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Full Length Research Paper

Effects of rotation of trap crop varieties on the reaction of some cereal host crops to *Striga hermonthica* biotypes

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Trials were conducted in the screen house of Niger State College of Agriculture, Mokwa (09° 18¹N; 05° 04¹E) in 2005 and 2006 to evaluate the influence of rotation of non-host trap crops on the different reaction of host crop genotypes to the parasitism of *Striga hermonthica* biotypes. A split-split arrangement in a complete randomized design with three replications was adopted. The three varieties each of the host crops, maize (Acr.97 TZL Comp.1-W, 9022-13 and 8338-1), rice (FARO 40, WAB 56-50 and FARO 45) and sorghum (SAMSORG 3, ICSV111 and SAMSORG 14) with and without *Striga* infection constituted the main-plot treatments. The sub-plot treatments were the three trap crop varieties each of groundnut (SAMNUT 10, SAMNUT 11 and SAMNUT 18), cowpea (SAMPEA 6, SAMPEA 7 and L25), soybean (TGx 1448-2E, TGx 1485-1D and SAMSOY 2) and cotton (SAMCOT 8, SAMCOT 9 and SAMCOT 10) while the sub-sub plot treatments consisted of crop sources (millet, maize and sorghum) of *Striga* collected in the two years. The result obtained indicated that the genotypes of maize (9022-13 and Acr.97 TZL Comp.1-W), rice (FARO 40 and WAB 56-50) and sorghum (SAMSORG 3) exhibited various levels of resistance to *Striga* parasitism by supporting lower infestation, exhibition of lower reaction syndrome and higher crop growth vigour as well as production of higher shoot dry matter than the respective susceptible varieties. The host crops exhibited differential reactions to different *Striga* biotypes following the order sorghum > millet > maize. Host crops preceded by rotation of groundnut var. SAMNUT 11, soybean var. TGx 1448-2E, cowpea var. SAMPEA 7 and cotton var. SAMCOT 10 consistently had greater reduction of *Striga* parasitism and increased growth vigour and productivity.

Key words: Rotation of trap crops, cereal host crops, *Striga hermonthica* biotypes.

INTRODUCTION

The major constraints to cereal production in the West and Central African savanna have been reported to be nitrogen deficiency and *Striga hermonthica* (Del) Benth parasitism (Berner et al., 1995). *Striga* which is endemic in the African savannas can cause serious devastation to cereals especially on the fields of resource poor farmers. Even under good management conditions about 79.5% reduction in yield was observed in susceptible varieties (Lagoke et al., 1999). Yield losses may reach 100% in heavily infested fields, causing farmers to abandon their fields in search of less infested areas (Doggett, 1984; Lagoke et al., 1991). *S. hermonthica* and *S. asiatica* (L) Kuntze among other species of *Striga* caused the greatest economic damage to cereals. The symptoms of *S. hermonthica* damage are mainly stunting and yellow blotching of leaves leading to leaf firing and death (Kim, 1994).

Striga diversity is reflected in species differences and also in distinct morphotypes, physiological strains and races of the species. The term biological strains was first used by Lewin (1932) for *S. asiatica,* physiologically

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adapted to specific hosts. Other studies have also reported specific and physiological strains of *Striga* species on cereals and cowpeas (Vasudeva Rao and Musselmann, 1987; Lane et al., 1994; Reda et al., 1994; Diallo and Ransom, 1996; Singh, 1999). Subsequently too, differences in host plant adaptation among populations of *Striga* from farmers field in the same area are being reported (van Male et al., 1992). For example, framida a resistant sorghum variety stimulated germination of only two samples of *S. hermonthica* of all 11 tested strains (Bebawi, 1981). In another related study, Johnson et al. (1997) indicated that when maize, rice, millet, and sorghum were sown into seeds of *S. hermonthica,* collected from maize and rice crops, *S. hermonthica* from either maize or rice showed no host specificity and parasitized all the four test crops. Kim et al. (1994) also indicated that both intercrop and intracrop strains of *S. hermonthica* exist in Nigeria. This is evidenced by the failure of *S. hermonthica* isolates collected on either of these hosts at one location to parasitize the same hosts at another location (Berner et al., 1995). Strain variation has been well documented as reflected in differential *Striga* seed germination by maize, millet and sorghum (King and Zummo, 1977; Kim et al., 1994)

Increased specialization has been associated with the intensity of crop cultivation of a particular host crop to the exclusion of the other, like creating a reproductive isolation between sorghum and millet *Striga* strains (Ramaiah, 1987; Stewart et al., 1991). This suggests that there is selection and gradual reproduction of races, which are phenologically and physiologically adapted to the different hosts.

Striga spp. has been known to exhibit variation in exerting its impact on the affected host plants. These have been attributed to intra-specific and inter specific allogamy of the parasitic weed. It undergoes cross pollination with other strains of the same species and other species of *Striga* namely, *S. aspera* (Ramaiah, 1984; Botanga et al., 2003).

It has also been reported that there is differential virulence of *Striga* among host crops. *Striga* collected from rice was observed to be more virulent on rice than that from maize (Johnson et al., 1997). Consequently, Ejeta et al. (1992) indicated that greater genetic differences among host crop germplasm may be obscured by diverse and shifting populations of *Striga*. This thus brings about the existence of different *S. hermonthica* biotypes (Efron et al., 1988; Adagba et al., 2002). This becomes a problem for plant breeders in developing resistant/tolerant cultivars to *Striga* parasitism.

However, various control methods have been identified for reducing *Striga* parasitism in cereal host crops including hand pulling and hoe weeding, proper land preparation, use of adequate fertilizer, use of herbicides, date of planting, use of resistant varieties, use of trap or catch crops in mixture with host crops and so on. Reda et al. (1996) and Lagoke et al. (1997) reported that no single method alone is capable of ensuring sustainable *Striga* control. Lagoke et al. (1999) thus suggested an integration of *Striga* control methods in a package that involves the use of appropriate trap crops in mixture with resistant/tolerant cereal crops. This might be because the use of host plant resistance has been considered the most important, durable, in expensive, cost effective and easily adoptable method (Kim, 1994). The *Striga* tolerant/resistant (STR) hybrids, which are open pollinated varieties, had been reported by Kim (1994) to have increased yield by 2.5% over the susceptible improved and local genotypes over years. The problem with the host plant resistance is the lack of universal resistance in crop genotypes due to the existence of different biotypes of *S. hermonthica*.

Legume food crops including, cowpea, soybean and groundnut and some other non-host crop plants including cotton were reported to stimulate *Striga* seed germination (Hamdoun and Babiker, 1978). Lagoke et al. (1997) reported wide variability in their ability to stimulate suicidal germination of *Striga* seed. They also reported that cowpea, soybean and groundnut stimulated *Striga* seed germination by 7.3 to 78.2%, 14.4 to 70.7% and 0 to 72.23% respectively. Botanga et al. (2003) also reported 13.3 to 50.0% stimulation of *Striga* seed germination by cotton varieties.

In view of wide variability among non-host species and their varieties in the stimulation of suicidal germination of different biotypes of *S. hermonthica*, it is important to evaluate the non-host crop varieties for trap cropping ability when planted in rotation with host crops. Since early studies have confirmed differential virulence of *S. hermonthica* biotypes on different host crop genotypes, the ability of the trap crops to alleviate the parasitism of the biotypes on the host crops deserve evaluation.

The objective of this study therefore was to evaluate the effect of rotating non-host crop plants (cowpea, soybean, groundnut and cotton) on the reaction of some genotypes of rice, maize and sorghum to infection of *S. hermonthica* of different crop sources.

MATERIALS AND METHODS

Trials were conducted at Niger State College of Agriculture, Mokwa (09° 18^{1}N; 05° 04^{1}E) screen house in 2005 and 2006. In the trials, the *S. hermonthica* seeds were collected from fields of maize, millet and sorghum in the two years. The trials were laid out in a split-split arrangement in a complete randomized design. The three varieties each of the host crop genotypes maize (9022-13, Acr.97 TZL Comp.1-W and 8338-1), rice (FARO 40, WAB 56-50 and FARO 45) and sorghum (SAMSORG 3, ICSV111 and SAMSORG 14) infected with and without *Striga* constituted the main-plot treatments. The sub-plot treatments consisted of three varieties each of trap crops, groundnut SAMNUT 11, SAMNUT 10 and SAMNUT 18, soybean TGx 1448-2E, TGx 1485-1D and SAMSOY 2, cowpea SAMPEA 7, L25 and SAMPEA 6 and cotton SAMCOT 10, SAMCOT 9 and SAMCOT 8 as well as no trap crop control. The sub-sub plot treatments consisted of *Striga* seeds collected from fields of maize, millet and sorghum as well as no *Striga* inoculation control. All the treatments were replicated three times.

The soils were collected from the crop farm of Niger State College of Agriculture, Mokwa and used to fill the pots of 27.5 cm diameter and 15 cm depth after sieving to get rid of stones and debris. The pots were filled to two-third depth with the sieved soil while the remaining one-third was filled with soil-*Striga* seed mixture for the inoculated pots. The soils were inoculated with 3,000 *Striga* seeds per pot using the procedure described by Kim (1994). In order to determine the volume of water required to bring the soil in the pots to field capacity before planting, three pots were filled with soil to the brim and a known volume of water was applied. The excess water, which drained through the perforated holes was collected and measured. The difference in the volume of water collected was the volume required and used to bring the soil in each pot to field capacity.

Three seeds of maize, five seeds of sorghum and seven seeds of rice were planted per pot and the seedlings were later thinned down to two per pot at 2 weeks after planting (WAP) for maize and at 5 WAP for sorghum. Rice was thinned to four plants per pot at 5 WAP. Three seeds of all the trap crops, groundnut, soybean, cowpea and cotton were planted and later thinned down to two at 3 WAP. Fertilizer at the equivalent 90 kgN/ha, 45 kg P_2O_5/ha and 45 kg K_2O/ha was applied to maize and sorghum and 60 kgN/ha, 40 kg P_2O_5/ha and 40 kg K_2O/ha to rice. In each case, half dose of N and full doses P_2O_5 and K_2O was applied at 3 WAP using NPK 15-15-15 and the remaining half dose of N was applied at 6 WAP using urea. All weeds with exception of *S. hermonthica* plants were hand pulled as soon as they emerged. The data collected include host crop height, vigour score, reaction syndrome at 9 and 12 WAP and shoot dry weight (kg/pot) at 15 WAP as well as number of days to first *Striga* emergence and *Striga* shoot count at 9 and 12 WAP. All the data collected were subjected to analysis of variance (ANOVA) and means partitioned using New Duncan's Multiple Range Test (DNMRT).

RESULTS

Infection of the three maize varieties and two maize varieties (Acr,97 TZL Comp.1- W and 8338-1) with *S. hermonthica* collected in 2005 and 2006 respectively resulted in significantly shorter plants compared with their respective no inoculation controls (Table 1). At 9 and 12 WAP, maize var. 8338-1 had shorter plants than the other two STR maize genotypes (9022-13 and Acr. 97 TZL Comp.1- W) with and without *Striga* infection (Table 1). The height of rice var. FARO 45 infected with *Striga* obtained in both years were shorter compared to when it was not infected throughout the crop growth period. With infection, FARO 40 and WAB 56-50 had taller plants than FARO 45 at 9 and 12 WAP in both years. The three sorghum varieties infected with *Striga* obtained in the two years resulted in significantly shorter plants compared with their respective no inoculation controls except at 9 WAP where the height of SAMSORG 3 infected in 2006 was comparable to its control (Table 1).

All the trap crop varieties planted in rotation with the cereal host crops infected in both years resulted in significantly taller host crops compared with their respective trap crop controls at 9 and 12 WAP (Table 1). At 9 and 12 WAP, rotation of groundnut var. SAMNUT 11, soybean var. TGx 1448-2E, cowpea var. SAMPEA 7 and cotton var. SAMCOT 10 with the host crops resulted in significantly taller host crop plants than the rotation with their other two respective varieties, SAMNUT 10 and SAMNUT 18 for groundnut, TGx 1485- 1D and SAMSOY 2 for soybean, L25 and SAMPEA 6 for cowpea and SAMCOT 9 and SAMCOT 8 for cotton except in 2005.

Crop vigour score using scale 1-5 where 1 – least\vigorous and 5 – very vigorous where cotton var. SAMCOT 9 at 9 WAP and soybean TGx 1485- 1D at 12 WAP had height comparable to SAMCOT 10 and TGx 1448- 2E respectively (Table 1).

The height of host crop genotypes infected with seeds of different crop sources in 2005 were significantly depressed following the order sorghum > millet > maize > control at 9 and 12 WAP but in 2006, it followed the order sorghum = millet > maize = control at 9 WAP and sorghum > millet > maize = control at 12 WAP (Table 1).

Host crop vigour score

The three genotypes of each maize, rice and sorghum infected with *S. hermonthica* collected in the two years resulted in significantly depressed host crop plants compared with their respective no inoculation controls (Table 1).

Irrespective of the year, plants of maize hybrid 9022-13 had significantly higher vigour score than Acr.97 Comp.1-W and 8338-1 at 9 and 12 WAP (Table 1). Acr.97 TZL Comp.1-W infected with *Striga* in 2005 at 9 WAP and in both years at 12 WAP had significantly higher vigour score than the susceptible maize var. 8338-1 (Table 1). When infected by *Striga* in both years at 12 WAP, the vigour scores of rice varieties significantly followed the order FARO 40 > WAB 56-50 > FARO 45 (Table 1). Under *Striga* infection in the two years, sorghum varieties SAMSORG 3 and SAMSORG 14 had significantly higher vigour score than ICSV111 at 9 and 12 WAP (Table 1).

The host crops planted in rotation with the entire trap crop varieties had significantly higher vigour scores compared with their respective controls in the trial except at 9WAP in 2005 where cowpea SAMPEA 6 supported host crop growth vigour compared with the respective control (Table 1).

The planting of trap crops, groundnut var. SAMNUT 11, soybean var TGx 1448-2E, cowpea var. SAMPEA 7 and cotton var. SAMCOT 10 in rotation with the cereal host crops resulted in significantly higher host crop vigour score than their other respective trap crop varieties at 9 and 12WAP except at 12 WAP in 2006 where groundnut var. SAMNUT 10 and cotton var. SAMCOT 9 supported host crop vigour score comparable to those of SAMNUT 11 and SAMCOT 10 respectively (Table 1).

The vigour score of host crop genotypes infected with *Striga* seeds of different crop sources irrespective of the year were significantly depressed following the order sorghum > millet > maize (Table 1).

Table 1. Plant height and vigour score of host crop genotypes as influenced by crop sources of *Striga hermonthica* and trap crops planted in rotation in the screen house at Mokwa, 2005 and 2006.

Treatments	Host crops height (cm)				Host crops vigour score			
	9 WAP		12WAP		9 WAP		12WAP	
	2005	2006	2005	2006	2005	2006	2005	2006
Trap crop (T)								
Groundnut								
SAMNUT 11	94.6^{a}	95.2^{a}	100.3^{a}	100.1^{a}	4.0^{a}	4.3^{a}	3.7^{a}	3.7^{b}
SAMNUT 10	86.9^{b}	89.3^{b}	94.3^{de}	94.3^{b}	3.7^{b}	3.7^{c}	3.3^{b}	3.5^{b}
SAMNUT 18	82.1^{c}	89.1^{b}	92.7^{e}	93.0^{bc}	3.0^{d}	3.5^{d}	2.3^{d}	2.5^{c}
Soyabean								
TGx 1448-2E	94.2^{a}	96.7^{a}	98.9^{ab}	98.2^{a}	4.0^{a}	4.3^{a}	3.7^{a}	4.0^{a}
TGx 1485-1D	86.3^{b}	80.1^{c}	96.9^{bc}	91.3^{cd}	3.7^{b}	4.0^{b}	3.3^{b}	3.5^{b}
SAMSOY 2	80.1^{c}	80.8^{c}	94.2^{de}	91.2^{cd}	3.2^{c}	3.5^{d}	2.3^{d}	2.5^{c}
COWPEA								
SAMPEA 7	94.5^{a}	94.3^{a}	98.9^{ab}	98.8^{a}	4.0^{a}	4.3^{a}	3.7^{a}	4.0^{a}
L25	86.7^{b}	87.2^{b}	95.7^{cd}	92.0^{bcd}	3.2^{c}	3.5^{d}	2.5^{c}	2.7^{c}
SAMPEA 6	80.3^{c}	80.1^{c}	92.5^{e}	89.7^{d}	2.7^{e}	3.2^{e}	1.7^{e}	2.5^{c}
Cotton								
SAMCOT 10	94.4^{a}	96.6^{a}	99.1^{a}	98.2^{a}	4.0^{a}	4.1^{b}	3.7^{a}	3.7^{b}
SAMCOT 9	91.3^{a}	90.4^{b}	96.5^{c}	92.3^{bcd}	3.7^{b}	3.7^{c}	3.3^{b}	3.5^{b}
SAMCOT 8	83.7^{bc}	82.1^{c}	92.6^{e}	91.1^{cd}	3.2^{c}	3.5^{d}	2.5^{c}	2.7^{c}
No trap crops	66.1^{d}	66.4^{d}	67.3^{f}	68.2^{e}	2.7^{e}	3.0^{f}	1.5^{f}	2.0^{d}
SE ±	1.04	1.01	0.51	0.65	0.03	0.03	0.04	0.05
Crop sources of *Striga* (C)								
Maize	103.2^{b}	96.1^{a}	113.0^{b}	101.3^{a}	3.7^{a}	3.7^{b}	3.0^{b}	3.0^{b}
Sorghum	83.8^{d}	80.7^{b}	92.2^{d}	84.1^{c}	3.0^{c}	3.2^{d}	1.7^{d}	2.0^{d}
Millet	91.1^{c}	85.2^{b}	95.8^{c}	89.9^{b}	3.5^{b}	3.5^{c}	2.0^{c}	2.5^{c}
No inoculation	107.2^{a}	99.8^{a}	116.1^{a}	104.3^{a}	4.9^{a}	4.9^{a}	4.8^{a}	4.8^{a}
SE ±	1.16	1.21	0.73	0.86	0.05	0.04	0.05	0.05
Interactions								
H x C	2.15*	2.22*	2.66*	2.62*	0.06*	0.05*	0.08*	0.09*
H x T	4.35*	4.41*	2.51	2.48	0.09*	0.04*	0.08*	0.07*
C x T	NS	NS	NS	NS	0.20*	0.23*	0.22*	0.27*
H x S x T	28.06*	27.37*	NS	NS	NS	NS	NS	NS
CV (%)	54.4	55.13	4.56	4.32	7.37	7.01	8.2	8.11

[1]Means followed by same letter(s) within a column are not significantly different at 5% probability (DNMRT); WAP: weeks after planting. * Significant at 5% probability (DNMRT); NS: Not Significant at 5% probability (DNMRT).

Host crops reaction score

The three varieties each of maize, rice and sorghum at 9 and 12 WAP infected with *Striga* seeds in the two years exhibited significant reaction to *S. hermonthica* parasitism compared with their respective controls (Table 2). The reaction scores of maize var. 8338-1, rice var. FARO 45 and sorghum var. ICSV 111 infected with *Striga* seeds in the two years were significantly higher compared with their other corresponding varieties at 9 and 12 WAP except in 2005 where sorghum var. SAMSORG 14 had reaction score comparable to ICSV 111 at 9 WAP (Table 2). All the trap crop varieties evaluated resulted in significantly lower host crop reaction to the parasitism in 2005 and 2006 at 9 and 12WAP compared with the control (Table 2). The groundnut var. SAMNUT 11, soybean var. TGx 1448-2E, cowpea var. SAMPEA 7 and cotton var. SAMCOT 10 consistently resulted in significantly lower host crop reaction score than their other respective varieties (Table 2).

The host crop genotypes infected with *Striga* seeds of different crop sources in 2005 at 9 WAP and in 2006 at 9 and 12 WAP had higher reaction score following the order sorghum > millet > maize while with Mokwa *Striga*

Table 2. Host crop reaction to *Striga hermonthica* parasitism and shoot dry weight as influenced by host crop sources of *Striga hermonthica* and trap crop varieties planted in rotation in the screen house at Mokwa, 2005 and 2006.

Treatments	Crop reaction score				Shoot dry weight g/pot			
	9WAP		12WAP		Host crop		Trap crop	
	2005	2006	2005	2006	2005	2006	2005	2006
Host Crop Genotypes (H)								
Maize								
Inoculated								
Acr.97TZL Comp. I-W	2.0^{b1}	1.9^{b}	2.5^{b}	2.3^{b}	80.3^{a}	70.2^{ab}	45.1	44.5
9022-13	1.7^{c}	1.7^{b}	2.4^{b}	2.2^{b}	76.2^{a}	63.4^{b}	45.3	44.6
8338-1	3.4^{a}	2.3^{a}	4.1^{a}	3.9^{a}	30.7^{b}	21.2^{c}	45.2	44.7
No inoculation								
Acr.97TZL Comp. I-W	1.0^{d}	1.1^{d}	1.1^{d}	1.1^{d}	81.2^{a}	74.3^{ab}	45	44.5
9022-13	1.1^{d}	1.0^{d}	1.1^{d}	1.0^{d}	88.8^{a}	82.6^{a}	45.2	44.6
8338-1	1.1^{d}	1.1^{d}	1.1^{d}	1.1^{d}	77.9^{a}	66.3^{ab}	45.2	44.6
SE ±	0.05	0.06	0.0^{4}	0.03	4.3	4.12	0.31	0.5
Rice								
Inoculated								
FARO 40	2.0^{b}	1.9^{c}	2.5^{b}	2.3^{c}	44.3^{bc}	40.3^{ab}	45.2	44.5
WAB 56-50	2.0^{b}	2.0^{b}	2.4^{b}	2.4^{b}	40.7^{c}	36.7^{b}	45.3	44.4
FARO 45	2.2^{a}	2.1^{a}	3.0^{a}	2.9^{a}	21.2^{d}	22.3^{c}	45.1	44.5
No inoculation								
FARO 40	1.1^{c}	1.0^{d}	1.1^{c}	1.0^{d}	50.1^{a}	46.7^{a}	45	44.6
WAB 56-50	1.0^{c}	1.0^{d}	1.1^{c}	1.0^{d}	46.8^{ab}	42.3^{ab}	45.2	44.6
FARO 45	1.0^{c}	1.0^{d}	1.0^{c}	1.0^{d}	44.1^{bc}	37.2^{b}	45.2	44.5
SE ±	0.04	0.02	0.05	0.03	1.4	2.33	0.52	0.41
Sorghum								
Inoculated								
SAMSORG 3	2.1^{b}	2.0^{c}	2.6^{c}	2.5^{c}	140.2^{b}	123.0^{b}	45.1	44.3
ICSV 111	2.5^{a}	2.6^{a}	4.3^{a}	4.1^{a}	66.4^{e}	59.9^{e}	45.2	44.5
SAMSORG 14	2.3^{ab}	2.2^{b}	3.2^{b}	3.0^{b}	80.2^{d}	71.1^{d}	45.3	44.4
No inoculation								
SAMSORG 3	1.1^{c}	1.1^{d}	1.1^{d}	1.1^{d}	91.2^{c}	80.3^{c}	45	44.5
ICSV 111	1.1^{c}	1.1^{d}	1.1^{d}	1.1^{d}	91.9^{c}	76.3^{cd}	45.1	44.4
SAMSORG 14	1.0^{c}	1.0^{d}	1.0^{d}	1.1^{d}	168.9^{a}	152.6^{a}	45.2	44.5
SE ±	0.05	0.04	0.06	0.04	2.44	1.44	0.3	0.4

at 12 WAP it followed the order sorghum > millet = maize (Table 2).

Host crop shoot dry weight

Maize hybrid 8338-1 infected with *Striga* in the two years and 9022-13 in 2006 produced significantly lower shoot dry weight compared with their respective *Striga* free controls (Table 2). When infected with *Striga* in the two years, the maize hybrid 8338-1 produced significantly lower shoot dry weight than the other two maize genotypes (Table 2). Rice FARO 45 infected with *Striga* in 2005 and 2006, FARO 40 and WAB 56-50 infected with *Striga* in 2005 had significantly lower shoot dry weight compared with their respective *Striga* free controls (Table 2).

The three sorghum varieties infected with *Striga* obtained in the two years produced significantly lower shoot dry weight compared with their respective controls (Table 2). When infected with *Striga* in both years, the host crops shoot dry weight significantly followed the order SAMSORG 3 > SAMSORG 14 > ICSV 111 (Table 2)

All the trap crop varieties planted in rotation with host crop genotypes resulted in significantly higher host crop shoot dry weight in the two years of study compared with the no trap crop control except cotton var. SAMCOT 8

Table 2. Continued: Host crop reaction to *Striga hermonthica* parasitism and shoot dry weights as influenced by host crop sources of *Striga* hermonthica and trap crop varieties planted in rotation in the screen house at Mokwa, 2005 and 2006.

Treatments	Crop reaction score				Shoot dry weights g/pot			
	9 WAP		12 WAP		Host crop		Trap crop	
	2005	2006	2005	2006	2005	2006	2005	2006
Trap crops (T)								
Groundnut								
SAMNUT 11	2.2^{h}	2.0^{l}	2.8^{f}	2.6^{f}	100.1^{a}	90.3^{cd}	48.6^{a}	48.2^{a}
SAMNUT 10	2.9^{f}	2.7^{g}	3.9^{e}	3.6^{d}	97.8^{a}	89.2^{d}	48.6^{a}	47.9^{a}
SAMNUT 18	3.5^{bc}	3.1^{d}	4.5^{c}	4.2^{b}	82.4^{c}	79.3^{f}	47.1^{b}	44.5^{b}
SE ±							0.28	0.29
Soyabean								
TGx 1448-2E	2.3^{gh}	2.3^{j}	3.0^{f}	2.6^{f}	98.1^{a}	91.1^{bcd}	43.7^{a}	43.4^{a}
TGx 1485-1D	2.8^{f}	2.6^{h}	4.2^{d}	3.0^{e}	96.7^{a}	91.2^{bcd}	43.6^{a}	43.2^{a}
SAMSOY 2	3.4^{cd}	3.2^{c}	4.6^{bc}	3.7^{d}	77.2^{d}	76.3^{g}	40.1^{b}	40.1^{b}
SE ±							0.3	0.26
Cowpea								
SAMPEA 7	2.3^{gh}	2.3^{j}	3.0^{f}	2.7^{f}	99.6^{a}	92.7^{bc}	38.5^{a}	38.9^{a}
L25	3.2^{e}	3.0^{e}	4.2^{d}	3.9^{c}	87.7^{b}	82.6^{e}	37.2^{a}	37.3^{b}
SAMPEA 6	3.3^{de}	3.3^{b}	4.8^{b}	4.1^{b}	73.5^{e}	63.9^{h}	31.4^{b}	31.7^{c}
SE ±							0.4	0.34
Cotton								
SAMCOT 10	2.4^{g}	2.2^{k}	3.0^{f}	2.7^{f}	101.3^{a}	96.7^{a}	42.4^{a}	41.6^{a}
SAMCOT 9	3.2^{e}	2.5^{i}	4.4^{cd}	3.0^{e}	97.8^{a}	93.3^{b}	43.1^{a}	41.5^{a}
SAMCOT 8	3.6^{b}	2.9^{f}	4.8^{b}	3.9^{c}	67.3^{f}	62.4^{hi}	39.6^{b}	40.2^{b}
No trap crops	4.0^{a}	3.9^{a}	5.5^{a}	5.3^{a}	64.6^{f}	60.3^{i}	-	-
SE ±	0.03	0.02	0.05	0.04	0.77	0.71	0.23	0.26
Crop Sources of *Striga* (C)								
Maize	1.9^{c}	1.8^{c}	2.3^{b}	2.1^{c}	113.9^{a}	110.1^{b}	43.7	42.1
Sorghum	2.1^{a}	2.0^{a}	2.7^{a}	2.5^{a}	70.3^{c}	68.7^{d}	43.1	42.9
Millet	2.0^{b}	1.9^{b}	2.4^{b}	2.3^{b}	76.7^{b}	72.3^{c}	43.9	42.2
No inoculation	1.1^{d}	1.1^{d}	1.1^{c}	1.1^{d}	115.1^{a}	111.8^{a}	43	42
SE ±	0.02	0.02	0.04	0.03	0.57	0.36	0.32	0.33
Interactions								
C x T	0.06*	0.05*	0.08*	0.06*	1.33*	1.22*	NS	NS
C x H	0.05*	0.04*	.0.06*	0.04*	0.85*	0.80*	NS	NS
T x H	NS	NS	NS	NS	NS	NS	NS	NS
C x T x H	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	15.16	14.17	16.7	14.13	8.05	7.69	3.71	4.32

[1]Means followed by same letter(s) within a column are not significantly different at 5% probability (DNMRT). WAP: weeks after planting. * Significant at 5% probability (DNMRT). NS: Not Significant at 5% probability (DNMRT). Crop reaction score using scale 1-9 where 1 – normal growth and 9 – completely dead plant.

that supported host crop shoot dry weight comparable to the respective controls (Table 2). When infected with *Striga* in both years, rotation of cotton var. SAMCOT 10 and SAMPEA 7 resulted in the maximum host crop shoot dry weight. Furthermore, rotation of groundnut varieties SAMNUT 11 and SAMNUT 10, soyabean varieties TGx 1448-2E and TGx 1485-1D and cotton var. SAMCOT 9 with host crops in 2005 resulted in significantly higher shoot dry weight compared with the other respective varieties (Table 2).

The host crop genotypes infected with *Striga* seeds of different crop sources in 2006 had higher shoot dry weight following the order no infection > maize > millet > sorghum while in 2005 it followed the order control =

maize > millet > sorghum (Table 2).

Trap crop shoot dry weight

Groundnut varieties SAMNUT 11 and SAMNUT 10, soybean varieties TGx 1448-2E and TGx 1485-1D, cowpea variety SAMPEA 7 and cotton varieties SAMCOT 10 SAMCOT 9 had significantly higher shoot dry weight compared with the other variety (ies) of their respective crops (Table 2).

Number of days to first Striga emergence

The number of days to first *Striga* emergence in the two years was significantly delayed on the two STR maize varieties 9022-13 and Acr. 97 TZL Comp. 1 - W, rice var. FARO 40 and sorghum var. SAMSORG 3 compared with their other respective varieties evaluated in this study (Table 3). The emergence of *Striga* in both years was also significantly delayed on rice var. WAB 56-50 and sorghum var. ICSV111 compared with rice var. FARO 45 and sorghum var. SAMSORG 14, respectively (Table 3).

All the trap crop varieties planted in rotation with host crop genotypes resulted in significantly delayed emergence *Striga* in the two years compared with the no trap crop control (Table 3). Groundnut var. SAMNUT 11, soybean var. TGx 1448-2E, cowpea var. SAMPEA 7 and cotton var. SAMCOT 10 planted in rotation with host crop genotypes caused significant delay in the emergence *Striga* in both years compared with their other respective varieties (Table 3).

Also, the emergence of *Striga* from maize and millet plants whose seeds were collected in the two years was significantly delayed on the host crop compared with *Striga* from sorghum plants (Table 3).

Striga shoot count

Maize hybrid 8338-1 consistently supported significantly higher *Striga* shoot count in the two years than the other two STR genotypes (Table 3). The hybrid 9022-13 at 9 WAP in 2006 also supported lower *Striga* shoot count than the open-pollinated Acr.97 TZL Comp.1-W (Table 3). The susceptible rice var. FARO 45 also supported higher *Striga* shoot emergence than their other respective varieties throughout the trials.

The host crop genotypes infected with *Striga* seeds from sorghum plant supported significantly higher *Striga* shoot counts in the two years than those infected with *Striga* from maize and millet plants at 9 and 12 WAP. Similarly, the host crops infected with *Striga* from millet plants supported higher *Striga* shoot count than those infected with that from maize plants in both years (Table 3).

DISCUSSION

Under *Striga* parasitism, maize genotypes 9022-13 and Acr.97 TZL Comp.1-W, rice varieties FARO 40 and WAB56-50 and sorghum var. SAMSORG 3 consistently exhibited more acceptable growth and production attributes viz; lower plant height reduction and crop reaction syndrome to *Striga* as well as higher crop vigour and shoot dry matter production compared to the other corresponding varieties viz; 8338-1 for maize, FARO 45 for rice and ICSV111 and SAMSORG 14 for sorghum. The former genotypes also had lower *Striga* infestation compared to the latter ones.

The results confirmed that the maize genotypes 9022-13 and Acr.97 TZL Comp.1-W, rice varieties FARO 40 and WAB 56-50 as well as sorghum variety SAMSORG 3 exhibited different forms and levels of resistance to *Striga hermonthica*. It had been reported by various workers that both susceptible and *Striga* tolerant maize varieties exhibited various levels of syndrome reaction to *Striga* (Kim, 1994; Lagoke et al., 1997; Lagoke et al., 1999). Lagoke et al. (1999) reported yield losses of 77.4% in 8338-1, 52.5% in 9022-13 and 30.5% in Acr.97 TZL Comp.1-W the precursor of Acr.97 TZL Comp.1-W in one of the several trials conducted in the Guinea savanna. Isah et al. (2009) later reported higher yield of 9022-13 and Acr.97 TZL Comp.1-W which were higher than that of 8338-1 by 1.9 and 1.5 respectively in trials conducted at Mokwa. Earlier reports have confirmed that rice varieties FARO 40 and WAB 56-50 exhibited high and moderate levels of resistance to *S. hermonthica* (Lagoke et al., 1999; Adagba et al., 2003).

Even though other varieties have also been reported, they have less consistent in the exhibition of STR features like FARO 40 and WAB 56-50. Many varieties of sorghum had also been identified including the SRN 4841, N13, Malisor 92-1, ICSV111 and SAMSORG 3, Kano farafara and ICSV1079 (Lagoke et al., 1999). However, in most cases, resistance to *Striga* in sorghum has been associated with low productivity. Many are also drought tolerant and adapted to low yielding potentials of the drier Sudan savanna and Sahel agro-ecological. This may be the reason for low dry matter production obtained from sorghum var. ICSV111 in this study. However, many land races including SAMSORG 3 have developed tolerance over time.

Johnson et al. (1997) indicated that when maize, rice, millet and sorghum were sown into seeds of *S. hermonthica* collected from maize and rice crops, *S. hermonthica* from either maize or rice showed no host specificity and parasitized all the four test crops. King and Zummo (1977) and Kim (1994) reported that strain variation has been well documented as reflected in differential *Striga* seed germination stimulated by maize, millet and sorghum and this diversity is in both the host and the parasite. In this study also, the *S. hermonthica* seeds collected from sorghum sources produced higher *Striga* shoot count and caused higher host crop reaction

Table 3. Days to first emergence and shoot count of *Striga* as influenced by host crop sources of *Striga hermonthica* and trap crops planted in rotation with host crop genotypes in the screen house at Mokwa, 2005 and 2006.

Treatments	Number of days to first *Striga* emergence		*Striga* shoot count/pot			
			9WAP		12WAP	
	2005	2006	2005	2006	2005	2006
Host Crop Genotypes (H)						
Maize						
Inoculated						
Acr.97TZL Comp. I-W	43.1^{a1}	40.7^{a}	2.1^{b}	1.9^{b}	3.4^{b}	3.0^{b}
9022-13	42.6^{a}	41.0^{a}	2.0^{b}	1.7^{c}	3.3^{b}	2.5^{b}
8338-1	40.2^{b}	39.2^{b}	4.7^{a}	2.9^{a}	6.3^{a}	5.1^{a}
No inoculation	-	-	-	-	-	-
SE ±	0.13	0.12	0.05	0.04	0.17	0.15
Rice						
Inoculated						
FARO 40	39.2^{a}	43.5^{a}	1.9^{b}	1.7^{b}	2.5^{c}	2.2^{c}
WAB 56-50	37.6^{b}	42.7^{b}	2.0^{b}	1.7^{b}	4.4^{b}	3.2^{b}
FARO 45	36.5^{c}	41.3^{c}	3.2^{a}	2.4^{a}	5.9^{a}	4.3^{a}
No inoculation	-	-	-	-	-	-
SE ±	0.15	0.1	0.06	0.05	0.18	0.16
Sorghum						
Inoculated						
SAMSORG 3	39.2^{a}	39.7^{a}	2.1^{c}	2.2^{c}	2.8^{c}	2.9^{c}
ICSV 111	37.6^{b}	37.8^{b}	3.6^{b}	3.2^{b}	4.2^{b}	4.1^{b}
SAMSORG 14	36.5^{c}	37.0^{c}	5.1^{a}	4.6^{a}	7.4^{a}	6.2^{a}
No inoculation	-	-	-	-	-	-
SE ±	0.15	0.12	0.05	0.04	0.16	0.17
Trap Crops (T)						
Groundnut						
SAMNUT 11	44.4^{a}	45.2^{a}	3.9^{g}	2.8^{f}	4.7^{ef}	4.0^{efg}
SAMNUT 10	42.0^{cd}	43.3^{c}	4.4^{ef}	3.1^{de}	7.0^{bc}	4.4^{cdef}
SAMNUT 18	40.5^{e}	40.9^{e}	5.7^{b}	3.5^{c}	7.6^{b}	4.9^{cde}
Soyabean						
TGx 1448-2E	43.4^{b}	44.1^{b}	3.5^{h}	3.1^{de}	4.8^{ef}	4.0^{efg}
TGx 1485-1D	40.2^{e}	40.7^{ef}	4.6^{de}	3.5^{c}	6.4^{cd}	4.3^{def}
SAMSOY 2	40.0^{e}	40.1^{f}	4.7^{d}	3.8^{b}	7.4^{bc}	4.9^{cde}
COWPEA						
SAMPEA 7	44.5^{a}	44.8^{a}	3.0^{i}	1.8^{g}	5.1^{ef}	3.7^{fg}
L25	42.0^{cd}	43.0^{c}	5.0^{c}	2.9^{ef}	6.5^{cd}	4.3^{def}
SAMPEA 6	40.5^{e}	41.2^{c}	5.1^{c}	3.3^{cd}	7.6^{b}	5.2^{c}
COTTON						
SAMCOT 10	44.4^{a}	45.1^{a}	2.6^{j}	1.9^{g}	4.1^{f}	3.2^{g}
SAMCOT 9	42.3^{c}	42.5^{d}	4.3^{f}	3.0^{ef}	5.5^{de}	4.8^{cde}
SAMCOT 8	41.5^{d}	41.3^{e}	5.7^{b}	3.5^{c}	7.7^{b}	6.1^{b}
No trap crops inoc	38.1^{f}	38.7^{g}	6.9^{a}	6.3^{a}	9.9^{a}	9.0^{a}
SE ±	0.18	0.15	0.06	0.05	0.27	0.22
Crop Sources of *Striga* (C)						
Maize	41.9^{a}	42.9^{a}	1.5^{c}	2.1^{c}	2.9^{c}	2.4^{c}
Sorghum	39.3^{b}	39.7^{b}	2.7^{a}	2.5^{a}	3.9^{a}	3.5^{a}
Millet	41.5^{a}	42.3^{a}	2.5^{b}	2.3^{b}	3.4^{b}	3.0^{b}
No inoculation	-	-	-	-	-	-

Table 3. Continued.

SE ±	0.13	0.15	0.02	0.02	0.11	0.09
Interactions						
C x T	NS	NS	NS	NS	0.47*	0.43*
C x H	NS	NS	NS	NS	0.30*	0.27*
T x H	NS	NS	NS	NS	NS	NS
C x T x H	NS	NS	NS	NS	NS	NS
CV (%)	7.48	6.52	23.16	19.87	72.27	68.23

[1]Means followed by same letter(s) within a column are not significantly different at 5% probability (DNMRT).

score with resultant lower shoot dry weight production than millet and maize *Striga* while the same trend was observed with millet *Striga* compared to maize *Striga*. This confirms the diversity in the strains of *S. hermonthica* in both the host and the parasite which is also a reflection of *Striga hermonthica*.

The varieties of trap crops SAMNUT 11 for groundnut, TGx 1448-2E for soybean, SAMPEA 7 cowpea and SAMCOT 10 for cotton planted in rotation caused delayed *Striga* emergence, reduced infestation on the host crop compared with their other respective varieties. Consequently, crop damage reaction syndrome were reduced and shoot dry matter production was increased when the planting of the promising trap crop varieties preceeded those of the host crops. However, consistent outstanding reduction in parasitism with consequent good crop performance was observed with groundnut var. SAMNUT 11 and cotton var. SAMCOT 10 among the trap crop varieties. The result of the study therefore confirms earlier report on the variability among trap crop varieties in reducing *Striga* problem on host crops. Lagoke et al. (1997) had earlier reported that cotton var. SAMCOT 10 and groundnut var. SAMNUT 11 are among those trap crop varieties that might have stimulated abortive germination of *Striga* seeds before the planting of host crops thereby reducing the parasitism on the host crop genotypes.

CONCLUSION AND RECOMMENDATION

It is obvious from this study that there exist a *S. hermonthica* biotypes among crop sources of *Striga* with *Striga* collected from sorghum plants been the most virulent. Rotation of cotton var. SAMCOT 10 and groundnut var. SAMNUT 11 with cereal crops such as Acr, 97 TZL Comp.1-W and 9022-13 for maize, FARO 40 and WAB 56-50 for rice and SAMSORG 3 for sorghum may go along in reducing *S. hermonthica* parasitism on the host crop plants.

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