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Management of Striga Hermonthica (Del.) Benth in Upland Rice: Influence of Upland Rice Varieties and Rates of Nitrogen Fertilizer

M. A. Adagba[1], [S]. T. O. Lagoke[2] and A. Usman[1]

1. National Cereals Research Institute Badeggi, P. M. B, 8, Bida, Nigeria

2. Department of Crop Production University of Agriculture, Abeokuta, Nigeria

ABSTRACT

The effects of different rates of Nitrogen (0, 30, 60, 90 and 120 kg N/ha) on the reaction of five (FARO 46, FARO 11, FARO 45, FARO 48 and FARO 38) and seven (FARO 46, FARO 11, FARO 45, FARO 48, FARO 38, FARO 40 and WAB 56-50) varieties of upland rice were studied in field trials conducted in both the dry and wet seasons of 1997 and 1998. The trials ware laid up in split plot design with three replications. The upland rice varieties formed the main plot treatments while the nitrogen levels were the subplot treatments. FARO 40 and WAB 56-50 did not support Striga emergence, and thus exhibited resistance to Striga hermonthica. FARO 48, a variety normally susceptible to *S. hermonthica*, supported delayed and low Striga emergence, exhibiting enhanced resistance. In spite of support for early and high Striga infestation, FARO 11 exhibited tolerance. All other varieties FARO 45, FARO 46 and FARO 38 exhibited susceptibility to S. hermonthica. In the study, the application of 90 and 120kg N/ha delayed and reduced Striga emergence on the crop, induced low crop reaction score which resulted into grain yield that were the maximum or significantly higher than the least. The lower rates of nitrogen (30 and 60 kg N/ha), which caused similar Striga incidence however, resulted in significantly lower yield than 90 and 120 Kg N/ha. The interaction of upland rice varieties and nitrogen was significant on the number of days to first Striga emergence, crop reaction syndrome and number of days to 50% flowering of rice, indicating that host plant resistance alone may also not be adequate for Striga management in upland rice.

INTRODUCTION

The observation that Striga occurs mostly on infertile soils raises the probability that fertilizers might help to alleviate the Striga menace. Consequently repeated studies have been conducted on the effect of fertilizers on Striga incidence. Most results have shown that adequate nitrogen actually decreases Striga infestation (Adeosun, 1990; Lagoke *et a;* 1991; Agbobli, 1991; Magani, 1994; Ndikawa, 1996). Aflakpui *et al.* (1996) observed that Striga population declined with increased rate of nitrogen fertilizer in Ghana. Others have also indicated that nitrogen enhances crop tolerance to the parasite (Babiker, 1991; Adetimirin *et al.*, 1997). Although the role of nitrogen in reducing Striga infestation is not yet clear, one of the effects is to decrease exudation by host roots of Striga seed germination stimulants (Bebawi, 1987)

The published information regarding role of nitrogen in reducing *S. hermonthica* infestation in maize and sorghum are in plenty, but no information in respect of rice is available. This might be due to the fact that in the past *S. hermonthica* was not a problem on upland rice. Therefore the present investigation was undertaken to study the role of upland rice varieties and nitrogen fertilizer in the management of *S. hermonthica* in upland rice.

MATERIALS AND METHODS

The field trials were carried out in the dry and wet seasons of 1997 and 1998 at Samaru (11° 11' N; 07°38E). The soil has a sandy loam texture. Mean soil test values were pH = 5.05 (H_2O/soil 1:1), organic C = 11.65, total N = 0.74 g/kg, and available Bray^{-1} P = 2.2 mg/Kg. Exchangeable cations (mol/Kg) were Na = 1.01, K = 0.30, Ca = 2.95 and Mg = 1.0. The trials were laid out in a randomized split plot design with three replications. Five (FARO 46, FARO 11, FARO 45, FARO 48 and FARO 38) and seven (FARO 46, FARO 45, FARO 48, FARO 38, FARO 40 and WAB 56-50) varieties of upland rice formed the main plot treatments in 1997 and 1998, respectively. Five rates of nitrogen (0, 30, 60, 90, and 120 kg N/ha) constituted the subplot treatments. The upland rice varieties were selected based on their reaction to *S. hermonthica* in previous screen house and field trials (Adagba, 2000), as well as their popularity with the farmers in the Striga endemic areas. In the dry season, land preparation was carried out manually after the experimental areas were well soaked with pipe-borne water using garden hoses. The land was first turned in once using hand hoes; the plots were marked out and bonded. The plots were leveled by breaking the lumps of soil also using hand hoes. In the wet season, the land was ploughed disc harrowed and ridged. The plots were marked out and turned into basins to prevent the flow of the nitrogen fertilizer from one plot to another. The inner ridges were manually levelled, while the outer ridges served as bunds. Planting was done on the 6th and 11th April in 1997 and 1998 dry seasons, respectively and 29th and 24th June in 1997 and 1998 wet season trials, respectively. About 20 seeds of the upland rice varieties were initially planted per hill at a plant spacing of 25cm x 25cm. These were later thinned to ten plants per hill at 21 days after sowing (DAS). All the phosphorus (30 kg P_2O_5) and potassium (30 kg K_2O) as well as half of the nitrogen of the various rates were applied at 21 DAS using 15-15-15 compound fertilizer. Muriate of potash and single super phosphate followed by a top dressing with Urea (46%) at the appropriate rate at 60 DAS. To ensure soil Striga seed uniformity, the fields were inoculated before planting of rice by placing 3.0 g of inoculum mixture in each planting hole using a calibrated Scoop. Thus, ensuring approximately 3000 germinable Striga seeds/hill (Kirn, 1994; Magani, 1994). In the dry season all the plots were watered to field capacity with garden hoses during the first two months (April/May). Two hoe weedings were carried out at 14 and 28 DAS. Thereafter hand pulling of other emerged weeds was employed till harvest in order to prevent the removal of the emerging Striga plants. Data were collected on the number of days to first Striga emergence, emerged Striga shoot (infestation) crop reaction syndrome at 9 weeks after sowing (WAS), number of days to 50% flowering of rice and grain yield. The crop reaction syndrome was based on a 1-9 scale where (1) was assigned to plots with healthy plants and (9) to those with completely dead plants (Kim, 1994). All the data were subjected to analysis of variance for the test of significance and the treatment means were compared using the new Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

The upland rice varieties differed significantly in their support for Striga emergence as well as Striga infestation (Tables 1 & 2). Striga emergence was significantly delayed in FARO 45 compared with FARO 46 in the wet season of 1997, while in 1998 Striga emergence was significantly delayed in FARO 48 compared with FARO 45 and FARO 38 in the dry season. Similarly in the wet season of 1998, FARO 11 had delayed Striga emergence compared with all the other varieties evaluated. No Striga emergence was observed in WAB 56-50 and FARO 40 in the two field trials conducted in 1998. FARO 45 and FARO 38 obviously supported earlier emergence than FARO 48 in the two trials conducted in 1998. Nitrogen application only had significant effect in time of Striga emergence on upland rice in 1997 trials. Application of 60 kg N/ha to 120 kg N/ha in the dry season and 90 and 120 kg N/ha in the wet season delayed Striga emergence compared with no nitrogen control In the dry season trial of 1998 with the exception of FARO 40 and WAB 56-50 where no emergence occurred, all the varieties supported similar Striga infestation through out the crop life cycle (Tables 1 & 2). However in the wet season, among the varieties that supported Striga emergence FARO 45 supported lower Striga infestation than FARO 46 until harvest and FARO 38 at harvest only, while at 9 WAS all the varieties supported lower Striga infestation than FARO 46. The effect of nitrogen was only significant in 1998 with 90 kg N/ha in the dry season and all the nitrogen levels in the wet season causing lower Striga emergence on upland rice than no nitrogen control. The upland rice varieties also differed significantly in their reaction syndrome to Striga at 9 WAS in the two years (Table 3). FARO 48 in both years (1997 and 1998) as well as WAB56-50 and FARO 40 in both trials of 1998 consistently exhibited lower reaction syndrome than the appropriate maxima. In 1997 while all the other varieties exhibited similar reactions to Striga in the wet season, FARO 11 and FARO 38 also had lower scores than FARO 45 in the dry season. In 1998, FARO 45 and FARO 38 in the dry season and FARO 46 in the wet season trials had higher crop reaction scores than FARO 48, WAB 56-50 and FARO 40. In 1997 nitrogen application at 60 to 120 kg N/ha in the dry season and at all rates in the wet season of 1997 and the two trials of 1998 significantly reduced crop reaction syndrome to Striga infestation in upland rice compared with no nitrogen. The crop reaction syndrome of upland rice decreased with increasing levels of nitrogen up to 90 kg N/ha in the wet season trial of 1997. In 1998, application of 90 and 120 kg N/ha significantly reduced crop reaction syndrome of upland rice compared with 30 kg N/ha. The interaction of upland rice varieties and nitrogen rates on the cop reaction syndrome was significant in the wet season trials of 1997 and 1998.

Table 1: Effect of Nitrogen on the number of days to first Striga emergence and Striga shoot count at 9 WAS in upland rice varieties at Samaru 1997 and 1998

Treatment	No of days to Striga emergence				Striga shoot count at 9was[2]/m[3]			
	1997		1998		1997		1998	
Varieties	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
FARO 46	69.9	55.6b	45.7ab[3]	45.4bc	3.0	3.8ab	7.6ab	10.8a
FARO 11	78.7	59.3ab	47.3ab	50.8a	2.9	1.7b	10.9a	4.6bc
FARO 45	73.9	63.5a	40.8b	39.9d	5.0	1.1 b	12.0a	2.8cd
FARO 48	75.0	61.5ab	50.3a	48.5ab	3.5	1.1 b	4.6ab	3.7c
FARO 38	75.0	57.7ab	41.9b	43.1ed	4.0	5.0a	12.2a	6.7b
FARO 40			ne	ne			0.0b	0.0d
WAB 56-50	1		ne	ne			0.0b	0.0d
SED	6.16	3.09	3.99	2.29	3.27	1.84	4.61	1.02
Nitrogen								
(N)	67.5b	54.9b	42.3	44.9	2.9	2.7	8.9	5.9
0	70.2ab	57.3ab	43.1	45.1	2.4	2.3	7.8	3.5
30	77.1a	57.0ab	47.0	45.5	3.9	4.1	6.3	3.7
60	79.1a	64.5a	47.5	45.7	3.8	1.7	3.6	3.7
90	78.9a	64.0a	46.1	46.5	5.3	1.7	7.2	3.7
120kgN ha	4.23	3.75	2.85	3.40		1.51	2.64	1.19
SED								
Interactions								
V x N	NS	*	NS		NS	NS	NS	NS

ne = no emergence of striga
1 = not available during the season
2 = Weeks after sowing
3 = Means following the same letter (s) within a column are not significantly different at 5%level of probability (New DMRT)

Table 2: Effect of Nitrogen on Striga Shoot Count at 12 WAS and at harvest in upland rice varieties 1997 and 1998

Treatments	Striga shot count/6m^2 12 WAS 1^2				Harvest			
	1997		1998		1997		1998	
Varieties	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
FARO 46	3.5	10.9ab	13.1a3	22.8a	6.3	20.1ab	15.9a	26.8a
FARO 11	3.1	4.1bc	13.5a	12.0ab	6.3	9.7b	11.7a	15.5ab
FARO 45	5.1	3.7c	16.0a	7.5bc	10.2	8.1b	16.7a	9.7bc
FARO 48	3.4	4.9bc	6.1bc	13.0ab	7.5	10.3b	8.8ab	16.6ab
FARO 38	4.5	16.6a	14.6a	17.1ab	9.4	30.9a	12.5a	24.3a
FARO 40	0.0b	0.0c	-	-	0.0b	0.0c		
WAB 56-50	1	0.0b	0.0c	-	-	0.0b	0.0c	0.00
SED	2.74	4.55	5.88	5.93	3.59	5.75	5.78	7.78
Nitrogen								
(N)	3.1	7.5	12.0a	16.3a	7.0	13.8	12.6	17.9
0	2.7	8.1	10.0ab	10.2b	6.6	19.3	10.0	13.7
30	4.1	11.7	8.8ab	9.1b	8.5	21.3	10.0	11.0
60	4.1	6.1	5.6b	9.4b	8.1	13.7	6.5	11.9
90	5.5	6.8	8.9ab	6.6b	9.5	10.9	7.9	11.9
120kgN/ha	1.33	3.28	2.84	2.75	1.88	6.41	2.85	3.61
SED								
Interactions VxN	NS	NS	NS	NS	NS	NS	NS	NS

1= Not available during the season
2= Weeks after sowing
3= Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (New DMRT)

Striga infestation significantly affected the number of days to 50% flowering (Table 3). The number of days to 50% flowering was maximum on FARO 48 in all the trials and FARO 40 in the wet season trial of 1998, also FARO 40 was comparable to the maximum in the dry season trial of 1998. In the study, the application of 90 kg N/ha significantly reduced the number of days to 50% flowering compared with no nitrogen only. The interaction of upland rice varieties and nitrogen on the number of days to 50% flowering was significant in the wet season trial of 1998.

The rice grain yield also differed significantly among the upland rice varieties under Striga infestation (Table 4). In 1997 FARO 11 produced grain yield that was maximum in the wet season and comparable to the maximum with FARO 48 in the dry season trial. FARO 46 and FARO 45 in the two trials and FARO 48 in the wet season trial produced significantly lower grain yield than FARO 11 in the same year. In 1998 FARO 46, FARO 11 and FARO 45 however produced lower grain yield than the maximum with WAB 56-50 in the dry season trial, while only FARO 11 produced lower grain yield than FARO 40 in the wet season. Nitrogen had significant effect on upland rice grain yield in all the trials. In 1997 grain yield was significantly increased by the application of 90 and 120 kg N/ha in the dry season trial and increased with increased nitrogen levels in the wet season trial. In 1998 application of 120 kg N/ha significantly increased grain yield compared with all other rates of nitrogen and the no nitrogen in the dry season. In the wet season 90 and 120 kg N/ha significantly increased grain yield compared with 0 and 30 kg N/ha.

DISCUSSION

FARO 40 and WAB 56-50 exhibited resistance to *S. hermonthica*. The varieties produced grains that were the maximum or comparable to the maximum. FARO 48 also exhibited enhanced resistance in the study in 1997 with consequent higher grain yield than the least. Berner *et al* (1995) also observed large increases in productivity with delayed parasitism in sorghum. Similarly Johnson et al (1997) confirmed that resistant varieties of rice exhibited no to lower level of parasitism by Striga compared to susceptible cultivars. In spite of support for early and high Striga emergence, FARO 11 produced higher grain yield and thus exhibited tolerance only in 1997. FARO 38, FARO 46 and FARO 45 supported high Striga shoot count in spite of delayed emergence of Striga on FARO 38. The varieties also exhibited high crop reaction syndrome resulting into low rice grain yield. Thus indicating susceptibility to *S. hermonthica* even with application of nitrogen This suggests that nitrogen alone cannot be adequate for the management of the parasitic weed in the highly susceptible rice cultivars. In 1997, the grain yields obtained were lower than the grain yields of same varieties in 1998 in all the corresponding trials. This might be due to the fact that the intensive precipitation and soil moisture which occurred in the months of August and September in 1997 caused leaching of the applied nitrogen in the later sown crop, while in the early sown crop also of 1997, the rainfall was very erratic which predisposed the crop to Striga attach than in 1998. In the study the application of 90 and 120 kg N/ha resulted in grain yields that were comparable to maximum or significantly higher than the least. Although no significant differences in the Striga infestation were observed among the nitrogen rates 30 to 120 kg N/ha higher grain yields were obtained at 90 and 120 kg N/ha than the lower rates and no nitrogen. Aflakpui *et al* (1996) had also reported that the rates of nitrogen application did not influence the emergence of Striga, while Lagoke *et al.* (1997) confirmed that higher nitrogen levels merely improved the crop tolerance to Striga. Earlier emergence of Striga occurred at 0 kg N/ha. This is evident that upland rice under nitrogen stress will be more susceptible to Striga attack. Ejeta and Butler (1993b) had earlier reported that Striga has a favourable disposition for attacking crop already under nutrient stress. In spite of delayed emergence of Striga with increasing rate of nitrogen in the dry season trial of 1997 later than the corresponding rates in the wet season trial, Striga emergence was higher in the wet season trial in all the years of the study. The first planted trial experienced long period of drought at different intervals such that occasional watering was always done using a garden hose. The delay in the Striga emergence in 1997 might be due to low stimulant production from reduced root growth arising from insufficient moisture. The eventual higher emergence recorded however lends credence to the fact that Striga thrives best under modest drought stress, erratic, rainfall and or limited rainfall (Parker 1984; Lagoke et al., 1991; Ejeta and Butler 1993b). The midseason flood experienced at the peak of Striga emergence might explain the low infestation obtained in the later planted trials. The interaction of upland rice varieties and nitrogen rates was significant on the number of days to first Striga emergence, crop reaction syndrome and number of days to 50% flowering. The results indicate that susceptible varieties of upland rice require higher rates of nitrogen than the resistant varieties to exhibit the same level of resistance to Striga. FARO 38 exhibited susceptibility to *S. hermonthica*. In the study, the application of 90 and 120kg N/ha delayed and reduced Striga emergence on the crop, induced low crop reaction score which resulted into grain yield that were the maximum or significantly higher than the least. The lower rates of nitrogen (30 and 60 kg N/ha), which caused similar Striga incidence however, resulted in significantly lower yield than 90 and 120 Kg N/ha. The interactions of upland rice varieties and nitrogen was significant on the number of days to first Striga emergence, crop reaction syndrome and number of days to 50% flowering of rice, indicating that host plant resistance alone may also not be adequate for Striga management in upland rice.

Table 3: Effect of nitrogen on the crop reaction score and number of days to 50% flowering of upland rice varieties, 1997 and 1998

Treatment	Crop reaction at 9 WAS[2]				No. of days to 0% flowering		
	1997		1998		1997	1998	
Varieties (V)	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	
FARO 45	4.4a	5.0a	3.6a	3.5b	82. 1e	74. 1e	82.5e
FARO 48	2.1d	4.1b	2.4bc	3.5b	107.4a	102. la	104.7a
FARO 38	3.5bc	5.5a	3.5a	3.8b	87.9c	88.3c	89.7d
FARO 40			1.9c	2.0c		100.3ab	105.la
WAB 56-50	1-	2.0c	2.5c			76.4de	92.9c
SED	1.49	0.03	0.50	0.34	0.74	11.11	1.18
Nitrogen							
0	4.7a	6.7a	4.4a	5.2a	93.2a	87,9	94.3
30	4.1a	5.7b	3.1b	3.2b	92.3ab	88.0	94.4
60	2.9b	5.1c	2.8b	2.9bc	92.2ab	88.5	94.5
90	2.5b	4.4d	2.0c	2.3d	91.9b	88.4	95.1
120 kg N/ha	4.3d	1.6cd	2.5cd	92.0ab	88.1	95.3	
SED	0.38	0.22	0.29	0.24	0.49	1.03	0.68
Interactions							
V x N	NS	*	NS	*	NS	NS	*

1= Not available during the season . 2= Weeks After Sowing 3= Mea level as followed by the sai of probability (New ne letter (s) D:'.RT) within a column are not significantly different at 5%

Table 4: Effectof nitrogen on the grain yield of upland rice varieties under artificial field infestation by the striga hermonthica, 1997 and 1998

Treatments	Grain yield			
	1997		1998	
Varieties (V)	Dry season	Wet season	Dry season	Wet season
FARO 46	1643c	24 lc2		1166ab
FARO 11	2469ab	374a	2646bc	858b
FARO 45	1773c	216c	2257c	1735ab
FARO 48	2772a	186c	2813abc	1144ab
FARO 38	2170bc	315b	2781abc	1552ab
FARO 40			3316ab	1790a
WAB 56-50	1		3711a	1255ab
SED	259.5	42.76	400.44	374
Nitrogen (N)				
0	1635b	103e	1573d	515c
30	2117ab	188d	2173c	1175b
60	2164ab	261c	2740c	1487ab
90	2383a	358b	3491b	1827a
120kgN/ha	2528a	422a	4162a	1782a
SED	260.14	28.76	30.26	248
Interactions				
V x N	NS	NS	NS	NS

1= Not available during the season. 2= Means followed by the same letters within a column are not significantly different at 5% level of probability (New DMRT

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