SELECTION FOR GRAIN YIELD IN LOW NITROGEN FERTILITY CONDITIONS*

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SUMMARY

A selection experiment was conducted with three random-mating populations of sorghum [Sorghum bicolor (L.) Moench]. The selections were made simultaneously in high and low nitrogen fertility for grain and biomass productivity. Yield trials of selected S_3 and S_4 bulks showed no advantage of selection in low fertility. These results indicate that breeding sorghum in low nitrogen fertility is not necessary; only the testing of advance generation progenies in low nitrogen environment may be sufficient to ensure that the newly selected cultivars perform reasonably well in the low fertility environments.

Key words: Sorghum, low fertility, selection for grain yield.

INTRODUCTION

Considering the small farmers' limited resources and traditional agricultural practices in the semi-arid tropical (SAT) regions where sorghum [Sorghum bicolor (L.) Moench] is grown extensively, it is important to develop cultivars with high and stable yields that perform reasonably well even under low fertility conditions. Normally, breeders select progenies in high fertility as this favours high heritability for yield (Frey 1964). A recent review of literature by Devine (1982) has revealed differing opinions regarding the usefulness of selection for yield under low fertility. We conducted an experiment on sorghum to compare the selections made at low level of applied nitrogen (20 kg/ha) with those in high nitrogen (100 kg/ha) regime for grain and biomass yields. Specifically, the objective of the study was to suggest the best selection strategy to breeders working for the poor farmers of the SAT.

MATERIALS AND METHODS

The scheme shown in Fig. 1 was followed for selection and testing, using three random-mating populations listed in Table 1. The resulting 32 S_3 bulks in 1980, and S_4 bulks in 1981, along with 4 checks were evaluated for grain and biomass yields at two fertility levels. A 6x6 lattice design, with the same randomization was used in each fertility. Spearman's rank correlations (r_s) for the performance at the two levels of fertility with respect to grain and biomass yields were computed between (i) ranks of selection made in high fertility only, (ii) ranks of selections made in

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Figure 1. Scheme of selection and testing

Year/Season	Activity	Generation planted
1977 rainy	Random mated population bulks planted in two grids of 75 m^2 each at two fertility levels. 80 male fertile plant selections (S_1's) made from each population under each fertility.	S_0
	↓	
1978 rainy	Both groups of S_1 families planted in respective fertility levels and individual plant selections made from the top 30 families.	S_1
	↓	
1979 rainy	30 S_2 families planted in respective fertility levels and 16 S_3 plant selections made from each.	S2
	↓	
1979 postrainy	The seed of the 16 families was increased by bulking 100 random fertile plants in each family.	S_3
	↓	
1980 rainy	A. Yield tests (see text) B. 16 single plant selections made from 'A'.	S_3 bulks
	↓	
1980 postrainy	Seed multiplication as in 1979 postrainy season.	S_4
	↓	
1981 rainy	Yield tests on S_4 bulks as in 1980 rainy season, A.	S_4 bulks

Table 1. Mean grain yield (q/ha) coefficients of variation (CV) and broad-sense heritability (h^2) in high and low nitrogen fertility (HF and LF, respectively) conditions of testing in 1980 rainy season. See text for details.

Population	Fast Lane Restorer (FLR)		West African Early (WAE)		Purdue Population 20 (PP_{20})	
Fertility	HF	LF	HF	LF	HF	LF
Grain yield ± SE	31.2±2.8	29.1±4.2	29.2±3.1	22.5±5.7	29.8±3.4	22.7±4.3
CV (%)	15.6	24.8	18.7	44.0	19.8	32.4
h^2(%)	75.4	57.9	79.5	41.9	56.8	47.1

Table 2. Spearman's rank correlation coefficients (r_s) between ranks of entries for yield and biomass in high and low nitrogen fertility during testing in the 1981 rainy season.

Populations	Variable	r_s with selections made in		
		A) low nitrogen (n = 16)	B) high nitrogen (n = 16)	C) pooled (A+B) + checks (n = 36)
FLR	Grain yield	0.597*	0.732**	0.706***
	Biomass	0.865***	0.603*	0.698***
WAE	Grain yield	0.679**	0.871***	0.837***
	Biomass	0.659**	0.726**	0.714***
PP_{20}	Grain yield	0.610*	0.790***	0.760***
	Biomass	0.465+	0.794***	0.723***

+, *, **, *** = P<0.10, 0.05, 0.01 and 0.001, respectively.

low fertility only, and (iii) ranks of all selections and four checks.

RESULTS AND DISCUSSION

As expected, the grain yield was more in high fertility plots, especially in WAE and PP_{20} populations (Table 1). The mean yield of all the three groups of selections for grain yield and biomass productions were similar (Table 2). Further, irrespective of the nitrogen level in which the selections were made, at least 4 of the 6 top ranking entries for grain yield were common during 1980. Similar results were obtained in 1981 test also. These results suggest that breeding separately for a low nitrogen situation was unnecessary. This is also consistent with the conclusion of Rao et al. (1981) that the top ranking hybrids and varieties maintain their relative ranks for yields regardless of the levels of fertility.

Although during selection of early progenies, nearly two-fold differences were measured in a check cultivar planted in the borders, the differences in yields between the two fertility levels were not large in both the years of testing. However, it is unlikely that this could have changed the outcome of the present study. In another experiment conducted with the same objectives (N. Seetharama, unpublished), in spite of more than four-fold differences in mean yields between the two fertility levels the conclusions were not different.

There was no practical way of determining whether the initial entries used for the synthesis of the random-mating populations had significant genetic variation in high response material for good performance under low nitrogen conditions. A similar sutdy with populations specially synthesized by using adapted and unadapted germplasm to low fertility conditions may be appropriate. Great emphasis should be placed on testing large number of advanced generation progenies in high and low fertility conditions before finally retaining the top ranking selections in each group. Such activities should be carried out, in the target areas only, with well defined narrow limits than the theoritical maximum stress and theoritical optimum growing conditions (Buddenhagen 1983). However, as better performance in low nitrogen condition is greatly influenced by location-, and season-specific variations in the nitrogen availability (e.g. mineralization, leaching, etc.) and assimilation (uptake, transfer to the grain from vegetative parts, etc.), detection of consistently significant differences is difficult (Maranville et al. 1980).

Most of the traditional sorghums of SAT farmers do not respond significantly to the applied nitrogen. with the improved cultivars it has now become possible to get higher yields with fertilizer application, without sacrificing any yield potential under no fertilizer input, both in India (Rao 1982) and Africa (Nicou 1982). As Graham (1978) has argued for wheat, modern cultivars of sorghum are highly efficient in the use of soil nitrogen (Kanwar and Rego 1983).

Genotypic differences for the individual component traits such as absorption, translocation, accumulation and partitioning of nitrogen is documentted (Clark 1982), but there is no conclusive demonstration of any practical method of effectively combining all these traits for overall nitrogen efficiency other than by mere emperical screening in the field. Therefore only the testing of advance generation selections in appropriate level(s) of fertility is enough and practical for most breeding programs. The results of this study also support the current practice of breeders to select their material in high fertility conditions.

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