striga count in 66 g/L Parkia concentration in 2012 and 2013 compared to 100 and 0 g/L confirms the ability of Parkia concentration in controlling Striga; although the mobility of Parkia pulp phytochemical in sorghum has not been documented, it is likely that the Parkia pulp concentration has an indirect mechanism by which it reduces level. This is similar to the findings of Marley et al. (2004) that all plant materials like neem and Parkia extract significantly reduced Striga emergence.

Fewer Striga count observed in July sowing date compared to June might be due to the lower weed pressure in July because of cooler soil temperature, high relative humidity and regular rainfall which cause the *Striga* seeds to undergo wet dormancy and fail to germinate. Dugje et al*.* (2008) had also reported that sowing maize in mid-July reduced *Striga* infestation compared to sowing earlier in mid-May or mid-June in parts of the Northern and Southern Guinea Savanna of Nigeria.

Severity score

The lower *Striga* damage in the ICSV1002 (resistant) compared to Local sorghum variety (susceptible) could be attributed to the delayed emergence and reduced attachment to the host root. This conforms with the report of Wilson et al*.* (2000) that resistant host genotype may limit the number of *Striga* plants that infest host plant or may reduce the impact of *Striga* on the host plants.

The less *Striga* damage in sorghum intercropped with soyabean compared to sole sorghum confirms the effectiveness of soyabean as trap crop to induce suicidal germination of *Striga* seed. As cover crop, soyabean interfered with the sun radiation and chemical environment of *Striga* seed, lowering the light and daily temperature and inhibiting emergence of *Striga* seed, as well as increasing soil fertility through nitrogen fixation. All these caused unfavorable condition for *Striga* seed germination and resulted in less attack and damages. This is similar to observation by Carsky et al*.* (2000); Schulz et al*.* (2003) that varieties of cowpea, groundnut and soyabean have potential to cause suicidal germination of S. *hermonthica* and improve soil fertility.

The significance of the lower *Striga* damage in 66 g/l compared to 100 and 0 g/l *Parkia* concentration could be due to lower *Striga* population in the former which decreased severity of attack on host. This is in agreement with the work of Ndungu (2009) that coating sorghum seed with herbicides reduced *Striga* infestation.

Reduction in *Striga* infestation accounted for fewer *Striga* damages.

The reduced *Striga* damage in planting in July compared to June could be attributed to less weed pressure and unfavorable environmental condition of low temperature and high humidity which inhibited *Striga* emergence and population and reduced attack on host. This is similar to observation by Odhiambo and Ariga (2004) that when planting is delayed *Striga* seeds are unable to germinate and seedlings fail to attach to host root systems due to unfavorable low soil temperature during the middle of the rainy season. This translated into less *Striga* damages.

Plant height

The taller plant height in ICSV1002 (resistant) sorghum compared to Local variety (susceptible) sorghum could be attributed to the ICSV1002 producing little or no root exudates to stimulate *Striga* seeds, hence reducing *Striga* population, which translates into higher performance over local variety. This is agreement with the findings of Rodenburg et al. (2006) that cultivation with resistant crops result in fewer *Striga* plant and higher crop yield than susceptible genotypes of the cultivated plant would do.

The taller plant height in sorghum intercropped with soyabean compared to sole sorghum in 2012 and 2013 might be due to combined effect of soyabean *Striga* inhibition by inducing *Striga* seed suicidal germination and reducing *Striga* attachment and growth covering effect of soyabean creating unfavorable environment for *Striga* germination and growth and nitrogen fixation and increased soil fertility. All these gave the intercropped sorghum plant good establishment and development compared to sole sorghum and this translated into higher plant height. This is similar to observation by Khan et al*.* (2002), that intercropping of cereal and cowpea reduced *Striga* infestation significantly, due to the soil cover of cowpea that created unfavorable conditions for *Striga* germination.

The taller plant height following priming with 66 g/L

Parkia concentration compared to 100 and 0 g/L *Parkia* treatment could be attributed to reduced *Striga* infestation and severity of attack on host crop at of 66 g/L *Parkia* treatment which gave the plant a better growth and development. This is similar to observation by Marley et al*.* (2004) that *P. biglobosa* releases allele chemicals that suppress the growth of other plant species.

The taller plant height in July compared to planting in June may however be attributed to delayed attack in relation to phenological development and reduced competition for the host nutrient and food with consequent luxuriant growth. This supports the findings of Van deft (1997) that early attachments and final growth reduction on the plant are a strong indication that control practices based on a reduction in the *Striga hermonthica* problem.

Grain yield

The higher grain yield in the ICSV1002 resistant sorghum variety compared to Local susceptible variety in 2012 and 2013 could be due to ICSV1002 variety good establishment and growth hence higher grain yield. This is in agreement with the finding of Rodenburg et al*.,* (2006) that in *Striga* infested areas cultivation with resistant crops results in fewer *Striga* plants and higher crop yield than a non-resistant genotype of the cultivated plant would do.

The higher grain yield from intercropping compared to sole sorghum in 2012 and 2013 might be due to effect of soyabean on soil conservation, nitrogen fixation and reduction in *Striga* emergence. Babiker et al*.* (1987) reported that intercropping sorghum with Dolichos lab-lab (labia) suppressed *Striga* emergence and growth and increased number of heads and straw yield of sorghum in the Sudan.

The higher grain yield at 100 g/L *Parkia* treatment in 2012 compared to 66 and 0 g/L *Parkia* treatment in that year, while in 2013 66 g/L *Parkia* treatment gave the highest grain yield compared to 100 and 0 g/L. The highest grain yield in the treated seeds compared to the control could be due to inhibition of *Striga* emergence, less parasitism by *Striga* which had allowed adequate quantities of both water and nutrients required by sorghum plant for yield and yield components.

Ndungu (2009) noted that coating sorghum seed with herbicide reduced *Striga* infestation, *Striga* flowering and *Striga* seed set, and it is considered as the most effective approach as it does not affect sorghum biomass.

The highest grain yield in July planting compared to June plant might be attributed to the combined effect of delayed infestation/attachment, low *Striga* population and good establishment and growth hence higher yield. This is in agreement with the findings of Berner and Ikie (1994) that delaying infection of *S. hermonthica* on both maize and sorghum until 4-6 weeks after planting significantly reduced emergence and reproduction of the parasite, and significantly increased host yield.

CONCLUSION AND RECOMMENDATION

The results demonstrate resistant sorghum varieties to reduce the impact of *Striga,* the high potentiality of using *Parkia* based products for *S. hermonthica* control by seed soaking at high concentration and the intensifying cropping by integrating soyabean variety. The relatively low *Striga* count and high yield in ICSV1002 resistant sorghum variety at 66 g/L *Parkia* concentration and under intercropping system indicate a reduced potential for flowering and capsule production and consequently a reduced capacity of increasing the *Striga* seed bank in the soil. *Parkia* pulp powder might be used in *S. hermonthica* control to reduce dependence on herbicides.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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