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RESEARCH PAPER

VARIATION IN MAIZE TOLERANCE TO *STRIGA LUTEA* (LOUR) AND INFLUENCE OF ARBUSCULAR MYCORRHIZAL FUNGI

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ABSTRACT

This study was conducted to assess the variation in maize tolerance to *Striga lutea* and influence of arbuscular mycorrhizal fungi (AMF). Screen house experiment was conducted at the Institute of Agricultural Research and Training, Ibadan while, Farm settlement and Temidire were striga endemic experimental fields in Eruwa. Complete randomized design was used in screen house while, randomized complete block design was adopted on the field with three replications. AMF (*Glomus mosseae, G. clarum*, *G. deserticola* and *Gigaspora gigantea*) in mixtures of soil and root fragments were inoculated at the rate of 25g per plant while, 10.4g of extracted striga seeds were artificially infested. Uninoculated and uninfested in pots and plots served as control. Four maize genotypes; ILE1-OB, ART-98-SW4-OB, ART-98-SW5-OB and ART-98-SW6-OB were screened for tolerance or susceptibility to *S. lutea* infestation on disease rating scale of 1 to 9. ART-98-SW5-OB and ART-98-SW6-OB were significantly tolerant ($P<0.05$) with striga damage rating (SDR) ranging from 1.18-2.48, ART-98-SW4-OB was moderately tolerant with SDR ranging from 3.59-4.57, while ILE-OB was highly susceptible with SDR ranging from 8.61-8.72. Influence of AMF was significant ($P<0.05$) for growth, yield and striga-related traits with SDR ranging from 1.28-2.70 and 1.21-2.64 at 8 and 10 weeks after planting respectively.

Key words: Maize, mycorrhiza, Striga lutea, tolerance, yield

INTRODUCTION

Maize is one of the most widely grown cereals with great economic value in countries like Nigeria. It is primarily used as an energy crop in which its increased production per unit area is the main focus in maize-breeding programmes (Turi *et al*., 2007). The distinctive characteristics of maize have important implications for crop genetic improvement efforts. Because maize is an open pollinating crop, new genetic combinations are continuously generated in farmers' fields through natural outcrossing (Morris, 1994).

Its productions in the savanna ecologies are threatened by striga parasitic weeds which cause between 20 and 80 % yield loss (Olakojo and Kogbe, 2003).The most commonly used control method is the application of herbicides, some of which are non-biodegradable and toxic. Host-plant resistance is also one of the economical and effective management strategies of plant diseases caused by pathogens, including fungi, bacteria, viruses and nematodes (Thakur, 2007).

Arbuscular mycorrhizal fungi (AMF) are of great importance to agricultural crops and forest species by contributing to soil nutrient cycling and protecting plants from pests and fungal diseases such as *Sclerotium*, *Phytophthora*, *Fusarium* and *Rhizoctonia* (Odebode *et al*., 1995; Norman and Hooker, 2000; Matsubara *et al*., 2001). However, the ability of AMF to complement host resistance has not been explored as part of integrated striga management. Variation in maize tolerance to *Striga lutea* and influence of AMF were therefore investigated in this study.

MATERIALS AND METHODS

The pot experiment was conducted using complete randomized design in screen house of the Institute of Agricultural Research and Training (IAR&T), Ibadan, while the two field trials conducted at Temidire and Farm settlement in Eruwa were laid out in randomized complete block design with three replications. Ibadan and Eruwa are both located in Oyo State, Southern Guinea Savanna of Nigeria.

Four maize genotypes (ILE1-OB, ART-98-SW4-OB, ART-98-SW5-OB and ART-98-SW6-OB collected from IAR&T germplasm were screened for tolerance and/or susceptibility to *S. lutea* infestation on a *Tolerance rating to Striga syndrome* 1-9 (Highly tolerant 1-3, Moderately tolerant 4-6, Moderately susceptible 7-8, and Highly susceptible 9) (Kim,1994).

The AMF (*Glomus mosseae*, *G. clarum*, *G. deserticola* and *Gigaspora gigantea*) inocula were multiplied in pot cultures. Morphological characterization of spores was carried out based on spore size, colour, reaction to Melzer's reagent and hypha attachment according to the standard procedure. The mixtures of soil and root fragments of AMF were inoculated at the rate of 25g per plant. Each pot was artificially infested with 10.4g of striga seeds and left for 14 days to undergo pre-conditioning to the new environment. Two seeds of maize were planted into 10kg plastic pots (20 cm diameter and 30cm deep) filled with sterilized soil. Uninoculated and uninfested treatments in pots served as control.

Maize planted on the field was done on four-row plots of 3m x 5m. Two maize seeds were planted per hill at a spacing of 75 x 50cm. Uninfested plot was planted directly opposite of infested plot at a distance of 1m. Plants were thinned to one plant per hill after two weeks of planting. Agronomic practices were done. Agronomic and striga-related traits were also rated on scale of 1 to 5 (1- Excellent, 3- Fair and 5- Poor). Data recorded for striga-related traits, growth and yield characters of maize genotypes were analyzed using ANOVA while, means were separated using DMRT test at 5% level of probability.

RESULTS

The result in Table 1 shows that ART-98-SW5-OB and ART-98-SW6-OB genotypes were highly tolerant to *S. lutea* infestation with mean striga damage rating (SDR) ranging from 1.18 - 2.48 while ART-98-SW4-OB was moderately tolerant with mean SDR ranging from 4.55-4.56, while ILE1-OB was moderately susceptible with mean SDR ranging from 7.61-7.72 in screen house trial.

Similarly, in farm settlement, ART-98-SW5-OB and ART-98-SW6-OB genotypes were highly tolerant to *S. lutea* infestation but not significantly different with mean SDR of 1.32 and 1.39 respectively at 8WAP. ART-98-SW4-OB was moderately tolerant with mean SDR ranging from 3.59 at 8WAP to 3.64 at 10 WAP while, ILE1-OB was moderately susceptible with mean SDR ranging from 6.73 at 8WAP to 6.76 at 10 WAP.

In Temidire, ART-98-SW5-OB was highly tolerant with mean SDR of 1.19 which is significantly different ($p<0.05$) from other genotypes while, ILE1-OB was highly susceptible with mean SDR of 8.61 at 8 weeks after planting (8WAP). Character means of significant differences for growth, yield and striga related parameters are also presented in Table1.

Plant height, leaf length, leaf, width, stem diameter, grain yields and field weight were significantly higher ($p < 0.05$) for ART-98-SW5-OB and ART-98-SW6-OB but lower in *Striga* emergence count and SDR, showing better tolerance to *S. lutea*. Mean syndrome rating, tolerance to striga, striga count, grain yield, and field weight differed significantly ($p<0.05$) from one location to another.

Results of grain yield stem diameter and plant height for maize genotypes in Farm settlement recorded significant values than Temidire and the screen house while farm settlement and screen house had similar tolerance rating to striga. The values of leaf width at 8WAP for ILE1-OB (3.59cm) and ART-98-SW4-OB (3.86cm) as well as ART-98-SW5-OB (4.30cm) and ART-98-SW6-OB (4.24cm) for leaf width at 8WAP were similar in Temidire. The grain yield of ART-98-SW5-OB (3.22t/ha) and ART-98-SW6-OB (3.10t/ha) did not differ significantly ($p>0.05$) from each other in Temidire while, SDR for ART-98-SW5-OB (1.32) and ART-98-SW6-OB (1.39) were not significantly different in Farm settlement. These indicate uniform performance of the genotypes in different locations.

The effect of AMF was similarly significant for yield and maize agronomic characters (Table 2). The number of leaves per plant ranges from 10.22 – 11.80, grain yield ranges between (2.11 – 3.64) t/ha and field weight ranges between (40.79 kg – 74.29 kg). Maize agronomic characters were significantly different ($p < 0.05$) for AMF species. *G. clarum* which performed best for husk cover, plant aspect, ear aspect and ear harvest, was significantly different ($p<0.05$) from other AMF species and control.

Result of Table 3 shows that the striga syndrome rating ranges from (1.28 - 2.70) and (1.21 - 2.64) at 8WAP and 10WAP respectively, striga emergence count ranges between (1.24 -3.59) at 8WAP and (0.35 – 1.65) at 10WAP. Mean value of stalk rot was similar for *G. clarum* (2.31) and *G. deserticola* (2.39) but significantly different from other AMF

Table 1: Variation in maize tolerance to Striga infestation, yield and striga related parameters in three locations.

Genotype	PH (cm)		LL (cm)		LW (cm)		SD (cm)		SDR		SEC		GY (t/h)	FW (Kg)	Tolerance to Striga
	8WAP	10WAP	8WAP	10WAP	8WAP	10WAP	8WAP	10WAP	8WAP	10WAP	8WAP	10WAP			
Temidire															
ILE 1	65.72d	77.04d	49.62d	53.32d	3.59b	3.71d	3.36c	3.54d	8.61a	8.72°	2.94a	2.96a	1.15c	34.99d	HS
SW4	69.96c	79.84c	55.33c	57.98c	3.86b	4.26c	3.74ab	3.72c	4.46b	4.57b	1.72b	1.71b	2.28b	37.97c	MT
SW5	78.76a	88.50a	61.09a	65.23a	4.30a	4.52b	3.98a	4.22a	1.19d	1.25d	1.13d	1.22d	3.22a	48.60a	HT
SW6	76.91b	86.21b	56.76b	61.42b	4.24a	5.51a	3.58c	3.91b	1.43c	1.48c	1.28c	1.25c	3.10a	44.63b	HT
MEAN	72.83	82.87	55.70	59.49	4.00	4.50	3.67	3.85	3.92	4.01	1.77	1.79	2.44	41.54	
CV	5.87	5.14	2.96	15.39	38.11	23.70	45.54	16.05	31.14	33.30	0.00	0.00	234.77	5.47	
S.E (0.05)	0.46	0.53	0.68	0.76	0.06	0.18	0.07	0.05	0.02	0.02	0.03	0.03	0.26	0.39	
Farm settlement															
ILE 1	74.82d	72.30d	3.67d	57.02d	4.43d	5.19d	4.80d	5.17d	6.73a	6.76a	1.67a	1.60a	2.13d	38.75d	MS
SW4	88.61c	85.42c	9.19c	75.00c	5.19c	5.78c	5.28c	5.64c	3.59b	3.64b	0.56b	0.50b	2.80c	50.07c	MT
SW5	122.21a	140.85a	8.32a	85.59a	5.82a	6.42a	4.94a	6.33a	1.32c	1.36d	0.38d	0.33d	3.73a	63.39a	HT
SW6	116.35b	135.36b	5.14b	81.98b	5.28b	5.83b	5.62b	55.99b	1.39c	1.40c	0.50c	0.47c	3.57b	58.34b	HT
MEAN	100.50	108.48	19.08	74.90	5.18	5.81	5.41	5.78	3.77	3.38	0.53	0.47	3.06	52.64	
CV	0.99	1.03	1.20	1.15	2.01	2.20	2.18	2.19	31.07	33.12	100.68	103.6	14.08	1.49	
S.E (0.05)	1.65	0.56	0.52	0.51	0.03	0.51	0.04	0.04	0.02	0.02	0.02	0.58	0.02	0.58	
Screen house															
ILE 1	56.44c	68.37c	6.09b	50.75c	3.63b	3.81c	3.45b	3.60c	7.61a	7.72a	1.78a	1.73a	1.055d	30.20c	MS
SW4	55.40d	66.69d	1.92c	45.98d	3.25c	3.52c	3.16c	3.42d	4.55b	4.56b	1.66b	1.62b	2.18c	29.29d	MT
SW5	66.24a	81.33a	3.22a	58.06a	4.26a	4.80a	3.83a	4.59a	1.18d	1.24d	0.19d	0.85d	2.94a	40.69a	HT
SW6	63.39b	76.95b	3.10a	54.79b	3.80b	4.53b	3.84a	3.83b	2.43c	2.48c	1.13c	1.10c	2.79b	37.4b	HT
MEAN	60.37	73.33	3.58	52.39	3.73	4.14	3.58	3.86	3.92	4.00	1.37	1.32	2.24	34.40	
CV	2.98	1.29	2.13	4.39	39.51	46.21	39.30	4.84	31.10	33.27	20.74	12.35	6.44	2.64	
S.E (0.05)	0.45	0.66	0.93	0.71	0.06	0.3	0.06	0.08	0.02	0.02	0.04	0.04	0.02	0.45	

Tolerance to Striga rating; 1-3= Highly tolerant (T), 4-6= Moderately tolerant (MT), 7-8= Moderately susceptible (MS), 9= Highly susceptible (S) PH = Plant Height, LL= Leaf length, LW= Leaf Width, SDM= Stem diameter, SDR= Striga damage rating, SEC= Striga Emergence Count ,WAP= Weeks after planting, GY= Grain yield, FW= Field weight

Table 2: Effect of AMF species on maize agronomic and yield related characters under mycorrhiza and striga interactions

Mycorrhiza species	Number of Leaves per Plant	Husk Cover	Plant Aspect	Plant Harvest	Ear Aspect	Ear Harvest	Grain yield (kg)	Field weight (kg)
Glomus mosseae	10.22d	3.58d	3.63d	3.56d	3.57d	3.55d	2.11d	40.79d
Glomus clarum	11.80a	1.26a	1.24a	1.19a	1.32a	1.29a	3.64a	74.29a
Gigaspora gigantea	10.97c	2.44c	2.46b	2.38c	2.47c	2.43c	3.10c	42.38c
Glomus deserticola	11.15b	2.14b	2.54c	2.28b	2.26b	2.18b	3.48b	66.08b
Control	8.37e	4.05e	3.99e	4.12e	3.89e	4.14e	1.02e	23.62e

Each value is the mean for 3 replicates. Means with the same letter in the same column are not significantly different at $P< 0.05$ using Duncan's Multiple Range Test (DMRT).

Table 3: Effect of AMF species on striga related characters of maize under mycorrhiza and striga interactions

Mycorrhiza species	Striga Damage Rating		Striga Emergence Count		Plant Stand	Stalk Lodging	Root Lodging	Ear Rot	Stalk Rot
	8WAP	10WAP	8WAP	10WAP					
Glomus mosseae	2.70d	2.64d	1.78d	1.65d	3.59d	3.57d	3.51d	3.58d	3.75d
Glomus clarum	1.28a	1.21a	0.38a	0.35a	1.24a	1.21a	2.15a	2.27a	2.31a
Gigaspora gigantea	1.42c	1.50c	0.85c	0.83c	2.88c	2.46c	2.40b	2.85c	2.71c
Glomus deserticola	1.40b	1.35b	0.78b	0.67b	2.57b	2.12b	2.50c	2.42b	2.39b
Control	3.96e	4.10e	3.98e	3.99e	4.31e	4.25e	4.18e	4.46e	4.39e

Each value is the mean for 3 replicates. Means with the same letter in the same column are not significantly different at P< 0.05 using Duncan's Multiple Range Test (DMRT).
WAP - Weeks after planting.

DISCUSSION

The observed effect of AMF showed that *G. clarum* performed best for all the variants followed by *G. deserticola*, *G. gigantea* and *G. mosseae*, while the least performance was recorded for control. ART-98-SW5-0B and ART-98-SW6-0B could serve as promising sources of tolerant gene for the development of tolerant genotypes. This confirms the report of Olakojo and Olaoye (2007). The significant performances of ART-98-SW5-0B and ART-98-SW6-0B genotypes with respect to plant height, grain yield, field weight, stem diameter and SDR were contributing component to the yield and striga tolerant in maize as similarly observed by Olakojo *et al*. (1999).

Reduction in plant height of ILE1-OB and ART-98-SW4-OB could be associated with striga damage as earlier reported by Olakojo *et al*. (2001) and Badu-Apraku *et al*. (2008) on other maize varieties. Therefore, yield and striga-related traits indicate variations in the performance of maize genotypes. The significant increase in growth and yield related characters of maize could be due to positve interactions between the plant and AMF. This supported the view of Mohammad *et al*. (2003), Reider, (2003) and Salami *et al*. *(*2005). Therefore, AMF should be combined with host-resistance approach in Integrated Striga Management.

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AUTHORS' CONTRIBUTIONS

Striga lutea and maize genotypes which were obtained from IAR&T were monitored and supervised by Dr S.A. Olakojo while, arbuscular mycorrhizal fungi were collected from the soil biology unit of the department of Botany and Microbiology under the authority and supervision of Dr A.C Odebode and Dr A. Adesoye.