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EVALUATION OF DIFFERENT SORGHUM VARIETIES FOR STRIGA RESISTANCE IN NORTHERN NIGERIA.

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ABSTRACT

Field evaluation of 147 local and exotic sorghum varieties in the northern Guinea Savanna of Nigeria revealed the presence of germplasm imparting resistance to striga parasitization. Overall variety rating ranged from 1- lines such as KSV 12, SSV 3, 7-31, Bauchi local and 28-137 (highly resistant), through entries with 3 or below (resistant), 5 or below (intermediate or moderately resistant), to a high 6 and above for varieties such as 15-56, 61993, CK 60B, Yarwasha and 23-91(susceptible-highly resistant). Susceptibility to the weed pest was described using mean values over 2 years of eight easily observed characters, namely: days to 50% anthesis, days to maturity, plant height, number of tillers, number of heads, straw weight, seed color and 100-seed weight. All the characters except number of tillers, number of heads and seed color showed significant correlation (P=0.01) with striga damage. The possible role(s) of these characters in the resistance phenomenon and possibility of combining these features with high yields are discussed.

INTRODUCTION

Guinea corn or grain sorghum (Sorghum bicolor (L) Moench) is the staple food crop in most arid and semi-arid countries of sub-Sahara Africa and Asia. It Is the world's fifth leading cereal crop after wheat, rice, maize and barley in terms of production and utilization (Rooney & Murty, 1982).

In Nigeria, sorghum is one of the most important cereals crops grown for food, feed, fodder and as industrial raw material. Although its production is concentrated in the Guinea and Sudan savanna agro-ecological zones where it occupies 7 million hectares, sorghum accounts for about 60% of the total cereals production covering about 46% of the total land area devoted to cereal production thereby making Nigeria the leading producer of the crop in Africa (FAO 1990). However, subsistence sorghum yields are presently on the decline at a time when increase production is needed. This is attributed largely to the increasing problem of the parasitic weed, striga (Striga *hermonthica* Benth).

Striga devastation of sorghum and other field crops is such a serious problem that crop losses varying between 10-100% have been recorded a caused by the most important striga species. *Striga asiatica* (L) Kuntze, S. *hermonthica* Benth and S. *densiflora* Benth (ICRISAT 1978: Ramaiah & Parker 1982; Obilana *et al*. 1983). Several control measures designed to potecy sorghum fields from striga devastation have been either tried or proposed. These include the use of (chemical) herbicides, simple cultural and agronomic practices and resistant varieties (Ramaiah & Parker 1982; Singh *et al*. 1991). Although an integrated approach (Singh *et al*. 1991) using all control measures may be describe, there is no reliable alternative to the development and use of resistant varieties.

A striga plant can produce up to 90,000 seed which area easily disseminated by wind and water. Despite this tremendous number of seeds which can remain viable in the soil for up to 20 years, field screening of sorghum varieties for striga resistance is difficult as seeds may not be uniformly distributed in the field under natural conditions. This difficulty not with-standing, field tests are desirable fully to characterized the variation for the resistance quality and the chances for identifying markedly superior lines increase as the number of the lines tested increases (Townley-Smith & Hurd 1979).

A field study was therefore undertaken to evaluate diverse sorghum germplasm for resistance to the witchweed, striga. It was intended to identify prospective donors of this trait and to earmark them for a quick call-up in hybridization programmes aimed at sorghum crop improvement.

MATERIALS AND METHODS

One hundred and forty seven (147) sorghum varieties comprising 115 local unimproved varieties, 16 improved elite varieties, 9 breeders' experimental materials and 7exotic varieties from the International Crops Research Institute for Semi-arid Tropics (ICRISAT) were evaluated for striga resistance in 1989 and 1990 field tests at Bauchi, Nigeria.

The entries were sown in 5m long, single-row plots randomized in complete block and replicated three times. Necessary cultural practices were employed as and when due, and all entries were limited to 10 plants per row. The plants were left to natural striga infestation with no supplementary artificial field inoculation since the farm was located in an area with constant heavy incidence of striga. Weed control was through hand-hoeing and at the booting stage hand puling of weeds was carried out to save the emerging young striga seedlings.

Characters used for variety description and assessment are shown in Table 1. Most of the characters were described following the Revised Sorghum Descriptors (International Board for Plant Genetic Resources (IBPGR) & ICRISAT 1984). Time of flowering was recorded as the number of days from sowing to 50% anthesis. Plant height was determined by measuring the main stalk at 50% anthesis from the grounded level to the tip of the panicle. Other characters were recorded as an assessment of the whole plot. Harvesting was done after all the striga plants had bloomed and set seeds during which period all sorghum seeds were ripe and dry. The 1000-seed weight was determined at 12% seed moisture content by weighing 1000 seeds from each of the 10 plants of the plot. After threshing to remove the grains, straw weight was determined at 12% moisture content by weighing all the 10 plants of each plot. Striga infestation was determined by counting the number of striga plants on each row. The mean values of all characters over 2years were recorded and are given for 50 of the 147 varieties in Table 2. Correlation and multiple regression analyses were performed using data from all the 147 varieties to determine the relationship between the characters and striga damage (Table 3).

RESULTS AND DISCUSSION

Striga damage rating of 50 of the sorghum varieties tested is shown in Table 2. Data for all varieties tested are available from the author on request. Overall variety ratings ranged from 1 for lines such as KVS 12, SSV 3, 7-31, Bauchi local, and 28-137 with zero infestation (highly resistant), through entries and 3 or below (resistant), 5 or below (intermediately or moderately resistant), to a high of 6 and above for varieties such as 15-56, 61993, CK60B, Yarwasha and 23-91 (susceptible-highly susceptible).

Table 1. Characters used for variety description and ranking

Character type	Character description	Scores
Plant height (cm)	Short	1
	Medium	2
	Tall	3
Days from sowing to 50% anthesis	Very early	1
	Erly	2
	Late	3
	Very late	4
Days from sowing to Maturity	Very early	1
	Early	2
	Medium	3
	Late	4
	Very late	5
Tillering capacity (no.)	Very low	1
	Low	2
	Medium	3
	High	4
	Very high	5
Straw weight (kg)	Low	1
	Medium	2
	High	3
Number of heads	Very low	1
	Low	2
	High	3

	Very high	4
Seed color	White	1
	Yellow	2
	Red	3
	Buff (brownish yellow)	4
	Brownish black	5
1000-seed weight (g)	Low	1
	Medium	2
	High	3
Striga infestation	Zero infestation	1
	Very low	2
	Low	3
	Low-medium	4
	Medium	5
	Medium-high	6
	High	7
	High-very high	8
	Very high	9

Associated among the various traits illustrated in Table 3 revealed that all the characters except number of tillers, number of heads and seed color showed significant correlation (P=0.01) with Striga damage. This corroborates the earlier report (Tsivion, 1978) that number of tillers and heads did not appear to be influence by Striga damage.

A significant correlation between time of flowering (r=-0.027) and maturity (r= -0.067) and Striga damage indicated that generally varieties of short growth duration (early maturing genotype) had a higher striga damage than those of long growth duration (late maturing genotypes). However, a few early maturing varieties such as KSV 15 and SPV 359, were not adversely affected by striga attack (Table 2). This probably corroborates the report of Ramaiah & Parker (1982) that crop plants maturing during the rainy season appear to thrive well with minimum damage by striga. On the whole, the significant relationship observed in this study contradicts an earlier report by Musselman et al. (in press) that no significant correlation existed between plant growth duration and striga devastation. This discrepancy might be explained by an earlier report (Parker & Reid 1979) that correlation between the characters and striga damage might depend on the striga strain involved.

Table 2. Characters associated with striga resistance in grain sorghum varieties

Varieties	50% anthesis		Maturity		Plant height		Tillering Capacity	Number of heads		Straw Weight		Seed Colour	1000-seed Weight		Striga infestation	
	Means (days)	Score (1-5)	Means (days)	Score (1-5)	Mean (cm)	Score (1-3)	(1-5)	Means	Score (1-4)	Means (kg)	Score (1-4)	(1-5)	Means (g)	Score (1-5)	Means (no)	Score (1-9)
Group I																
KSV 4	74	2	96	2	120	2	2	22	3	13	2	3	20.4	3	67	8
KSV 12	67	2	88	1	90	1	2	16	2	14	2	3	34.3	2	0	1
KSV 15	63	1	90	2	115	2	2	12	2	13	2	4	24.0	3	19	3
S.32	92	4	110	3	101	2	1	4	1	11	2	3	17.7	4	67	8
S.35	73	2	93	2	164	3	2	14	2	23	3	3	31.9	2	11	3
SSV 3	98	4	115	4	67	1	3	11	2	26	3	2	25.6	3	0	1
SSV 6	91	4	111	4	71	1	1	8	1	18	2	2	24.5	3	1	2
SSV 10	86	3	96	2	150	3	2	7	1	12	2	1	22.4	3	22	4
SSH 3	73	2	96	2	31	1	2	5	1	7	1	3	20.6	3	83	9
SK 5912	71	2	96	2	45	1	1	13	2	20	2	3	19.0	4	16	3
Group II																
61592	75	2	89	1	128	2	2	21	3	15	2	3	26.6	3	60	8
62007	83	3	102	3	171	3	1	13	2	14	2	3	25.5	3	25	4
61738	76	2	90	2	106	2	1	7	1	21	3	1	23.5	3	118	9
61758	76	2	90	2	106	2	1	7	1	21	3	1	23.5	3	118	9
61987	80	3	99	2	104	2	2	14	2	11	2	3	22.4	3	68	8
61799	82	3	96	2	114	2	2	19	2	21	3	1	21.5	3	21	4
61993	85	3	95	2	98	1	2	10	1	16	2	2	21.9	3	126	9
61798	70	2	81	2	92	1	1	31	4	17	2	2	21.6	2	11	3
62024	72	2	94	2	89	1	1	5	1	12	2	2	21.5	3	95	9
Group III																
SAR-2	74	4	119	3	67	1	1	7	1	13	2	2	16.2	2	10	3
GAR-148	76	2	103	3	78	1	1	15	2	10	1	3	17.9	4	17	3
CK60B	64	1	93	2	71	1	2	13	2	8	1	2	23.8	3	68	8
SPV 359	49	1	63	1	74	1	2	6	1	15	2	3	14.0	4	9	2
20775	48	1	68	1	67	1	2	8	1	7	1	2	27.0	3	31	5
SWARNA	64	2	77	2	101	2	2	12	2	12	2	3	32.8	2	50	7
MALDANDI	49	3	61	1	141	3	1	4	2	10	1	2	14.9	4	61	8

Table 2. Continue

Varieties	50% anthesis		Maturity		Plant height		Tillering Capacity	Number of heads		Straw Weight		Seed Colour	1000-seed Weight		Striga infestation	
	Means (days)	Score (1-5)	Means (days)	Score (1-5)	Mean (cm)	Score (1-3)	(1-5)	Means	Score (1-4)	Means (kg)	Score (1-4)	(1-5)	Means (g)	Score (1-5)	Means (no)	Score (1-9)
Group IV																
27-125	70	2	87	1	109	2	2	19	2	13	2	2	17.0	4	103	9
7-23	70	2	94	2	107	2	2	17	2	12	2	3	43.7	2	39	5
7-31	71	2	97	2	151	3	2	16	2	25	3	2	41.1	1	0	1
20-76	73	2	97	2	150	3	2	13	2	15	2	1	35.6	2	15	3
7-29	80	3	90	2	124	2	3	14	2	19	2	1	29.6	3	6	2
7-33	65	1	90	2	138	2	2	19	2	11	2	2	24.1	3	113	9
27-127	61	2	93	2	104	2	2	20	2	25	3	2	36.8	2	0	1
16-60	83	3	98	2	115	2	2	9	1	12	2	3	24.1	3	70	9
15-56	63	1	91	2	128	2	3	15	2	23	3	1	33.2	2	45	6
15-54	69	2	98	2	111	2	2	13	2	7	1	3	38.3	2	140	9
22-89	63	1	57	1	144	3	2	25	3	20	2	4	26.1	3	30	5
26-99	64	1	92	2	123	2	2	13	2	13	2	4	37.7	2	14	3
YARWASHA	74	2	85	1	103	2	3	19	2	12	2	3	21.5	3	71	9
7-34	72	2	90	2	136	2	2	11	2	14	2	3	31.7	2	10	3
7-32	61	1	88	1	126	2	3	23	3	16	2	2	28.4	3	66	8
BAUCHI	82	3	89	1	190	3	2	17	2	18	2	1	30.0	2	0	1
LOCAL	62	2	89	1	140	3	2	14	2	12	2	2	34.0	2	71	9
26-102	65	1	92	2	123	2	3	25	3	11	2	4	29.4	3	9	2
22-88	71	2	97	2	95	1	2	7	1	13	2	2	19.4	3	113	9
27-128	66	1	81	1	142	3	1	18	2	15	2	4	32.8	2	48	6
27-137	58	1	74	1	190	3	1	35	4	21	3	2	23.1	2	100	9
9-39	40	1	65	1	107	2	2	8	1	11	2	2	29.7	3	0	1
18-67	75	3	91	2	110	2	2	22	3	19	2	2	34.4	2	19	3
22-83	77	3	94	2	81	1	1	8	1	27	3	4	26.0	3	0	1
28-137	69	2	86	1	143	3	2	17	2	14	2	1	24.7	3	127	9
23-91																

*Group I =improved/commercial varieties of interest; Group II=breeder's/experimental varieties; Group III=exotic (ICRISAT) varieties; Group IV=unimproved local varieties of interest

Table 3. Simple correlation among characters associated with striga damage

Character	Correlation +	Mean	Standard deviation
Striga score	-----	43.10	3.19
Days from sowing 50% anthesis	- 0.027**	67.89	11.40
Days from sowing to maturity	- 0.067**	82.69	13.40
Plant height (cm)	- 0.043**	131.15	48.82
Number of tillers	0.075	2.08	0.73
Number of heads	0.061	21.68	7.40
Straw weight (kg)	- 0.154**	1.31	0.59
Seed color	- 0.074	2.39	1.09
Seed weight (1000) (g)	- 0.244	29.48	7.1

+Correlation coefficient derived from 147 data values

**Significant at the 0.01 probability level

Plant height and straw weight showed a significant correlation with striga damage, indicating that tall varieties such as 61799 and 22-89 with high straw weights (2.1 and 2.0 kg respectively) were more resistant while dwarf varieties such as 61993 and 27-128 were more susceptible. This can be explained by the fact that tall varieties are land races while the short are improved varieties. The former obviously better adapted to co-evolved pests than the latter. Generally, the more crop plants become 'eaten', the more they grow thinner in size and this ultimately results in overall loss in weight. The varieties with inherently low dry matter (dwarfs) would therefore have a lower straw weight in case of striga devastation. However, some dwarf varieties (S.35, SSV 3 and SSV 6) were resistant to then attack and gave consistently high straw weights (2.3, 2.6 and 1.8 kg respectively) (Table 2). These are improved varieties with in-built striga resistance (Obilana *et al*. 1983; House 1985). It is pertinent to observed here that there is little evidence to pin-point the causes for the substantially pooper growth of infected sorghum plants and the substantial transfer to the parasite of host nutrients even after the striga plants are above ground and photosynthesizing (Williams 1959; Okonkwo 1966; Ismail & Obeid 1975). More work is therefore needed in this area to establish the parasitic relationship between the weed and its host in terms of nutrients distribution and utilization.

The use of the 1000-seed weight as a reliable index for yield determination in cereal food crops dried for safe storage to moisture contents in the range of 10-12% is well established (Eckebil *et al*. 1977; Ross and Kofoid 1978). The significant correlation between seed weight (r= -0.244) and striga damage (Table 3) indicated generally that susceptible varieties had low seed weights. This was manifest in resistant varieties such as 61798, 7-34 and Bauchi local with high seed weights of 31.6, 31.7 and 30 g respectively (Table 2). On the other hand, susceptible varieties, 27-125, Yarwasha and 9-39 had low seed weights (17.9, 21.5 and 23.1 g respectively). This observation supports an earlier report that lines with low yields are usually associated with 'striga sick' fields. However, some varieties such a 15-54, 7-32, 26-102 were able to support high infestation of the parasitic weed while still maintaining consistently high yields. Such varieties are considered tolerant. The implication of varieties tolerant of pest infestation is clear. Such varieties should be selected in breeding programme since they encourage the multiplication of pest.

Table 3 indicated that seed color showed no significant correlation (r=0.074) with striga damage. However, it is important to observe that susceptible lines such as 16-60, 15-54, Yarwasha and 27-137 had fully pigmented seed coats while the un - pigmented SSV 3, 7-31, 7-29, 27-127 and Bauchi local were highly resistant. This observation supports an earlier one (House 1985) that sorghum plants with brighter seed coats (white) were more hardened and more tolerant of striga attack than the lines with colored coats. As with the other characters discussed above there were obvious deviants in GAR-148, SPV 359, 26-99, 22-88 and KSV 15 with colored seed coats but still proved resistant. More work is therefore desirable fully to characterize the striga resistance quality *vis-à-vis* sorghum seed color particularly as pigmentation has been shown to play significant role in resistance of sorghum varieties to bird attack (Okonkwo & Kilishi 1990), heat tolerance in the common bean, *phaseolus vulgaries* (Okonkwo & Clayberg 1984) and probably in drought tolerance in grain sorghum (Okonkwo 1990).

The insignificant correlation (p=0.01) between number of tiller (r=0.075) and heads (r=0.060) and striga damage were not unexpected since tillering as a factor for yields becomes important only in crop (such as wheat) where each tiller produces a panicle. This is uncommon in grain sorghum.

It is important to recall the few inconsistencies in the characters considered to be associated with susceptibility to the weed pest. For instance, some early maturing genotypes were not susceptible as expected. Similarly some dwarf varieties resisted the attack better than the tall co-evolved local varieties, and so on. This shows the multi-character nature of resistance and implies that evaluation of striga resistance in grain sorghum based on a single factor can be misleading. However, multiple regression analysis indicated that in this study the major character which accounted for the highest proportion (r^2) of the variance in the level of striga damage is seed weight (r^2 =0.050). The other characters (r^2 =0.062) may be less important but no single factor is enough to confer full protection to any sorghum variety against the parasitic weed, striga.

Correlations among traits are of interest to the plant breeder because they indicate the correlated responses that may occur when single trait selection or index selection is practiced (Eckebil *et al*. 1977). In the present study many correlation were statistically significant (Table 3) indicating that simultaneous selection for high yield and striga resistance in a sorghum breeding programme is possible. However, the overall low r^2 value (r^2=0.112) suggests that in selection will be slow and that other morphological, physiological and bio-chemical characters may be involved in the resistance phenomenon (Ramaiah & Parker 1982) that relatively little work has been carried out on this parasite and several gaps exist in our knowledge of striga infestation yields losses in fields crops and the resistance phenomenon. Despite this, the result of this investigation revealed the presence of germplasm imparting resistance striga devastation. However, striga continues to be a serious threat because it thrives very well in the poor agronomic conditions faces by subsistence farmers and small holders in the arid and semi-arid tropics. Physical, agronomic and chemical methods of control will always be difficult because they are labor and capital intensive. The only method of control that will offer an effective long term solution is the development and use of resistant varieties. This calls for increased collaboration between research groups involving plants breeders, biochemists and physiologists.

Table 2. Shows that most of the resistant and moderately resistant sorghum varieties identified so far belong to group IV (the unimproved locally adapted farmers' materials). Of particular interest in the case of Bauchi Local-an unimproved, tall and late maturing variety almost universally used by local farmers in the scrub savanna region of Bauchi and adjoining states. Results of the present investigation revealed that it is highly resistant to striga infestation (striga count =0), has a high-yielding ability (1000-seed weight =30g) and is white seed-coated (Table 2). These desirable attributes coupled with its drought resistant capability (Okonkwo, 1990) probably explain why the local/native farmers are reluctant to accept our improved, dwarf and early-maturing varieties with high yielding potential as substitutes for their land race materials. This stress the need for an immediate and thorough exploration of sorghum gene-resources and their safe conservation particularly now that rapidly expanding human population in the centres of origin (the developing countries of tropical Africa)

is resulting in the cultivation of more virgin lands simultaneous destruction of the native flora which they harbor (Okonkwo & Kilishi, 1990). Such in-depth exploration is likely to reveal sorghum genotypes which are more striga resistant than those presently identified. Such varieties will be great assets in breeding programmes design for sorghum crop improvement.

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