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Combating the Menace of *Striga hermonthica* Infestation: An Integrated Approach Adopted in North-Eastern Ghana

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Abstract: The objectives of this study are to promote the growing of striga tolerant maize varieties in striga endemic locations of Northern Ghana. Three striga tolerant/resistant maize (STR) varieties, ACR 94 TZE Comp 5-W, ACR 97 TZL Comp 1-W and IWD STR C1, were grown in rotation and in intercropping with soybean, TGX 1442-2E, in 2003, 2004 and 2005 on farmers fields. Striga incidence was recorded as the number of striga plants at ten weeks after planting, visible effects due to striga, height of maize and maize grain yield. The results showed that the STR varieties grown in sole cropping supported few striga plants and produced up to 70% more grain than the farmers' maize. The maize grown under intercropping supported fewer striga plants compared to those grown in sole cropping. STR grown in intercropping with soybean lead to a reduction of 17.6% emerged striga plants while when grown in rotation for three seasons had up to 89.4% less emerged striga plants as compared to maize grown after maize. Therefore, the growing of STR varieties in rotation with soybean may be one of the best and practical methods of control.

Key words: Maize, striga, tolerant/resistant, cropping system

INTRODUCTION

Striga species are known to cause serious economic losses to cereal crops such as millet, sorghum and maize. Among the known species, *Striga hermonthica* (Del.) Benth. of the Scrophulariaceae family, constitutes the most economically important biological constraints to maize production in Ghana. The prevalence of *Striga hermonthica* (striga shall be used) was not known in maize in Ghana, but as the cultivation of maize and the release of hybrid maize have been accepted nation-wide. The gravity of the situation has also become a reality with the droppings of migratory animals from neighboring Sahelian countries where the parasitic weed is really a menace to cereal production. Striga infestation accounts for seven billion US dollars of food production annually (Kim *et al*., 2004). In order to reduce losses due striga infestation, hand pulling and hoe weeding (Thalouarn and Fer, 1993), intercropping with trap and catch crops (Logake *et al*., 1991) application of high doses of nitrogen fertilizers (Carson, 1989) and herbicide application are among the most common control methods practiced by farmers. These control methods are either impractical or labor intensive to the capital deficient farmers. Okonko (1987), Heller and Wegmann (1999) have demonstrated that, for each of the five stages of striga parasitic development which include, striga seed germination, haustorial initiation, penetration of host root tissues, physiological compatibility and parasitic growth and maturity, to be completed, enzymes play a major role. Hence maize varieties with the genes controlling the expression of parasitic weed germination and development would be very important in controlling striga infestation. The control of striga had been through cultural methods because of the lack of resistant maize varieties. As the International Institute of Tropical Agriculture started developing these varieties a more practical method of control is to grow resistant maize varieties. In the absence of absolutely resistant varieties Kim (1994) has recommended the adoption of host tolerance that is controlled by quantitatively inherited genes whose expression depends on the environmental conditions. Growing maize in association with trap and catch crops may provide an environment not conducive to striga infestation.

Therefore, the objectives of this research were to promote the growing of striga tolerant maize varieties and to practice some integrated control methods in striga endemic locations of North-Eastern Ghana.

MATERIALS AND METHODS

This study was carried out in four districts in Guinea and Sudan Savannah zones of Ghana (between long 1°W and 1/2°E and between lat 9°N and 11°N) from 2002 to 2005. Three striga tolerant/resistant (STR) maize varieties,

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ACR 94 TZE Comp 5-W, ACR 97 TZL Comp 1-W and IWD STR C1, developed by the International institute of Tropical Agriculture and a farmers' variety, were planted on-farm in two cropping systems (rotation and intercropping maize with soybean, TGX 1442-2E) to demonstrate an integrated method of controlling striga on infested soils. The farmers' variety was an improved variety that was not resistant to striga and had also lost its identity. For the rotation, three 20×20 m plots were demarcated. One of the plots was planted to the farmer's variety, the second to an improved striga tolerant/resistant variety (STR) and the third planted with soybean. The farmers' variety was replanted on the same plot each season whereas the STR was rotated with the soybean. For the intercropping, four plots were demarcated. Two of the plots were intercropped with soybean while the other two were sole. The striga tolerant variety used in the Guinea Savannah zone was ACR 97 TZL Comp 1-W instead of IWD STR C1 when the farmers complained that both ACR 94 TZE Comp 5-W and IWD STR C1 were very early and were not adapted to that agro-climatic conditions of the zone. In 2002 planting season, all the participating farmers were male. This was so because all the demonstrations were done on family lands which were controlled by men. However, the situation was different after that and up to 10 of the farmers who participated were women. The youngest was 28 years old while the oldest was 63 years. The fields were generally degraded and abandoned. In some cases, the fields were rejected because they could not support a maize crop due to striga infestation.

The fields were prepared using either bullocks or the hand hoes. The pair row system (i.e., two rows of soybean alternating with two rows of maize) was adopted. This was modified to suit the demonstrations for ease of planting and to avoidance of shading. In some cases the farmers planted the soybean within the maize rows a week after the maize had germinated. Starter fertilizer (NPK) was distributed evenly at 25 kg N ha^{-1} among all maize plants in the plot at planting or 7-10 days after sowing at 5-8 cm away from the hills. Sulfate of ammonia was distributed (25 kg N ha^{-1}) evenly among all plants in the plots at 4-5 weeks after sowing at 5-8 cm from the hills. Weeds were controlled normally until the striga plants started emerging.

Data were recorded on number of plants at thinning and harvesting, number of striga plants at 10 and 12 weeks after planting, maize grain produced and soybean grain produced. All observations made were based on a hectare. The data were analyzed statistically using Genstat statistical package.

RESULTS AND DISCUSSION

The participating farmers were selected based on, i. their previous involvement in some demonstrations, ii. how severe their farms were endemic to *Striga hermonthica* infestation, iii. the willingness to cooperate with the scientists and iv. availability of the Agricultural Extension Agents (AEA) of the Ministry of Food and Agriculture (MOFA) in the area to facilitate in data collection. The number of farmers who participated in the demonstrations from 2003 to 2005 across the districts is presented in Table 1. In 2003, the number of farmers who agreed to do the rotation demonstration was high, but the number went down in 2004 and further down in 2005. This could be due to the fact that small holder farmers do not embrace sole cropping even with all its advantages such as planting and harvesting. On the other hand the number of farmers willing to adopt the intercropping method remained fairly constant. Therefore, as the study period progressed some of the farmers were replaced when conditions changed. Those who were replaced had no option but to adopt the intercropping system because data from an incomplete rotation could not be analyzed.

There were significant differences ($p<0.05$) for plant height from farmer to farmer for each variety (Table 2). This was due to the varied management ability of the farmers. The farmers' variety was usually taller (161.8 cm) than the striga tolerant varieties (134 to 138 cm). The farmers' variety was also an improved variety that had lost its identity and was not tolerant to striga. It was not uniform but could produced economic yields under favorable conditions.

When the data of the intercropping plots were analyzed, there were significant differences ($p<0.05$) among the varieties with respect to days to silk extrusion and plant height. The number of striga plants that emerged twelve weeks after planting varied from district to district and tended to decrease from year to year. On the other hand many more striga plants emerged from the sole cropping system than the intercropping system. This was due to the fact that soybean is a trap crop that triggered the suicidal germination of some of the striga seeds in the intercropped plots before the host maize roots got to them. In intercropping, the reduction was not prominent. However, STR maize varieties grown in intercropping system lead to a reduction of about 17.6 % by the third year (Table 3) intercropping with soybean (Table 3).

Fewer striga plants emerged in the STR maize plots than the farmers' variety plots at all districts (Table 4). The emerged striga plants per hectare at Bawku district was 36,700 and 24,900 for the farmers' and STR maize

Table 1: Number of farmers that participated in demonstration in some districts from 2003 to 2005

	Intercropping			Rotation		
District	2003	2004	2005	2003	2004	2005
Tamale	4	13	13	5	3	3
Tolon-Kumbungu	3	-	7	2	-	1
Yendi	2	-	-	2	-	-
Bawku east	10	11	11	4	7	3
Bawku west	6	-	-	4	-	-
Gushiegu	4	-	-	3	-	-
	29	24	31	20	10	7

Table 2: Means of farmers' maize variety evaluated in intercropping from 2003 to 2005

	Inter-cropping									Sole cropping					
	Maize yield (kg ha^{-1})			Soy yield (kg ha^{-1})			Striga count 12wap			Maize yield (kg ha^{-1})			Striga count 12wap		
District	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Bawku	250.0a	433.75c	300.00b	1750.00	-	1200.0	950.50b	218.33b	2500a	579.17b	525.75b	1000.0b	10825a	3563c	2450a
Tamale	362.5b	1253.85a	450.00a	750.00	1942.00	2187.5	1550c	15035a	1950b	775.00ab	1481.15a	1320.0a	170c	337003a	2325a
Tolon-Kumbungu	457.0ab	950.50b	218.33b	525.00	1250.00	1833.3	0d	1200c	1308c	835.00a	1200.50a	1309.2a	725c	8000b	958b
Yendi	-	-	-	525.00	-	-	13800a	-	-	-	-	-	5300b	-	-

Table 3: Means of Striga tolerant maize varieties evaluated in intercropping from 2003 to 2004

	Inter-cropping									Sole cropping					
	Maize yield (kg ha^{-1})			Soy yield (kg ha^{-1})			Striga count 12wap			Maize yield (kg ha^{-1})			Striga count 12wap		
District	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Bawku	403.57a	875.00c	450.00a	2392.86	-	1245.00	5828a	2450a	2000a	614.29c	875.00 c	1150.00b	14492d	950c	-2225a
Tamale	425.00a	1980.00a	500.50a	700.00	1300.00	2000.00	410c	2000ab	1500 b	831.25b	2320.00a	1450.00a	300c	25900a	650b
Tolon-Kumbungu	150.00b	1500.00a	470.00a	600.00	1000.00	1800.00	0d	1500b	500c	675.00c	1700.00b	950.00c	25d	2250b	300c
Yendi	630.00a	-	-	525.00	-	-	1900b	-	-	1160.00a	-	-	4750b	-	-

Table 4 Means of all maize varieties evaluated in rotation from 2003 to 2005

	Farmers variety						Striga tolerant variety						Soy bean		
	Maize yield (kg ha^{-1})			Striga count 12 wap			Maze yield (kg ha^{-1})			Striga count 12 wap			Grain yield (kg ha^{-1})		
District	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Bawku	650.00c	725.00	1000.0b	36700b	3900a	1950a	715.00c	875.00c	1200.0b	23100a	2500a	770a	1750.0	1200.0	1100.5
Tamale	1700.00a	2000.0a	1288.33a	18785a	1350b	1833a	1890.00a	2830.00a	1480.0a	3750b	500b	845a	2000.0	1350.0	1225.0
Tolon-Kumbungu	1100.00b	1800.0a	1260.00a	4900c	1000b	1200b	1250.00b	1900.00b	1295.0a	24900a	150c	550b	1500.0	1100.0	1075.0
Yendi	1250.00b	-	-	650d	-	-	1850.00a	-	-	150c	-	-	1450.0	-	-

varieties, respectively, in 2003. In Tamale district, the emerged stiga plants were 4,900 and 3,750 for the farmers' variety and STR maize, respectively. By the third year of the study, the number of emerged striga plants for both maize types had reduced to less than 550 plants per hectare. For the STR maize there was a reduction of about 89.4% emergence compared to the first year of the rotation (Table 4).

Grain production for the crops was best in Yendi district than all the other districts (Table 2 and 3) for intercropping but no data were available for completion of the study in that district. Maize grain production was better at Tamale district than the rest of the districts during the three years the study was carried out. In fact, Tamale district is in a high producing environment compared to Bawku which is in a low yielding one for maize. However, the farmers in Bawku district have started commercial cultivation of maize because of the relatively high yield compared to the substitute pearl millet due to striga infestation. When the farmers' variety was compared to the STR, at each district the STR produced higher grain that the farmers' variety even when striga infection rates were comparable. In Bawku district, the grain produced by the farmers' variety in rotation increased from 650 kg ha^{-1} in 2003 to 725 kg h^{-1} a in 2004 and to 1000 kg ha^{-1} in 2005. On the other hand in Tamale and Tolon-Kumbungu districts, grain production increased from 2003 to 2004 and decreased in 2005. This trend could be attributed to the poor rainfall pattern in the two districts compared to Bawku district. The relatively high production in Bawku district could be attributed to the reduction in striga infestation as a result of the effect of rotation with soybean. The grain production pattern over the study period STR maize was similar to that of the farmers' variety. The difference was that the STR maize produced more grain at each of the districts than the farmers' variety. The STR maize grown in sole cropping system produced up to 70 % more grain than the farmers' variety grown under similar conditions.

CONCLUSIONS AND RECOMMENDATIONS

The goal of this study are to ensure food security by promoting the growing o f STR maize varieties in intercropping or rotating with trap crops (e.g., TGX 1442-2E) in striga endemic locations of North

Eastern Ghana where *Striga hermonthica* is a very serious parasitic weed on maize. Three striga tolerant/resistant maize varieties, ACR 94 TZE Comp 5-W, ACR 97 TZL Comp 1-W and IWD STR C1, were grown in rotation and in intercropping with soybean from 2002 to 2005 on farmers' fields. Striga incidence was recorded as the number of striga plants at 10 and 12 weeks after planting, visible effects due to striga such as leaf chlorosis, stunting and maize grain yield. The results showed that the STR varieties grown in sole cropping supported few striga plants and produced up to 60 % more grain than the farmers' variety grown under similar conditions. The maize grown under intercropping supported fewer striga plants as compared to those grown in sole cropping due to the reduced plant stand as well as the effect due to the soybean. There was a reduction of 89% emerged striga plants when STR maize was rotated with soybean from 2003 to 2005 compared to 17.4 % when grown in intercropping system. Therefore, the growing of STR varieties in rotation with soybean may be one of the best and practical method of controlling *Striga hermonthica* on farmers' fields.

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