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Relationships Between Sources and Levels of Nitrogen Fertilization and the Control of *Striga hermonthica* in Sorghum

F.A. Showemimo
Department of Crop Science, School of Agriculture, University of Cape Coast, Cape Coast, Ghana

Abstract: *Striga hermonthica* has been identified as an economic parasitic weed affecting high grain yield production of sorghum in Africa particularly Nigeria. Seven sorghum varieties were evaluated for three years (1998-2000) in soil treated with *Striga* seeds using two sources of nitrogen fertilizer and at five levels of nitrogen to study their association in the control of *Striga*. The experiment was split-split plot with three replication having sorghum varieties as main plot, source of fertilizer as sub-plot and levels of N as sub-sub plot treatments. There were no significant differences among sources of fertilizer and their interactions. Levels of N and varieties were significant for all the traits ($p<0.001$). There was positive and significant association between levels of N applied and plant vigour, dry matter yield (shoot and root) $p<0.01$ and *Striga* count ($p<0.05$). The significant linear relationship obtained, recognized plant vigour, dry matter yield and *Striga* count as beneficial *Striga* resistance indicator. Between 50 to 100 ppm (when converted 110 to 170 kg of N ha^{-1}) is significant in the control of *Striga*. SK-5912, KSV-4, KSV-8 and NR71150 are potential sources of *Striga* resistance.

Key words: Regression, N-fertilization, *Striga*, control, sorghum

Introduction

Striga hermonthica is the most damaging species of *Striga* and it is native to Africa and does major damage to sorghum and millet especially in the Savanna and Sahel agro-ecological areas. The adverse grain yield effects on sorghum by *Striga* vary from 70 to 90% on improved cultivar while 40-50% for the local (Ramaiah, 1991; Elemo and Ogungbile, 1995; Showemimo, 2003, 2006; Showemimo and Kimbeng, 2005). In monetary term a conservative estimate of $950 million US is lost annually due to *Striga* menace in Nigeria, while more than 40% of arable lands in Africa are likely to be abandoned due to heavy *Striga* infestation (Lagoke *et al*., 1988).

Parasitic weeds virulence on host crops have been associated with soil fertility, the effect of N has been reported to affect sorghum-*Striga* co-existence. Parker (1984) reported that nitrogen fertilizer tend to reduce the production of stimulant by the host crop. In trials conducted at Samaru, Nigeria, nitrogenous fertilizer from 100 kg of N to 150 kg of N ha^{-1} reduced *Striga* infestation (Mansfield, 1982; Hamdoun and Babiker, 1989; Showemimo *et al*., 2002)

This study was carried out to obtain information on the association between two sources of nitrogen at different rates and their relevance in the control of *S. hermonthica* in sorghum.

Materials and Methods

Seven sorghum varieties adapted to the savanna agro-ecological zone were evaluated for three years (1998-2000) in the screen-house at Institute for Agricultural Research, Samaru, Nigeria for *Striga* control. Soil samples were collected from *Striga* free field; the soil samples were sun-dried, crushed and sieved through a 2.0 mm sieve. Initial soil Nitrogen content of 5.6% was assumed as described by Kowal (1968). Each pot contains 5 kg of soil thoroughly mixed with 0.5 g of *Striga* seeds collected in the previous year. Single Superphosphate and Muriate of Potash at the rate of 8 and 1.2 g, respectively, were added to each pot as basal fertilizers. Two sources of fertilizers (Urea and Calcium Ammonium Nitrate) were used each at five levels of N (0, 50, 100, 150 and 200 ppm).

Five seeds of each variety were planted in each pot and latter thinned down to two seedlings per pot. The trials were a split-split plot design with the seven sorghum varieties as main plot, sources of fertilizer as sub-plot treatments and levels of N as sub-sub plot treatments. The main plot treatments were arranged in a randomized complete block design with three replications. Each pot received equal amount of water throughout the trial. Data were obtained on plant vigour on a scale of 1 to 5, where 1 = least vigourous and 5 = most vigorous; plant samples were oven dried to a constant weight to obtain dry matter weight (shoot and root), *Striga* count data were subjected to square root transformation for analysis. Analysis of variance was done by general linear models procedure of SAS (SAS, 1988). Associations (correlation) and relationships (regression) were calculated as described by Gomez and Gomez (1984).

Results

Analysis of variance revealed non significant differences for sources of fertilizer, sources of fertilizer × levels of N, sources of fertilizer × varieties, levels of N × varieties and sources of fertilizer × levels of N × varieties. However, levels of N fertilizer and varieties were significant for all the traits, therefore, mean data of levels of N fertilizer averaged over sources and varieties and varietal performance averaged over sources of fertilizer and levels of N applied are presented in this study.

The most vigorous varieties under *Striga* infestation are KSV-4 (4.11), SK5912 (3.97), NR71150 (3.65) and NR71156 (3.04). KSV-4, SK5912 and NR71150 are clearly above overall mean plant vigor (Table 1). Dry matter shoot weight was higher in KSV-4, KSV-8 and SK-5912 compared with the other sorghum varieties evaluated in this study. While dry matter root weight was high for SK5912 (6.78 g), KSV-4 (5.11 g) and KSV-8 (5.04 g). *Striga* count was least for SK5912, KSV-4 and KSV-8, while L. 2123 accommodated the highest number of *Striga* 27.97 (Table 1).

In Table 2, nitrogen application influenced plant vigour with an average increase of 44.2% over control at 200 ppm, but no significant difference among plant vigour when N fertilizer is applied between 150 and 200 ppm. There was significant gradual increase in dry matter shoot weight as the level of N fertilizer increases. The least dry matter root weight was at the control and the highest; 6.53 g was at 200 ppm, no significant difference in root weight when N fertilizer was applied between 100 and 200 ppm. The least *Striga* count (4.11) was recorded at 200 ppm and no significant difference in number of *Striga* between 100 and 200 ppm of N fertilizer, the highest *Striga* count was at 50 ppm, thus, 46.6% decrease in *Striga* infestation.

Table 1: Mean performance of seven varieties of sorghum averaged over sources of fertilizer and levels of application

Variety	Plant vigour (1-5)	Dry matter shoot weight (g)	Dry matter root weight (g)	*Striga* count
SK-5912	3.97	35.01	6.78	7.24(2.68)
KSV-4	4.11	27.59	5.11	10.66(3.25)
KSV-8	3.26	27.66	5.04	11.23(3.33)
NR71150	3.65	25.04	3.57	15.12(3.87)
NR71182	2.81	24.77	2.88	19.00(4.32)
NR71156	3.04	23.89	2.39	23.81(4.87)
L.2123	2.66	23.17	2.09	27.97(5.27)
Mean	3.36	26.73	3.98	16.43
LSD (0.05)	0.35	3.16	1.21	3.69

Square root transformed values in parentheses

Table 2: Mean values for four resistance traits of *S. hermonthica* at different levels of fertilizer average over source and varieties

Level of Nitrogen fertilizer (ppm)	Plant vigour (1-5)	Dry matter shoot weight (gm)	Dry matter root weight (gm)	*Striga* count
0	2.85	7.51	2.44	6.61
50	3.57	9.66	4.59	9.42
100	3.79	10.96	4.87	5.03
150	3.81	13.34	5.62	4.38
200	4.11	12.01	6.53	4.11
Mean	3.63	10.70	4.81	5.91
LSD (0.05)	0.54	5.73	1.76	3.41

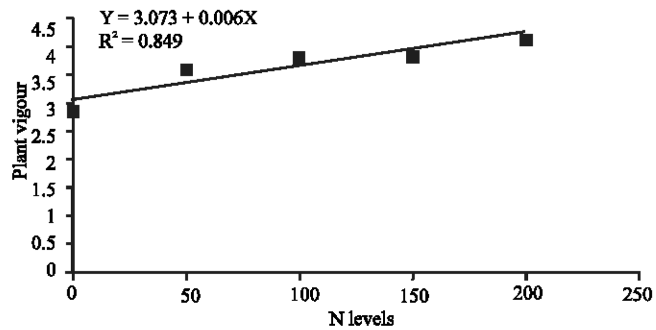

Fig. 1: The relationship between N levels and plant vigour across seven sorghum varieties

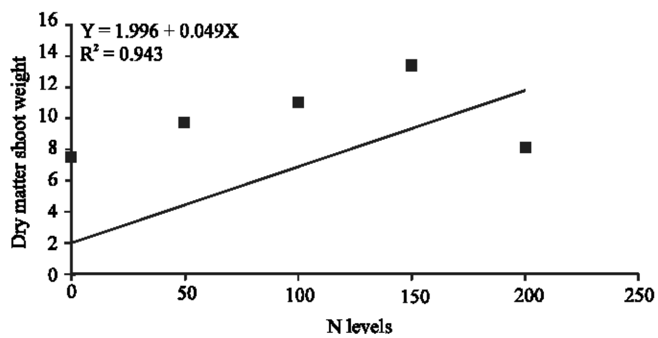

Fig. 2: The relationship between N levels and dry matter shoot weight across seven sorghum varieties

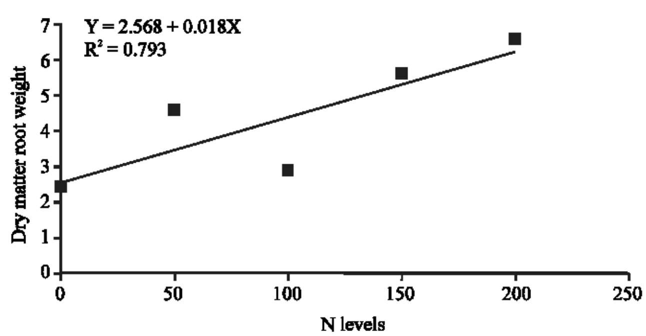

Fig. 3: The relationship between N levels and dry matter root weight across seven sorghum varieties

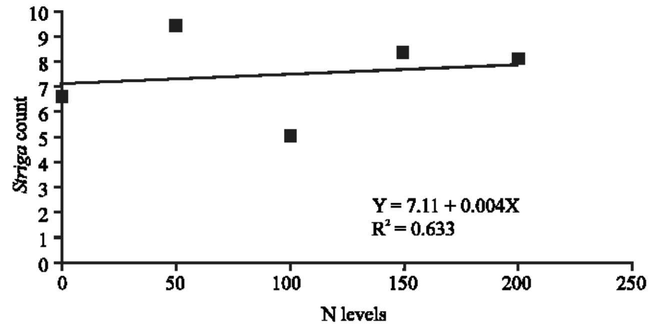

Fig. 4: The relationship between N levels and Striga count across seven sorghum varieties

Correlation coefficient (r) and coefficient of determination (R^2) between N levels and plant vigour (0.921 and 0.849) dry matter shoot weight (0.971 and 0.934) and dry matter root weight (0.891 and 0.793) were highly significant, while level of N was significantly correlated with *Striga* count (0.796 and 0.633). Positive and significant linear relationship between levels of N and plant vigour, dry matter shoot and root weight and *Striga* as measured by linear regression analysis are in Fig. 1-4.

Discussion

Genetic variability for resistance to *Striga* infestation is present among the sorghum varieties evaluated and the resistance was qualitatively expressed. Similar genetic variation in sorghum under *Striga* infestation had also been reported by Ramaiah (1991), Elemo and Ogungbile (1995). Showemimo *et at.* (1998), Showemimo *et al.* (2002) and Showemimo (2003).

The gradual increase in plant vigour, dry matter weight (shoot and root) as levels of N fertilizer increases is due to the responsiveness of the varieties to increase dosage of N fertilizer irrespective of the N sources. Good plant vigour and high dry matter weight are important criteria for selecting sorghum that are resistant/tolerant to *Striga* menace. This was further demonstrated by the significance of their association. Between 100 and 200 ppm of N, *Striga* count was significantly low, thus, the sorghum varieties were able to overcome the *Striga* competitiveness for nutrients. This finding was in agreement with those of Lagoke *et al.* (1988), Hamdoun and Babiker (1989) and Showemimo *et al.* (2002). The significant correlation indicated differential sorghum response to *Striga* and levels of N fertilizer. These observations collaborated with those of Hamdoun and Babiker (1989) and Showemimo *et al.* (2002) and Showemimo (2003).

The correlation (r), coefficient of determination (R^2) and linear regression results obtained in this study revealed that the traits studied are suitable screening criteria for *Striga* resistance. Therefore, level of nitrogen fertilizer from 100 to 150 ppm (approximately 110-170 kg of N ha^{-1} when converted) was appropriate for the control of *Striga hermonthica* in sorghum. SK-5912, KSV-4, KSV-8 and NR71150 posses some level of *Striga* resistance and responsiveness to levels of N to aid good agronomic performance under *Striga* infestation.

Conclusions

There is no significant difference in Nitrogen source; therefore, either Calcium Ammonium Nitrate or Urea could be used in the control of *Striga* on sorghum fields. A minimum of 110 kg of N ha^{-1} up to 170 kg of N ha^{-1} was appropriate to control the menace of *Striga* in sorghum. SK-5912, KSV-4, KSV-8 and NR71150 showed good resistance/tolerance to *Striga* infestation.

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