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Testing of striga resistant composite maize varieties for response to two levels of nitrogen fertilizer up-take

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ABSTRACT

Trials were carried out using five composite maize varieties in *a Striga lutea* (Lour) endemic soil of Temidire-Eruwa, Oyo State, Nigeria, in 2004 and 2005. The composite maize varieties were tested under varied fertilizer types, Nitrogen (N) concentrations and artificial striga infestation. The objective was to test these striga resistant maize varieties for yield and agronomic performance under the above conditions. The result showed that, variety and year of evaluation differed significantly ($P<0.01$) for almost all agronomic characters such as plant stand, days to anthesis (silking and tasselling), plant and ear heights as well as root and stalk lodging resistance at both 100kgN and 200kgN/ha. Variety x Year interaction were also significantly different ($P<0.01$) for all agronomic characters except root lodging and husk tip cover. Fertilizer type differed only for days to silking, plant height and plant aspect, while Year x Nitrogen source and Variety x Nitrogen source was highly significant ($P<0.01$) for field weight. Plant stands were better in 2004 than 2005 for all varieties except Acr 97syn-W and DMR-LSR-W. The composite maize varieties tolerated high N-concentration except DMR-LSR-Y which do not utilize excess Nitrogen above 100kgN/ha. Use of striga resistant maize varieties concomitantly with Nitrogen fertilizer is recommended for farmers in *Striga lutea* endemic ecology, for higher grain yield.

Introduction

Maize is an important cereal crop in the farming system of tropical and subtropical Africa. It constitutes the bulk of the diet of people and livestock as a source of energy for survival and for growth. Maize is adaptable to almost all agro-ecologies of Nigeria where moisture is adequate for its growth (Olakojo and Olaoye, 2006). Among the major problems of maize production especially in the southern and Northern Guinea savanna is striga parasitic weed, a pest capable of reducing yields by between 30 and 70% and sometimes results in total crop failure especially in the endemic area of maize producing belts of Nigeria. Many workers had suggested various control measures for striga. These include: the use of nitrogen fertilizer (Igbinnosa *et al*, 1996; Kim, and Tanimonure, 1993 and Kim and Adetimirin, 1997, Olakojo *et al*., 2001), breeding for striga resistance crop genotypes (Kim, 1994; Ogunbodede and Olakojo, 2001; Olakojo and Olaoye, 2006; Olakojo and Olaoye, 2005; Olakojo and Olaoye, 2006) and the use of striga resistant genotypes in combination with adequate moisture supply(Olakojo and Olaoye, 2006).

Other suggested control measures include: cultural control method using manual hoeing, pulling of striga seedlings from the field before flowering and crop rotation using leguminous crops such as cowpea and soybean on maize fields in alternating years (Parkinson and Boxque-Perez, 1988). Use of suicidal striga germination or trap and catch cropping, whereby the striga seeds are stimulated to growth by planting susceptible host plant like sorghum and maize, striga seedlings, are then ploughed off before flowering with the susceptible host plant. This method is very effective at reducing striga seed density in the soil if practice for at least three consecutive years (Bashir, 1987).

Our experience at Moor Plantation, however, shows that integrated control method seems to be the best. The present study therefore made use of both resistant host plants and nitrogen fertilizers to assess yield performance of maize under artificial striga infestation and varied N-concentrations. The objective of the study therefore was, to test some striga resistant composite maize varieties under varied fertilizer types and N concentrations for yield and agronomic performance, with a view to making valid recommendation for control of *S.lutea* in Southern Guinea savanna of Nigeria.

Materials and methods

Inoculation and Planting of maize: Five composite maize varieties (Acr 97 syn-Y, Acr 97 sym-W, DMR-ESR-Y, DMR-LSRY and DMR-ESR-W) were selected and tested in Temidire, Eruwa, *Striga lutea* endemic area of Oyo State, Nigeria. Land preparation was done mechanically by ploughing, harrowing and ridging, using tractor. Seeds were planted in four-row plots of 3 x 5 meters at 75 x 50cm at 2 seeds per hill to obtain a plant population of 53, 333 stand/ha. Planting was done under natural infestation in a highly endemic soil. The 200kg N treated plots were directly opposite the 100kg N treated maize plots.

Design: The design was a factorial plot design of 5 x 4 where maize varieties was the main plot, having five varieties and four fertilizer types as sub plots. The evaluations were carried out under the two separate Nitrogen concentrations 100kg N (low) and 200kg N (high) per hectare. The nitrogen concentration was not taken as a factor, but as a treatment. The trial was carried out for 2 years (2004 and 2005) and was a Randomized Complete Block Design (RCBD) with 3 replications. NPK 15-15-15, Urea, urea +NPK, fertilizers were used while none fertilizer treated plot serve as control. They were applied at 100kgN and 200kg N/ha.

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Data taken : The following parameters were taken from the two middle rows of each plot: Plant stand, days to 50% silking and pollen shed, plant and ear heights (cm), root and stalk lodging, husk tip cover, plant aspect, (using a rating of 1-5, where 1=excellent and 5 =poor), plant harvest and field weight (kg/plot) according to Kim (1994). Striga related parameters were not taken into account because they have been assessed and reported earlier in another similar study.

Data analysis: Data were analysed using Mstat, to compute analysis of variance (ANOVA) and significant differences were determined at probability levels of 5 and 1%. Significant interactive means were separated using standard error at $P<0.05$, while differences in character means were determined at $P<0.05$.

Results

Table 1 presents mean squares (MS) for maize agronomic characters under varied fertilizer types (N) and concentrations. Years of evaluation differed significantly for all agronomic characters such as plant stand, days to silking, days to pollen shed, plant and ear heights as well as root and stalk lodgings for both 100kg N and 200kg N/ha at $P<0.05$ and/or 0.01. Variety (V) also differed significantly for maize agronomic characters at both levels of N- concentration except for plant aspect, root and stalk lodging, as well as husk tip cover which were significantly different from one variety to another. The magnitude of MS for plant and ear heights and plant stand were generally larger than the other traits. For example, year of evaluation recorded MS of 18302.70 and 9381.08 respectively for plant height under low and high N concentrations as against 18.4 each for stalk lodging at low and high nitrogen concentrations.

Response of maize varieties to nitrogen sources were significantly different for days to silking, plant heights and plant aspect at $P<0.05$ and 0.01 for low and high N concentrations. Year x Variety interaction was significant for plant stand, days to silking and pollen shed under 100kgN/ha, as well as ear height under 200kgN/ha. First order interactions of Year x Nitrogen were not significant for any of the agronomic maize characters at both levels of N-concentrations (Table 1).

Mean square (MS) for the interaction of variety x year for yield related characters are presented in Table 2. Years of evaluation were significantly different for plant harvest and field weight at both nitrogen levels with means of 896.53 and 1613.33 for plant harvest and, 11.49 and 2.38 for field weight at low and high N-concentrations respectively. Variety was significantly different for plant harvest and field weight only at 100kg/ha N concentration. Variety x year interactive means for these two characters were also significant at low (100kg/ha N) concentration, significant field weight was obtained at high level of N. Similarly, Year x Nitrogen source and Variety x Nitrogen source were significant for field weight at low N-concentration (Table 2). The MS magnitudes of plant harvest were fairly larger than that of field weight in all sources of variation assessed. Second order interaction of Y x V x N were not significant for either of these two yield characters.

Table 3 presents the interactive means of variety x year interaction for maize agronomic characters. Varieties differed significantly from one year of evaluation to another for plant stand, days to silking, days to pollen shed and ear height at $P<0.05$. Plant establishment count (plant stand) were generally better in year 2004 compared to 2005, in all varieties except for Acr 97 Syn-W and DMR-ESR-W with higher plant stand in year 2005 than 2004. In year 2004, Acr 97 Syn-W recorded plant stand of 15.00 compared to 18.0 in 2005, similarly, DMR-ESR-W recorded 17.6 in 2004 compared to 22.8 in 2005. Days to silking was generally longer in year 2004 compared to 2005 in almost all varieties ranging from 50.0 to 59.6 in 2004 and 49.5 to 56.5 in 2005. DMR-LSR-Y was however, found to be responsible for the significant differences in its ANOVA, with 59.6 days to silking in 2004 as against 54.7 in 2005. In the same vein, days to pollen shed varied for DMR-LSR-Y in the two years. While it took 61 days for pollen to shed in 2004, this was reduced to 53.7 days in 2005 (a difference of 7.6 days). Acr97 syn-W was also found to be responsible for significant differences observed in these maize varieties for ear height with a mean of 65.1cm in 2004 compared to 64.2 in 2005 All other varieties tested recorded significantly higher ear heights in 2005 compared to 2004 (Table 3) except DMR-LSR-Y with a slight decrease in ear height in 2005. Across variety means were generally higher in 2004 for all agronomic characters with 22.4, 54.0 and 54.3 for plant height, days to silking and days to pollen shed respectively.

Interactive means of Nitrogen x year for ear aspect are presented in Table 4. Mean ear aspects for all varieties were generally favoured by NPK in year 2005 by nitrogen from all sources with reduced ear aspects of 2.5, 2.2 and 2.3 for NPK, Urea and NPK + Urea in 2004 as against 2.24, 2.3 and 2.24 in year 2005. It was also observed that DMR-LSR-Y Acr 97syn-W and DMR-ESR-W were better utilizers of nitrogen for improved ear aspect. The two recorded generally low ear aspects when supplied with urea and the mixture of the two especially in 2005 compared to other varieties. Character means of *S. lutea* tolerant maize varieties under varied fertilizer types and concentrations are presented in Table 5. Maize varieties treated with 200kg N/ha generally established better than those treated with 100kg N/ha with a mean plant stands of 22.87 compared WITH 22.40 TO 100 kgN. Days to 50% silking and pollen shed also differed significantly at $P<0.05$ for both N concentrations. Plant and ear heights differed significantly for the two levels of N. Values obtained from 200kg N/ha were generally higher than those obtained from 100kg N. The reverse was, however, the case in DMR-LSR-Y for these two traits. Stalk lodging resistance were generally better under 200kgN than 100kgN in all varieties of maize tested. Lodging resistance was reduced to 0.85 in 100kg N and to 0.66 in 200kgN across varieties at $P<0.05$ (Table 5).

Table 6 presents character means for *S. lutea* resistant maize varieties for plant harvest and field weight. Plant harvests were generally higher for 200kgN in three varieties than 100kgN meanwhile in DMR-ESR-Y and DMR-LSR-Y, it was slightly lower compared to 100kgN, but not at significant threshold. Plant harvest ranges from 11.75 to 18.45 for 100kgN and 13.16 to 17.66 for 200kgN in the tested varieties. In the case of the field grain weight, the composite maize varieties responded differently to varied levels of N. While Acr 97-Syn-Y, Acr 97 Syn-W and DMR-ESR-W recorded increased field weight with increase in N from 100 to 200kg/ha, DMR-ESR-Y and DMR-LSR-Y recorded relatively lower field weight as N concentration increases from 100kg to 200kg (Table 6).

Discussion

The results from the evaluation showed that year of evaluation as well as maize variety differed significantly for almost all agronomic characters at both levels of Nitrogen (100kgN and 200kgN/ha) concentrations. Similar, result was reported by Olakojo and Olaoye, 2006where interaction between fertilizer type and maize variety was highly $P<0.01$ significant for grain yield under striga infestation. Although other workers such as Vogt et al., (1991) and Olakojo *et al*., 2011) have reported on similar findings, farmers in striga endemic ecologies should make use of nitrogen fertilizer to enhance better performance of maize agronomic characteristics and more importantly grain yield.

Table 1: Mean square (MS) for maize agronomic characters of *Striga lutea* tolerant maize varieties under artificial striga Infestation, fertilizer types and N concentrations.

Source of variation	DF	Plant stand	Days to silking	Days to pollen shed	Plant height	Ear height	Plant aspect	Root lodging	Sta1k lodging	Husk tip
Replicate (R)	2	448.93	44.12	16.24	3421.9	2513.26	1.25	3.80	0.11	0.83
		(505.08)	(17.43)	(23.25)	(4711)	(1351.27)			(5.16)	
Year (Y)	1	112.13*	16.13**	31.00**	18302.70**	(2548.40**	1.00	7.0*	18.40**	0.01
		(40.83)	(13.33**)	(1.41)	(9381.08**)	(816.40*)			(18.4**)	
Variety (V)	4	514.84**	1782.80**	230.36**	2017.11**	399.28*	0.22	2.67	1.03	0.17
		(414.49**)	(244.12**)	(172.97**)	(2568.05**	(981.59**)			(0.65)	
Y x V	4	290.78**	269.20**	94.69**	168.28	297.78	0.22	2.69	1.03	0.36
		(261.62**)	(43.12**)	(54.80**)	(790.82)	(664.05**)			(1.38)	
Nitrogen source (N)	3	0.13	9.20**	0.18	1211.94*	398.40	0.83*	0.94	0.18	0.07
		(4.67)	(1.26)	(0.67)	(218.74)	(92.23)			(0.16)	
Y x N	3	0.13	9.20	0.18	343.50	10.54	0.83	0.34	0.18	0.18
		(4.69)	(1.26)	(0.67)	(141.07)	(285.76)			(0.16)	
V x N	12	1.44	29.46	3.98	454.00	130.31	0.17	0.96	0.17	0.17
		(6.80)	(2.55)	(2.84)	(314.49)	(188.79)			(0.39)	
Y x V x N	12	1.45	29.46	3.98	120.11	74.33	0.15	1.05	0.17	0.26
		(6.80)	(2.55)	(2.84)	(281.24)	(171.88)			(0.3A)	
Error	78	26.89	251.78	2.85	430.4	160.61	0.29	1.49	0.62	0.28
		(43.88)	(2.90)	(3.95)	(378.23)	(188.32)			(0.48)	
Total	119									

*, ** Significant at P<0.05 and 0.01 respectively

+ Figures in parenthesis are for 200kgN while those outs of parenthesis are for 100KgN.,DF=Degree of freedom

Table 2: Interactive means of variety x year interaction for maize yield characters.

Source of variation	DF	Plant harvest	Field weight
Replicate (R)	2	893.02	0.15
		(751.40)	(0.23**)
Year (Y)	2	896.53**	11.49**
		(1613.33**)	(2.38**)
Variety (V)	1	147.51**	0.50**
		(64.83)	(0.03)
V x Y	4	120.26**	0.44**
		(103.16)	(0.55**)
Nitrogen source (N)	3	3.08	0.12
		(7.87)	(0.04)
Y x N	3	9.22	0.24**
		(3.22)	(0.06)
V x N	3	6.29	0.09**
		(11.62)	(0.09)
Y x V x N	12	8.39	0.08
		(8.63)	(0.03)
Error	12	36.30	0.08)
	78	(51.21)	(0.23)
Total	119		

*, ** Significant at P<0.05 and 0.01 respectively

+ Figures in parenthesis are for 200KgN, while those outs of parenthesis are for 100kg N. DF is the degree of freedom.

Table 3: Interactive means of variety x year interaction for maize agronomic characters

Variety	Plant stand		Days to silking		Days to pollen shed		Ear height(cm)	
	2004	2005	2004	2005	2004	2005	2004	2005
Acr 97syn-Y	19.0	18.1	54.3	56.5	55.3	55.5	68.5	73.4
Acr 97syn-w	15.6	18.0	54.6	55.4	55.6	54.0	53.0	69.2
DMR-ESR-Y	30.3	27.1	51.3	50.3	50.0	52.5	59.5	73.0
DMR-LSR-Y	29.3	16.3	59.6	54.7	61.3	53.7	65.1	64.2
DMR-ESR-W	17.6	22.8	50.0	49.5	49.3	50.7	55.0	67.4
Mean	22.4	20.0	54.0	53.3	54.3	53.3	60.2	69.4
S.E (0.05)		0.66		0.2		0.2		1.63

Table 4: Interactive means of Fertilizer type x Y interaction for ear aspects

Variety	N.P.K.		Urea		NPK+Urea		Control	
	2004	2005	2004	2005	2004	2005	2004	2005
Acr97syn-Y	3.0	2.3	2.0	2.3	2.6	2.3	2.3	2.0
Acr97syn-W	3.0	2.3	2.3	2.3	3.0	2.0	2.0	2.0
DMR-ESR-Y	3.0	2.3	2.0	2.6	2.3	2.6	2.3	2.3
DMR-LSR-Y	2.6	2.3	2.0	2.3	2.0	2.0	2.6	2.3
DMR-ESR-W	2.6	2.0	2.3	2.0	2.3	2.3	2.0	2.0
Mean	2.5	2.24	2.2	2.3	2.3	2.24	2.2	2.12
S.E (0.05)								0.06

Table 5: Character means for *Striga lutea* tolerant maize varieties under varied nitrogen concentrations

Variety	Plant stand		Days to silking		Days to pollen shed		Plant height (cm)		Ear height (cm)		Stalk lodging (1-5)	
	100kgN	200kgN	100kgN	200kgN	100kgN	200kgN	100kgN	200kgN	100kgN	200kgN	100kgN	200kgN
Acr 97syn-Y	18.54	22.12	55.58	55.45	55.41	54.95	163.37	168.91	70.95	76.75	0.83	0.66
Acr 97syn-W	16.83	22.08	55.50	55.04	54.87	54.20	144.83	152.50	61.12	68.12	0.58	0.87
DMR-ESR-Y	28.70	29.79	49.75	50.83	51.25	51.37	164.79	170.21	66.29	71.45	0.83	0.54
DMR-LSR-Y	22.83	21.45	58.25	57.20	57.54	56.91	156.62	152.71	64.71	62.42	1.16	0.45
DMR-ESR-W	20.25	18.62	48.08	49.79	50.04	50.33	146.95	147.81	61.21	61.37	0.87	0.75
Mean	22.40	22.87	53.43	53.67	53.82	53.55	153.32	158.44	64.85	68.02	0.85	0.66
S.E (0.05)	0.66	0.85	0.23	0.22	0.25	0.25	2.67	2.51	2.58	1.77	0.10	0.08

Table 6: Character means for yield related maize traits under varied N concentration.

Variety	Plant harvest		Field grain weight	
	100kgN	200kgN	100kgN	200kgN
Acr97syn-Y	13.75	14.42	0.75	0.82
Acr97syn-W	11.75	15.00	0.52	0.85
DMR-ESR-Y	18.45	17.66	0.91	0.82
DMR-LSR-Y	13.58	13.16	0.80	0.76
DMR-ESR-W	14.45	15.16	0.76	0.81
Mean	14.40	15.08	0.75	0.82
S. E. (0.05)	0.66	0.92	0.03	0.05

Maize varieties evaluated showed significant differences to different fertilizer types, especially for days to silking, plant and ear heights as well as plant aspects. This suggests that, the fertilizer types can be selected to influence these agronomic maize characters for grain yields. Olakojo *et al.*, (2001) reported that urea and sulphate of ammonia contributed significantly to maize field weight if striga resistant maize variety is used, while NPK and urea reduces significantly striga syndrome rating in susceptible maize varieties. Similarly, variety x Year interaction was significant for days to silking and pollen shed under low and high N concentrations. Farmers and agronomist may therefore influence days to silking and pollen shed under *S. lutea* infestation to a reasonable extent using ideal N concentration. Interactive means of Variety x Year further revealed that varieties of maize use performed differently for plant harvest and varieties to utilize prevailing climatic weather conditions for varied yield performances. This was further confirmed when across varietal means for both yield and agronomic traits were relatively higher in year 2004 than 2005. Olakojo *et al* (2004) had earlier reported that increase in moisture supply to maize plants under striga stress do significantly enhance higher yield. Meteorological data for this location shows that precipitation was relatively higher in 2004 than 2005.

DMR-LSR-Y and DMR-LSR-W were better N users for enhanced ear aspect. The two varieties recorded significantly lower ear aspect which was good for an improved maize variety, the lower the ear aspect, the better the maize variety. It was discovered that higher (200kgN/ha) N concentration on maize seedlings significantly enhances stalk lodging resistance. Stalk lodging resistance of 0.45 to 0.87 at 200 kgN/ha seems to be relatively better than that of 0.5 to 1.16 at 100kgN under striga infestation. Its therefore, implies that higher N concentration do not only enhance higher field weight, it also confers on maize better lodging resistance and ear aspect.

Conclusion

The composite maize varieties responded differently to vary N-concentration. Acr 97 Syn-Y and Acr 97 Syn-W as well as DMR-ESRY tolerated higher (200kgN/ha) N-concentration, hence could be applied at reasonable quantity to enhance higher field weight. DMR-LSR-Y on the other hand did not utilize excess of N concentration above the optimum of 100kg/ha, thus, should be discouraged. In fact, it reduces field weight by as much as 5%.

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