Tropical and Subtropical Agroecosystems, 7 (2007): 21-28

Tropical and Subtropical Agroecosystems

RESPONSE OF MAIZE (*Zea mays* L) TO DIFFERENT NITROGEN FERTILIZER FORMULATIONS UNDER *Striga lutea* (LOUR) ARTIFICIAL INFESTATION

[RESPUESTA DEL MAIZ (*Zea mays* L) CON INFESTACION ARTIFICIAL DE *Striga lutea* (Lour) A DIFERENTES FORMULACIONES DE FERTILIZANTES NITROGENADOS]

S.A. Olakojo[1*] G. Olaoye[2]

[1] Institute of Agricultural Research and Training, Obafemi Awolowo University P.M.B 5029, Moor Plantation, Ibadan, Nigeria.
[2] Department of Crop Production, University of Ilorin , Ilorin, Nigeria.
saolakojo@yahoo.co.uk or Saolakojo@excite.com
***** *Corresponding author*

SUMMARY

An experiment was conducted in the glass house of the Institute of Agricultural Research and Training of Obafemi Awolowo University, Moor Plantation, Ibadan, Nigeria in year 2000. The objective was to assess the response of maize to different fertilizer formulations under *Striga lutea* artificial infestation, and to test the efficacy of nitrogen fertilizer in controlling striga on maize. Six fertilizer types, two maize varieties and two infestation conditions were used. The analysis of variance resulting from the 2 x 2 x 6 factorial experiment showed that Nitrogen fertilizer type affected significantly striga rating, while infestation conditions had a significant impact on striga emergence count and ratings. Variety on the other hand affected significantly striga emergence count and rating, kernels/rows and maize grain yield. Similarly, fertilizer types x infestation condition as well as fertilizer types x variety both affected striga rating. The interactive effects of fertilizer types x variety for striga rating showed that N P K 20-10-10 and compost were not significantly different from one another, but differed significantly from those of calcium ammonia nitrate (CAN) and ammonium sulphate for the striga resistant hybrid maize. Fertilizer type x variety x infestation on the other hand showed that sulphate of ammonia was not a striga suppressing fertilizer but enhanced higher grain yield. NPK and CAN however, significantly reduced striga emergence count in the susceptible hybrid maize. Maize agronomic characters were also significantly different under different fertilizer formulations while resultant grain yield showed that, use of striga resistant genotypes in combination with nitrogen fertilizer may reduce striga infestation and consequently enhance grain yield.

Key words: Striga infestation, nitrogen fertilizer formulations, Striga count and rating, grain yield.

RESUMEN

Se condujo un experimento de invernadero en Nigeria durante el año de 2000. El objetivo fue evaluar la respuesta del maíz con infestación artificial de *Striga lutea* a diferentes formulaciones de fertilizantes y para probar la eficacia de la fertilización nitrogenada para controlar el striga en el maíz. Seis tipos de fertilizantes, dos variedades de maíz y dos condiciones de infestación fueron empleados en un diseño factorial 2x2x6. El tipo de fertilizante nitrogenado tuvo efecto significativo en el daño causado por estriga, mientras que las condiciones de infestación tuvieron efecto sobre la emergencia de estriga y el daño por estriga. La variedad de maíz influyó sobre la emergencia, el daño, el número de mazorcas y la producción de grano. Las interacciones tipo de fertilizante x condición de infestación y el tipo de fertilizante x variedad de maíz fueron significativas para el daño causado por estriga y mostraron que NPK 20-10-10 y la composta tuvieron efectos similares, pero diferente de los efectos observados con nitrato cálcico amoniacal (CAN) y sulfato de amonio para la variedad híbrida maíz resistente a estriga. La interacción tipo de fertilizante x variedad x infestación mostró que el sulfato de amonio no suprimió estriga pero incremento la producción de grano. NPK y CAN sin embargo, redujeron la emergencia de estriga en la variedad de maíz susceptible a estriga. La respuesta agronómica del maíz indicó que el uso de genotipos resistentes a estriga en combinación con fertilización nitrogenada podría reducir la infestación de estriga e incrementar la producción de grano.

Palabras clave: Estriga, infestación, fertilización nitrogenada, daño por estriga, producción de grano.

INTRODUCTION

Maize is an important cereal crop in Nigeria. It is widely consumed in various forms by teeming population as staple food and sometimes forms the major ingredient for breakfast and fast food recipes. Maize is grown in many parts of Nigeria cutting across the coastal lowlands, the mid-altitude and the Northern Guinea Savanna (NGS) where soil moisture and fertility are adequate for its survival. Maize grain yields in Nigeria varied from 0.8t/ha to 8.0t/ha depending on variety used, ecology, farming system adopted and management practice involved.

Although maize is naturally adaptable to almost all agroecological zones of Nigeria, several factors constitute to its low yield and productivity. These include lack of improved maize varieties, poor soil fertility, frequent drought events, prevalence of pests and disease of the tropical humid environment, as well as low input supply that can enhance grain yields.

Recently, striga parasitic plant pest was becoming endemic to many of the maize producing belts of Nigeria. For example, *Striga hermonthica* have been ravaging maize fields for some years back in the Northern Guinea Savanna (NGS) while *Striga lutea* is currently threatening maize production in the Southern Guinea Savanna (SGS). The effect(s) of striga infestation on maize is enormous, thereby reducing grain yields from 30-70% representing annual revenue loss of about US $ 7billion.

Some of the control measures suggested against striga infestation include application of cultural, biological and chemical methods, use of host-parasite resistance as well as the use of Nitrogen fertilizers. Although, inorganic fertilizers are not readily available because of the prohibitive costs in the open markets. Farmers in the striga endemic soils of Nigeria on the other hand, apply nitrogen fertilizer indiscriminately to maize without the usual soil testing to ascertain the type and dosage required (Igbinnosa *et al.*, 1992). This practice may not necessarily be injurious to plants but could constitute an inherent hazards to soil chemical composition and a waste of resources. Olakojo *et al.* (2001) have reported that varied nutrient status as well as indiscriminate use of different fertilizer formulations and/or concentrations are major problems that compound striga control in Africa.

It is therefore important to assess the effects of varied fertilizer formulations on maize under striga infestation. The objectives of this study therefore were: (i) To test the response of maize to varied fertilizer formulations under *S. lutea* infestation. (ii) To identify suitable fertilizer type for use in striga endemic areas and, (iii) To assess the efficacy of the use of nitrogen fertilizer in striga control.

MATERIAL AND METHODS

The trial was conducted in the glass house of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan in 2000. Plastic pots containing 5kg top soil were placed in glass house. Each pot was inoculated with about 44,000 germinable seeds of *Striga lutea* /pot (infested), while corresponding uninfested pots served as control. Striga seed extraction and inoculum preparation was done according to Berner *et al*., (1997). Each treatment consists of 10 pots of infested and non-infested plants. The treatments included six fertilizer types from different compound fertilizers viz: Urea, Calcium Ammonia Nitrate (CAN), NPK 20-10-10, sulphate of ammonia $(NH_4)2\ SO_4$. Compost (made from plant materials and crop residues) and zero fertilizer level as control. Two maize varieties (Tzpi 97 striga resistant and Tzi 9. Striga susceptible) and two striga infestation levels (striga infested and non infested plots) were used (2 x 2x 6). Planting was done 14 days after striga inoculation to allow striga to re-condition itself to the new environment. Two maize seeds were planted per pot, but thinned to one, one week after planting and was replicated four times in randomized complete block design.

Data taken included: Striga emergence count, striga rating using scale 1-9 where 1= normal plant growth with no visible symptoms, 2= Small and vague, purplish-brown leaf blotch, 3=Mild leaf blotching, with some purplish-brown necrotic spot. 4=Extensive blotching and mild wilting. Slightly but noticeable stunting and reduced ear and tassel size. 5=Extensive leaf blotching, wilting, and some scorching. Moderately stunting, ear and tassel reduction. 6= Extensive leaf scorching with mostly gray necrotic spots. Some stunting and reduction in stem diameter, ear size and tassel size. 7=Definite leaf scorching, with gray necrotic spots, and leaf wilting and rolling. Severe stunting and reduction in stem diameter, ear size, and, tassel size, often causing stalk lodging, brittleness, and husk opening at the late growing stage. 8= Definite leaf scorching with extensive gray necrotic spots. Conspicuous stunting, leaf wilting, rolling, severe stalk, lodging, and, brittleness. Reduction in stem diameter, ear size and tassel size. 9=Complete scorching of all leaves, causing premature death or collapse of host plant and no ear formation] according to (Kim, 1994). Other parameters were plant and ear heights (cm), flag leaf length (cm), kernel rows/ear and maize grain yield (t/ha). Data were analysed using SAS (1992) model to compute analysis of variance (ANOVA), while means were separated using the new Duncan Multiple Range Test (Duncan, 1955). Relationship between striga related parameters and fertilizer types as well as grain yield were assessed through regression.

RESULTS AND DISCUSSION

The effectiveness of nitrogen from fertilizer in control of striga had been reported by many workers including Andrew (1945); Last (1960); Parker (1976); and Vogt *et al*. (1991). The effect of fertilizer types in this study was significant for striga rating and maize grain yield, while the effect of infestation was significant for stirga emergence count and rating (P<0.01). Variety also affected significantly striga count and rating, kernels/rows, as well as maize grain yield. The first order interaction of fertilizer type x variety interaction was highly significant for striga count, striga rating and maize grain yield, while fertilizer type x infestation was only significant for striga rating and grain yield.

Fertilizer type x variety also affected significantly striga rating and maize grain yield. Similarly, fertilizer type x infestation x variety was significant only for striga rating (P<0.01) (Table 1). The influence of these three agronomic factors and their significant interactive effects suggests that they should be taken into consideration among other factors in the control of *S .lutea* for higher grain yield.

Table 1. Mean Square (MS) of ANOVA for striga related characters and agronomic traits of maize under different fertilizer types and striga infestation.

Source of Variation	Df	Striga count	Striga rating	Plant height	Ear height	Flag leaf length	Kernels/row	Grain yield
Replication	3	0.717n.s	0.158	373.87	73.92	68.95	6.19	43.76
Fertilizer (A)	5	1.416	0.427**	498.16	226.16	121.48	48.63	263.06*
Error A	15	0.672	0.083	609.57	221.19	98.31	17.66	60.82
Infestation (B)	1	23.651**	27.58**	1239.84	446.34	27.09	105.00	346.03
A x B	5	1.460	0.306**	1308.54	296.92	72.62	10.98	143.76**
Error (B)	18	0.679	0.067	721.71	190.32	124.89	17.39	46.17
Variety (C)	1	12.535**	0.552*	810.84	78.84	276.76	2481*	985.34**
Error C	1	25.021	0.040	7.59	29.86	173.34	6.72	656.6**
A x C	5	1.528	0.348**	798.49	192.23	53.04	8.78	541.33**
A x B x C	5	0.631	6.040**	1-27.04	129.58	42.22	5.11	100.54
Pooled	36	0.764	0.347	550.37	138.84	80.50	5.19	66.88
Error		30.30	13.77	16.53	18.46	34.36	31.36	31.27

*, **, Significant at 0.05, 0.01 probability levels.

Partitioning of the interactive effects of fertilizer type x variety for striga rating shows that the effects of NPK and compost were not significantly different from those of CAN and sulphate of ammonia for tolerant maize hybrid. CAN, NPK and compost on the other hand significantly reduced striga syndrome rating in the susceptible maize hybrid (Table 2).

Agbobli and Huguenin (1985) earlier reported that ammonia nitrogen ($NH4^+$) directly inhibits the attachment of *S. hermonthica* to seedling of the host roots. From this result, CAN and NPK may also be included in the list of striga suppressing inorganic fertilizer.

The interactive effects of fertilizer type x variety x infestation shows that sulphate of ammonia was not a striga suppressing fertilizer when striga tolerant is used. For the striga susceptible hybrid, however, only NPK and probably CAN significantly reduced striga emergence count (Table 3).

Adetimirin and Kim (1996) have recommended a dosage of 150kg N/ha for control of striga in maize plots. The use of NPK, Urea and CAN at this recommended dosage will therefore reduce striga infestation and possibly enhance higher grain yield.

Table 2. Interactive effects of fertilizer types x variety for striga rating under *S. lutea* infestation.

Fertilizer	Striga rating	
	Tolerant	Susceptible
UREA	1.41a	2.68ab
CAN	1.82b	2.55a
NPK	1.40a	2.54a
$(NH_4)2\ SO_4$	2.04b	2.78b
Compost	1.40a	2.57a
Control	1.41a	2.79b
Mean	1.58	2.65
S E	0.29	

Calcium Ammonia Nitrate (CAN), NPK 20-10-10, sulphate of ammonia $(NH_4)2\ SO_4$.
Values in the same column with different letters are significantly different at P<0.05

Character means for *S. lutea* and maize agronomic parameters are presented in Table 4 for infested and uninfested maize plants. Striga emergence count and ratings were significantly different from one fertilizer type to another under infestation. Similarly, maize plant height under striga infestation varied significantly from one fertilizer type to another, while other agronomic characters such ear height and flag leaf length varied from one fertilizer type to another under non infestation. This suggests that maize will perform differently under different fertilizer formulations with respect to its agronomic characteristics even under non striga infestation.

Sulphate of ammonia enhanced higher grain yield under fertilizer type x variety interaction for striga tolerant hybrid, while NPK and Urea significantly enhanced higher grain yield in *S. lutea* susceptible hybrid maize for similar interaction (Table 5).

Table 3. Interactive effect of fertilizer type x variety x *S. lutea* infestation on the tolerant and susceptible hybrids maize varieties.

	Tolerant variety (1-9)		Susceptible	Variety(1-9)
Fertilizer type	Infested	Uninfested	Infested	Uninfested
UREA	2.24a	2.83a	5.31c	2.24a
CAN	2.24a	2.24a	3.29ab	2.24a
NPK	2.80a	2.24a	3.80a	2.24a
$(NH_4)2\ SO_4$	4.03b	2.80a	3.92b	2.24a
Compost	2.24a	2.60a	4.01b	2.24a
Control	2.24a	2.34a	5.16c	2.24a
Mean	2.51	2.50	4.25	2.24a
S.E.		0.43		

Values in the same column with different alphabets are significantly different from one another at P<0.05

Table 4. Character means for *S. lutea* and maize agronomic traits under different fertilizer types.

Fertilizer type	Striga count	Striga rating (1-9)	Plant height (cm)		Ear infested height (cm)		Flag leaf length (cm)	
			Infested	Uninfested	Infested	Uninfested	Infested	Uninfested
Urea	16.60a	6.00c	153.38a	120.75a	70.89a	70.50a	28.50a	30.00a
	(0.00)	(0.00)	(152.0a)	(114.50a)	(69.25a)	(50.50b)	(33.62a)	(22.75b)
CAN	12.27ab	5.90	149.0ab	122.70a	67.70ab	55.50b	27.37a	25.75ab
	(0.00)	(0.00)	(144.25a)	(129.50a)	(66.25ab)	(53.00b)	(26.50a)	(26.75ab)
NPK	7.25b	5.80b	138.00ab	144.75a	67.00ab	61.25ab	26.60a	23.75ab
	(0.00)	(0.00)	(141.50a)	(121.50a)	(60.00ab)	(59.75b)	(26.37ab)	(23.50b)
$(NH4)_2S0_4$	6.40ab	5.60b	133.13abc	143.75a	65.81ab	57.75b	25.62a	29.25a
	(0.00)	(0.00)	(140.50a)	(154.25a	(60.50ab)	(59.75b)	(26.25ab)	(38.00a)
Compost	5.10ab	5.30b	128.25bc	150.50a	65.37ab	63.50ab	25.00a	21.25b
	(0.00)	(0.00)	(139.13a)	(156.25a)	(58.75ab)	(75.00a)	(23.62b)	(20.5b)
Control	3.60c	4.60a	117.63c	126.25a	56.00b	59.500b	23.00	27.50
	(0.00)	(0.00)	(1027.50a)	(149.75a)	(54.20b)	(73.00a)	(20.87b)	(25.50ab)
Mean	14.40	0.63	28.12	16.24	13.94	8.05	10.24	5.90
	(0.00)	(0.00)	(24.09)	(13.90)	(12.98)	(7.40)	(9.37)	(5.11)

Values in the same column with different letters are significantly different at P<0.05 .
Values in parenthesis are for the susceptible variety

Regression analysis showing the effects of fertilizer type on *Striga* emergence count is presented in Figure1a For striga resistant maize hybrid. Effects of fertilizer type were not clearly shown on striga emergence count. Urea on the other hand significantly enhanced higher striga emergence (20% higher than the control). Hence, may be used to achieve uniform infestation in crop screening exercise for striga tolerance. Figure 1b similarly presents regression analysis for the effects of different fertilizer types on striga syndrome rating, While Urea and NPK slightly reduced striga syndrome rating in the resistant hybrid maize, other fertilizer formulations did not contribute markedly to striga syndrome rating for both the resistant and susceptible hybrid maize.

Figures 2a and b show the maize yield trend under different fertilizer formulations and striga infestation. Maize yields increased significantly in striga resistant hybrid maize with application of sulphate of ammonia and urea. They contributed better to maize grain yield compared to other fertilizer types. For the susceptible maize hybrid, urea, NPK and sulphate of ammonia (in that order) enhanced higher grain yield. It was also observed that the susceptible hybrid maize possessed higher yield potential than the resistant. This might be associated to its parent inbreds which were bred originally for high yield and savanna adaptation.

Table 5. Interactive effect of fertilizer type x variety interaction for grain yield under *S. lutea* infestation.

Fertilizer type	Maize variety	
	Tolerant	Susceptible
UREA	13.25c	16.18b
CAN	9.78d	4.95d
NPK	14.78c	20.73a
$(NH_4)2\ SO_4$	19.32b	10.53c
Compost	14.35c	7.77c
Control	31.31a	4.19d
Mean	17.13	10.72
S.E.	0.20	

Values in the same column with different letters are significantly different at P<0.05

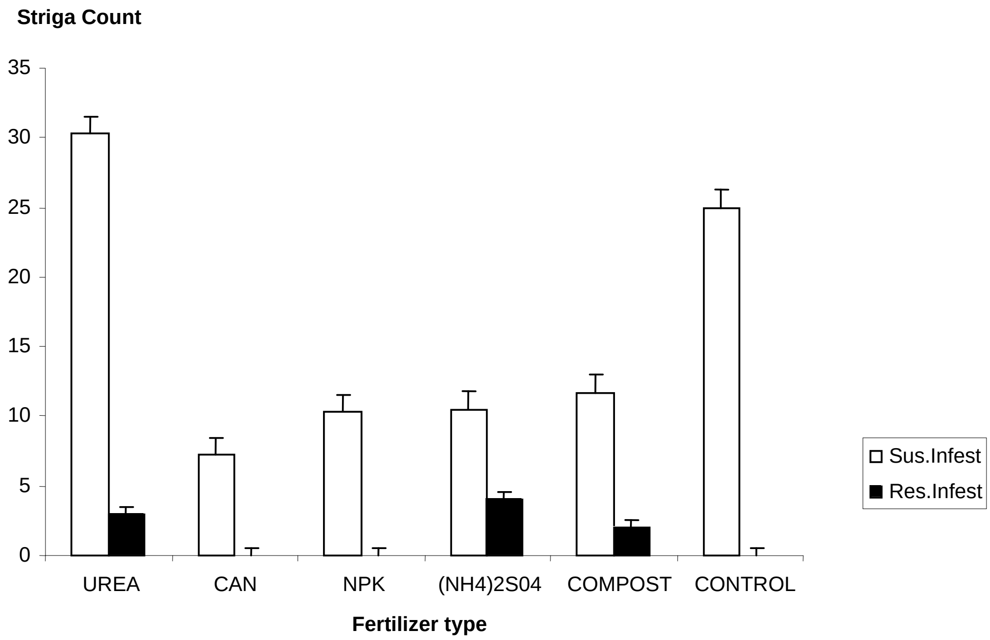

Fig. 1a: Effect of different fertilizer types on *Striga lutea* emergence in the resistant and susceptible maize variety.

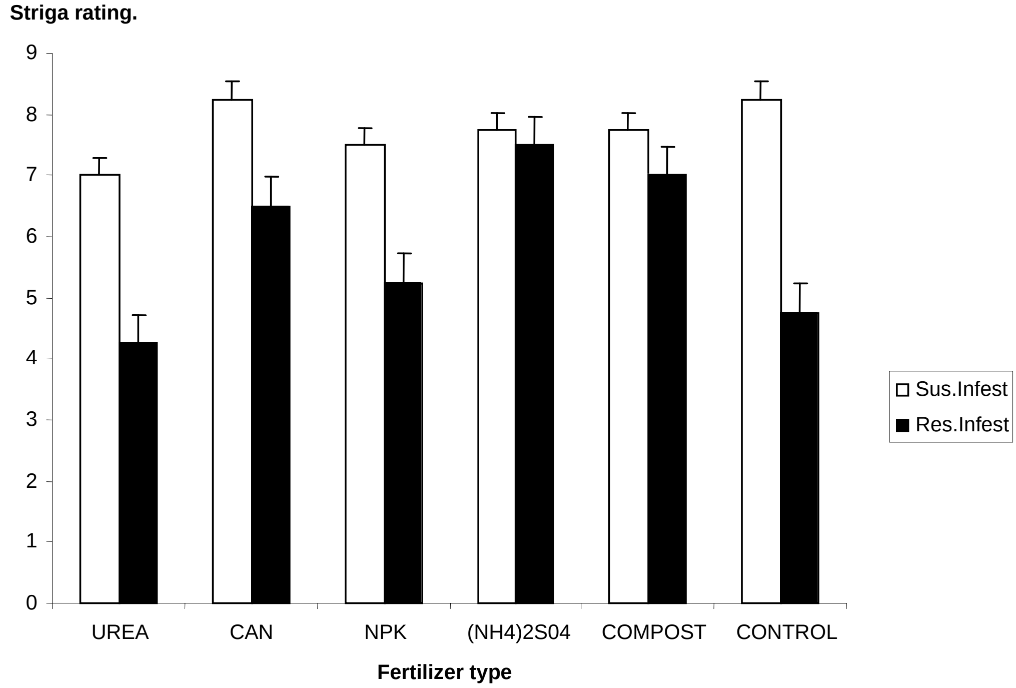

Fig. 1b: Effect of different fertilizer types on Striga syndrome rating in the resistant and susceptible maize variety.

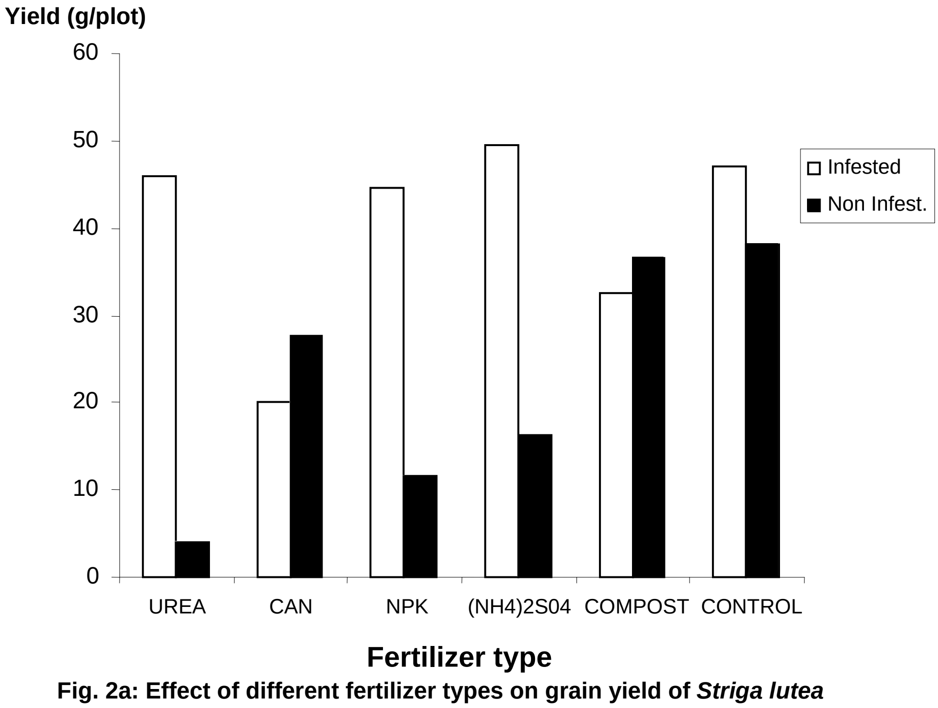

Fig. 2a: Effect of different fertilizer types on grain yield of *Striga lutea* resistant maize variety

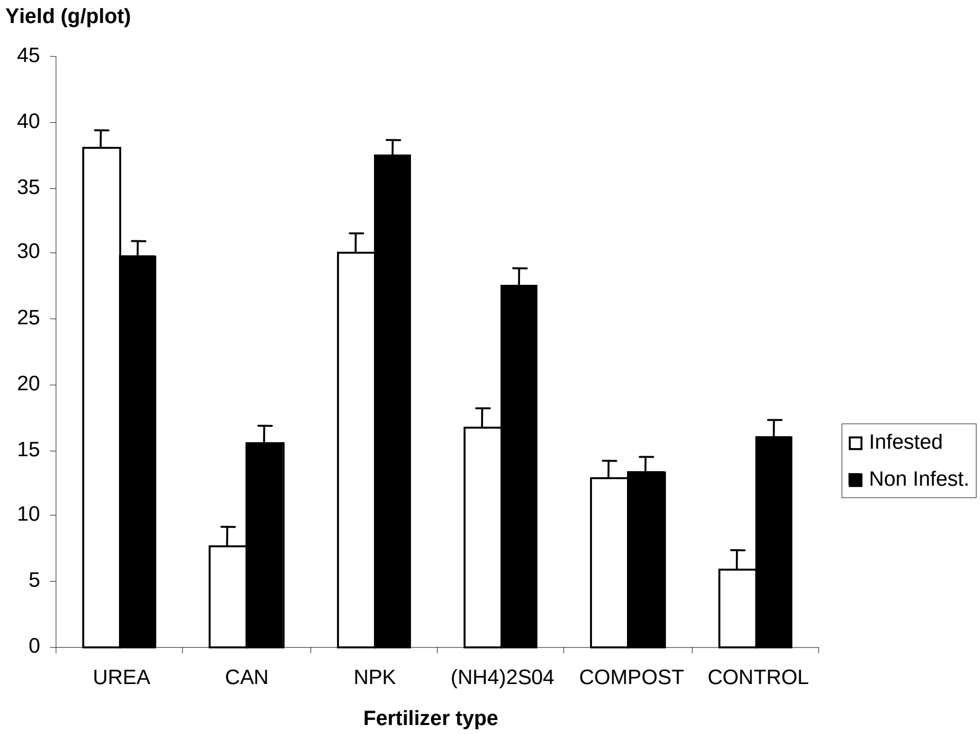

Fig. 2b: Effect of different fertilizer types on grain yield of *Striga lutea* susceptible maize variety

CONCLUSION

Combination of NPK and use of striga resistant maize genotypes will reduce striga infestation and consequently enhance higher grain yield. Prior confirmation by field studies, urea, NPK and sulphate of ammonia fertilizer may therefore be adopted by farmers in *Striga lutea* endemic areas especially when applied prior anthesis for higher grain yield. Farmers may adopt this technique as part of the integrated striga control method to boost maize production.

REFERENCES

Adetimirin V.O. and S.K. Kim 1996. Contribution of tolerance, resistance and nitrogen to striga control in maize. *In* B. Badu- Aparaku, M.O Akoroda , M Quedraogo and F. M. Quin (eds). Proceedings of a Regional Maize Workshop, held in May 28-June 2, 1995 at IITA, Cotonou, Republic of Benin pp 85-91.

Agbobli C.A. and B. Huegnin 1985. Evolution agronque du probleme parastesme du *Striga asiatica* sur maize dan le Sud Togo. In: H Che Weber and Forestuter (eds) Parasitic flowering plants. Yaunde, Camerun. Pp. 11-26.

Andrews F.W 1945. Parasitism of *Striga hermonthica* L. Benth on Sorghum under irrigation 1. Preliminary results and effect of heavy and light irrigation on striga attack. Annals of Applied Biology 32: 193-200.

Berner D.K, M.D Wilson, A.E. Awad, K.F. Cardwell, D Mohan Raj and S.K. Kim 1997. Striga Research Mothods – Manual , 2nd ed. June 1997, 1-15.

Duncan E.B. 1955. Multiple Range and Multiple F-test. Biometrics 11: 1-42.

Igbinnosa K.D. Cardwell F. and Okonkwo S. N .C 1992 . Effect of Nitrogen nutrition on germinated embryo of the giant witch weed. *Striga hermonthica* (Benth) cultured in vitro. Phytopthology. pp

Kim S.K. 1994. Genetics of maize tolerance of *Striga hermonthica.* Crop Science 34: 900-907

Last F.T. 1960. Effect of cultural treatments on yield of sorghum in Sudan. Field Experiments. Annals of Applied Biology 48: 207- 229.

M'boob S.S. 1986. A regional program for West and Central Africa In proceedings of the

FAO/OAU All-African consultation on Striga control. Yaounde, Cameroon pp168-176

Olakojo S.A. J.O.S.Kogbe, V. Olajide and A. Dohnell 2001. Host-parasite relationship of *Striga asiatica* and maize (*Zea mays* L) under varied moisture levels and Nitrogen sources, Nigeria Journal of Weed Science 14: 451-46.

Parker C. 1976. The influence of parasitic striga species on host crop sorghum and maize. Annals of Applied biology 83: 390 -394.

SAS Institute 1992. SAS Technical Report pp29 SAS/ STAT soft ware. Changes and Enhancement Release pp 289-359.

Vogt W., Sauerborn J., Honisch M. 1991. *Striga hermonthica*, distribution and infestation in Ghana and Togo on grain crops. In: Ransom J.K., Musselman L.J., Worsham A.D., Parker C. (eds.) Proc. 5th Int. Symp. on Parasitic Weeds, Nairobi, Kenya. Pp. 372-377.

Submitted November 15, 2004 – Accepted May 05, 2005
Revised received August 22, 2005