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Suppression of Witch-Weed (*Striga hermonthica*) in Sorghum: Cowpea Mixture as Affected by Cowpea Varieties and Planting Patterns

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Abstract: An experiment was conducted during the 2002 and 2003 cropping seasons on a *striga* infested field at Bauchi in the Northern Guinea Savannah ecological zone of Nigeria in order to evaluate the effect of some cowpea varieties and planting patterns on striga suppression. Sorghum variety (SAMSORG 14) was grown in mixture with three cowpea varieties (Kano 1696, Yaro da kokari and IT89KD-288) and three planting patterns (alternate ridge, 1:1 and 2:1 sorghum: cowpea combination ratio on same ridge). These treatments were factorially combined in a randomized completely block design and replicated three times. Sorghum intercropped with cowpea variety Kano 1696 in alternate ridge significantly reduced striga density and striga dry matter production. The same factorial combination also gave the highest percent nitrogen (N) in sorghum grain, total N uptake by sorghum, cowpea and the highest contribution of symbiosis to N uptake of sorghum. It could be suggested from this study that any striga control package to be developed for small scale farmers around the study area, should consider intercropping sorghum/cowpea as a central focus. However, screening of more cowpea varieties should be taken into cognizance in order to determine the most suitable variety for reducing striga seed bank.

Key words: Intercropping, *Striga*, density, suppression

Introduction

Giant witch-weed or striga (*Striga hermonthica*) represents the largest single biological barrier to sorghum production in Africa. It is an angiospermous obligate parasite belonging to the family *Scrophulariaceae* (Parker and Riches, 1993). Approximately fifty species of Striga that are parasitic to plants have been identified but *Striga hermonthica* is the largest and the most damaging of them (Ramaiah, 1991; Parker and Riches, 1993).

In Nigeria apart from being a staple food, sorghum is also used as feed for livestock and industrially for brewing beer both at local and recently in modern breweries. Sorghum is the most important cereal both in terms of the volume of production and total land cultivated (FAO, 2000).

Meanwhile, several attempts made in combating/suppressing striga such as; use of N fertilizer (Aflakpni *et al*., 1994); deep cultivation to bury striga seeds (Lagoke, 1991); Zero-tillage and minimum tillage (Udom *et al*., 2006); biological control (Gworgwor, 1993); use of resistant/tolerant varieties of sorghum (Ramaiah, 1991; Okonkwo and Garba, 1993) and use of herbicides (Carsky *et al*., 1994; Adagba *et al*., 2002) have not been successful.

Effective and economically feasible control method of striga suitable for adoption by small scale farmers in Nigeria is still elusive. It is in realization of these, that a research such as suppression of striga using sorghum/cowpea intercrop is deemed fit. Alongside in this study, some cowpea varieties were screened for possible superiority in reducing the menace of striga.

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Materials and Methods

Field experiment was conducted during the wet/cropping seasons of 2002 and 2003 on a *striga* infested field at the School of Agriculture, Research and Training Farm of Abubakar Tafawa Balewa University, Bauchi. The site is situated along latitude 10°7'N; longitude 9°49'E and 690 m above sea level in the Northern Guinea Savannah ecological zone of Nigeria. The land had not been used for sorghum or the cultivation of any other cereal crop that can be parasitized by *striga* for two years. Physico-chemical properties of soil in the experimental site are shown in Table 1.

Treatment involved one sorghum variety (SAMSORG 14) which was intercropped with three cowpea varieties (Kano 1696, Yaro da kokari and IT89KD-288) and three planting patterns (alternate ridge, 1:1 and 2:1 sorghum: cowpea combination ratio). The treatments were factorially combined in a randomized complete block design and replicated three times.

Sorghum and cowpea seeds were obtained from the Bauchi State Agricultural Development Programme, Bauchi, Nigeria. The seeds were treated with Apron plus at the rate of 1.7 g kg^{-1} of sorghum and 2.5 g kg^{-1} of cowpea. The sorghum variety SAMSORG 14 is a tall growing plant commonly grown in the region and matures between 130-140 days. The cowpea varieties used were improved Kano 1696, which is a spreading type and matures late between 100-120 days, Yaro da kokari is semi spreading with maturity period of between 80-90 days and IT89KD-288 is erect and matures in 60 days.

The land was ploughed, harrowed and ridges were constructed manually across the slope in both years of experimentation. The treated seeds of sorghum were sown immediately after the establishment of rain in both years and then followed by cowpea planting after the first weeding at two weeks intervals. The plot size was 5×4.5 m each. A spacing of 75×25 cm was maintained for both intercrops in all the treatments. Two plants per stand were maintained for both intercrops.

Three hoe weeding operations were carried out in both seasons. Incidence of shoot fly (*Atherigona socatta*) was observed in 2002 but no plant protection measure was undertaken because the infection was mild. NPK (20:10:10) was split applied to sorghum at the rate of 60: 30:30 kg ha^{-1}, respectively. The fertilizer was side dressed and covered with soil to minimize losses. There was no fertilizer application on the cowpea varieties as suggested by Parker and Riches (1993). Harvesting of both crops was done manually after attainment of physiological maturity. Yield was sampled from the two center rows of each plot.

Sorghum grains and stover as well as cowpea shoot sample were analyzed for their total N content. The total N uptake by grains and stover or haulm were calculated by multiplying percentage N with their respective oven dried weight per hectare as described by Parker *et al*. (1979).

Table 1: Physico-chemical properties of the soil in the experimental site (mean of two years)

Soil properties	Soil depth (0-30 cm)
Particle size distribution (%)	
Sand	76.00
Silt	9.00
Clay	15.00
Texture	Gravelly sandy loam
Soil pH (1:2 H_2O)	6.01
Organic carbon (g kg^{-1})	2.00
Total N (mg kg^{-1})	0.34
Available P (mg kg^{-1})	8.60
CEC Cmol ($^+$) kg^{-1}	6.20
Exchangeable bases Cmol ($^+$) kg^{-1}	
Ca	2.03
Mg	0.51
K	0.37
Na	0.11

Data collected were number of emerged striga per m^2, striga dry matter production per m^2, striga score, other weed score, crop vigour, percentage infected plants, nodule fresh weight (g/plant), number of nodule(s) per plant, nodule size (cm), percent N in sorghum grain, total N uptake by sorghum, total N uptake by cowpea, total N uptake by sorghum + cowpea (kg ha^{-1}) and contribution of symbiosis to N uptake of sorghum (kg ha^{-1}). Data collected were analyzed using MINITAB 11 computer software and Duncan Multiple Range Test (DMRT) was calculated to compare the means.

Results

Effect of Cowpea Intercrop on Striga Suppression

Striga density was significantly higher in sorghum monoculture than when sorghum was intercropped with cowpea varieties as shown in Table 2. Sorghum intercropped with Kano 1696 had the lowest density of emerged striga in both cropping seasons. Higher density of emerged striga was observed in 2003 than in 2002. Striga density was not significantly influenced by planting pattern.

Table 2 further showed that dry matter production was significantly influenced by cowpea varieties as well as planting pattern. Striga dry matter production was highest in monoculture and lowest when intercropped with Kano 1696 in 2002 and 2003. Concerning planting patterns, the lowest was found in alternate ridge.

Striga score was significantly affected by variety and planting pattern in both years (Table 3). The striga score in monoculture was higher than in intercropping. Alternate ridge had lower striga score than

Table 2: Effect of variety and planting pattern on number of emerged striga per m^2 and striga dry matter production per m^2 at 14 WAS (harvest) in 2002 and 2003

	No. Emerged striga		Striga dry matter	
Treatments	2002	2003	2002	2003
Varieties (V)				
SAMSORG 14: Monoculture	204.0a	398.0a	87.09a	114.01a
SAMSORG 14: Kano 1696	50.0b	80.0b	27.03c	41.12c
SAMSORG 14: Yaro da kokari	72.0b	98.0b	37.12b	58.11b
SAMSORG 14: IT89KD-288	94.0b	136.0b	47.17b	62.02b
SE ±	48.6	59.4	8.47	4.62
Planting Pattern (PP)				
Alternate ridge	124.0c	172.0c	33.26b	57.12c
1:1	155.0b	217.0b	57.35a	77.17b
2:1	167.0a	258.0a	59.11a	79.02a
SE ±	20.6	41.7	6.73	7.81

Means followed by the same letter(s) within sub columns are not significantly different, WAS = Week after Sowing

Table 3: Effect of variety and planting pattern on striga score, other weed, crop vigour and percent infected plants in 2002 and 2003

	Striga score (1)		Other weed (2)		Crop vigour (3)		% Infected plant	
Treatments	2002	2003	2002	2003	2002	2003	2002	2003
Varieties (V)								
SAMSORG 14: Monoculture	6.75a	5.98a	0.41a	0.20a	3.16a	2.68b	100.0a	100.0a
SAMSORG 14: Kano 1696	3.65b	4.20b	0.31a	0.23a	4.01a	3.50a	94.4b	100.0a
SAMSORG 14: Yaro da kokari	3.87b	4.31b	0.40a	0.11a	4.01a	3.50a	100.0a	100.0a
SAMSORG 14: IT89KD-288	4.04ab	4.37b	0.22a	0.11a	4.17a	3.68a	100.0a	100.0a
SE ±	0.11	0.80	0.41	0.10	0.21	0.26	1.12	0.10
Planting Pattern (PP)								
Alternate ridge	3.69b	4.53b	0.42a	0.00a	3.76a	3.30a	94.83a	100.0a
1:1	4.42a	4.73a	0.32a	0.81a	3.80a	3.30a	100.0a	100.0a
2:1	4.32a	4.71a	0.31a	0.30a	4.01a	3.50a	100.0a	100.0a
SE ±	0.10	0.07	0.11	0.27	0.80	0.30	0.10	0.10

Means followed by the same letter(s) within sub columns are not significantly different, (1) = Base on 0-10 scale; where 0 = No striga shoot to 10 = Complete striga cover, (2) = Base on 0-10 scale; where 0 = No weed to 10 = Complete weed cover, (3) = Base on 0-10 scale; where 0 = Completely killed plant to 10 = Vigorous plants

Table 4: Effect of variety and planting pattern on nodule fresh weight, number of nodules per plant and nodule size in 2002 and 2003

	Nodule fresh weight (g/plant)		No. of nodule/plant		Nodule size (cm)	
Treatments	2002	2003	2002	2003	2002	2003
Varieties (V)						
SAMSORG 14: Kano 1696	0.75b	0.76c	213.51b	218.65b	1.58b	1.58b
SAMSORG 14: Yaro da kokari	1.49ab	1.76b	251.87b	258.54b	2.34a	2.17a
SAMSORG 14: IT89KD-288	1.79a	2.20a	369.42a	433.98a	1.88b	1.88b
SE ±	0.14	0.16	39.86	50.61	0.10	0.10
Planting Pattern (PP)						
Alternate ridge	0.37b	0.49b	124.23b	176.10b	1.91b	1.71b
1:1	1.81a	2.09a	399.71a	421.00a	1.95ab	1.95a
2:1	1.81a	1.96a	411.00a	423.61a	1.97a	1.96a
SE ±	0.16	0.18	38.96	43.05	0.10	0.10

Means followed by the same letter(s) within sub columns are not significantly different

the other planting pattern. Other weeds score were not significantly affected by variety and planting pattern in both seasons. It was also observed that striga vigour was not significantly influenced by variety and planting pattern. However, percent infected plants were significantly influenced by variety but not planting pattern in both cropping seasons.

Effect of Nitrogen Fixation by Cowpea on Striga Suppression

Nodule fresh weights, number of nodules per plant and nodule size were significantly influenced by variety in both seasons (Table 4). Significantly lower nodule fresh weight, number of nodules and size were recorded in Yaro da kokari in both seasons. Kano 1696 produced the highest nodule fresh weight and number of nodule, while IT89KD-288 had significantly higher nodule size.

From same Table 4, planting pattern significantly affected nodule fresh weight, number of nodules and size. Alternate ridge recorded a significantly low nodule fresh weight, number and size. No significant differences were recorded in terms of fresh weight and number of nodules between 1:1 and 2:1 planting patterns. However, nodule size was significantly better in 2:1 than in either alternate ridge or 1:1 ratio in 2002 and 2003.

Nitrogen (N) Uptake by Sorghum and Cowpea and its Contribution to Symbiosis

The amount of N in grain was significantly influenced by variety in 2002 and 2003 (Table 5). When all treatments were considered, sorghum intercropped with Kano 1696 contains higher level of grain N than other cowpea varieties. In 2002, the N content of sorghum intercropped with cowpea varieties was significantly better than the sorghum monoculture. Planting pattern did not significantly affect the amount of N in sorghum grain in both years.

Total N uptake by sorghum was generally higher in treatments involving cowpea varieties in 2002 and 2003 than in monoculture. Total N uptake was also significantly affected by planting pattern with alternate ridge having the highest level. Uptake by cowpea was significantly affected by cowpea varieties as well as planting pattern. Alternate ridge gave the highest level of uptake by cowpea.

Furthermore, it was observed that uptake by sorghum + cowpea combined was significantly influenced by cowpea varieties and planting patterns. However, contribution of symbiosis N^2 fixation to uptake of sorghum was significantly affected by variety in 2002 but not in 2003. More N was contributed by Kano 1696 than either Yaro da kokari or IT89KD-288. Considering planting pattern, the contribution was significantly appreciable with alternate ridge pattern having the highest.

Table 5: Effect of variety and planting pattern on nitrogen (N) uptake and its contribution to symbiosis in 2002 and 2003

Treatments	% N in grain (Sorghum)		Total N uptake sorghum (kg ha^{-1})		Total N uptake cowpea (kg ha^{-1})		Total N uptake sorghum+cowpea (kg ha^{-1})		Contribution of symbiosis to N uptake of sorghum (kg ha^{-1})	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Varieties (V)										
SAMSORG 14: Monoculture	0.71c	0.62c	25.81c	17.65c	-	-	31.42c	17.41c	-	-
SAMSORG 14: Kano 1696	1.79a	1.45a	100.52a	51.32a	43.61a	42.22a	152.33a	82.46a	82.46a	42.20a
SAMSORG 14: Yaro da kokari	1.69ab	1.36b	87.51b	52.61a	35.21b	38.60b	126.45b	78.53b	63.51b	32.43a
SAMSORG 14: IT89KD-288	1.69ab	1.33b	77.52b	42.00b	18.53c	17.41c	93.41bc	62.73b	48.79c	32.37a
SE ±	0.08	0.06	9.78	3.87	2.67	3.25	11.27	5.47	12.21	0.75
Planting Pattern (PP)										
Alternate ridge	1.61a	1.23a	132.10a	61.21a	32.10a	21.10b	151.42a	78.71a	96.20a	41.10a
1:1	1.45b	1.18b	73.22b	31.43b	32.21a	31.12a	93.46b	61.52b	33.70b	13.50a
2:1	1.47b	1.19b	79.81b	41.21b	21.36b	21.42b	98.56b	62.58b	52.20c	22.70b
SE ±	0.02	0.05	7.64	3.73	2.68	2.87	10.00	4.64	11.56	3.68

Means followed by the same letter(s) within sub columns are not significantly different

Discussion

The emerged striga number and dry matter production in sorghum monoculture was exceptionally high. Lower striga density with Kano 1696 intercrop was due to delayed emergence before first sampling. This was in conformity with the report of Linke and Vogt (1987) while observing germination and early development in striga. Also striga under alternate ridge pattern was observed to be more bustle and etiolated than in either 1:1 or 2:1 ratios, suggesting that striga, being an obligate parasite could not photosynthesize adequately under such condition. Kamara *et al*. (2002) had earlier reported similar effect on striga grown on alternate ridge pattern. Striga was reported by Mbiele (1989) as capable of living independently from host for about four months.

The decrease in yield of cowpea in alternate ridge involving all the varieties was because of intense competition with sorghum growth. Competition for space and solar radiation may particularly be responsible for the lower cowpea yield. The depression of cowpea in mixtures with cereals has been reported by Odo (1991) and Udom *et al*. (2006). The failure of IT89KD-288 to exhibit high degree of striga suppression compared with other varieties could be attributed to its relatively shorter life cycle. The reason for greater suppression of striga by Kano 1696 could be the sustained growth period beyond the peak of striga growth.

Crop vigour score was similar for treatments and therefore not significantly affected by either variety or planting pattern. This contradicts the work of Gworgwor (1993) who reported that lack of significant difference between treatments could be due to relatively high tolerance exhibited by the sorghum variety used. Other weed scores were not significant because the field was kept relatively weed free. It was also observed that the major weeds were out-lived by sorghum. This implies that the reduction performance by sorghum was not due to other weed population but was strictly and mainly due to the damaging effect caused by striga.

Even though IT89KD-288 had fewer numbers of nodules, it had significantly bigger sizes compared to Kano 1696 and Yaro da kokari. This agrees with the findings of Burias and Planchon (1990) and Udom *et al*. (2003), who reported that various sizes and shape of nodules influences the effectiveness of N_2 fixation.

The high N content observed in sorghum : cowpea intercropping is a measure of protein and hence the nutritional status. This agrees with the findings of Wylde (1991), who while working with pearl millet showed that protein and water soluble protein could be reduced by up to 80% in striga infested condition. The highest N_2 fixation was achieved by Kano 1696, which was estimated/averaged to fix 74.63 kg ha^{-1}. Using different method, Senaratna *et al*. (1995) reported N_2 fixation to be 552 mg/plant. The N fixed by Kano 1696 was not up to the estimated world average of 109 kg ha^{-1} reported by Stewart *et al*. (1992). The high N_2 fixed by Kano 1696 could be the reason for its greater success in reducing striga population more than other varieties. The high estimated N_2 fixation of 94.55 kg ha^{-1} in alternate ridge suggest that it is suitable for maximum N_2 fixation and hence greater striga suppression.

The fact that there was a build up of striga density from 2002 to 2003 and decrease in yield means that the N_2 fixed by cowpea was not sufficient to confer effective control and this method can not be solely relied upon as a means of striga control. In fact, it was reported by Mansfield (1982), that up to 150 kg N ha^{-1} is needed for effective striga control.

Conclusion

The success of Kano 1696 on striga suppression appears to be due to its relatively longer duration of maturity and ability to fix high nitrogen. IT89KD-288 an early maturing variety may not be compatible with medium maturing variety of sorghum like SAMSORG 14, hence the need for a cowpea component whose life cycle will synchronize with that of the sorghum to provide sustained ground cover for a greater period of the crop growth to suppress striga growth. Emerged striga in alternate ridge pattern were observed to be more brittle and etiolated than those in 1:1 and 2:1 ratio.

There is need to consider integrated control measure, which involve the use of more than one control measure. It is however recommended, that any striga control package, should consider intercropping sorghum with cowpea in alternate ridges as a central focus. It is compatible with prevailing cultivation practices in most sorghum growing areas of Nigeria under small scale farmers situation. Kano 1696 showed greater potential for suppressing striga growth. Nevertheless, there is need for screening of more cowpea varieties in order to determine the most suitable variety for reducing striga seed bank and ameliorating its effect on sorghum.

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