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USE OF GRAIN NUMBER COMPONENTS AS SELECTION CRITERIA IN PEARL MILLET*

F.R. BIDINGER, G. ALAGARSWAMY AND K.N. RAI

Cereals Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Patancheru, Andhra Pradesh 502324

ABSTRACT

Grain yield in cereals is often closely related to grain number per unit area, but it is not feasible to use grain number as a direct selection criterion. In this experiment, two indirect selection criteria for increased grain number-penicle number per plant and panicle size (panicle surface area) were compared to visual selection for yielding ability, for their potential as selection criteria for increased grain yield in pearls millet (*Pennisetum glancum* (L.) Br.). The criteria were used on spaced, So plants and on the resulting S_1 rows from a dwarf synthetic variety. Selection for panicle number per plant and panicle size resulted in improvement in these components, as expected, but not in a change in grain number per unit area. Selection for increased panicle size, however, did result in an increase in grain mass and, therefore, an increase in grain yield. In contrast, neither visual selection nor selection for panicle number per plant affected grain yield. Possible reasons for the response to selection for panicle size are discussed.

INDEX WORDS: *Pennisetum glaucum* pearl millet selection creiteria, grain number, panicle number, panicle size.

Differences in grain yield among cereal cultivars are more often related to differences in grain number per unit land area than to differences in seed mass (e.g. Adams, 1967). Direct selection for grain number per unit area, however, is not a practical approach to breeding for increased yield potential because of i) its high cost of measurement on large numbers of progeny rows, and ii) its probable lack of relevance when measured in spaced plants. Indirect selection for increased grain number per unit area is often practised (intentionally or otherwise) through selection for inflorescence number and/or seed number per inflorescence. Becuase of the common negative correlation, however, between inflorescence number and size (Adams, 1967), differences in grain number per unit area are often much smaller than differences in either of these two components.

Recurrent selection methods used in pearl millet involve visual selection of individual (often spaced) S_0 plants followed by replicated yield testing of selected half sib or S_1 progenies (Ahluwalia and Patnaik, 1963; Alagar Swamy and Bidinger, 1985). Individual plant selection concentrates on phenotypic traits the breeder considers desirable. These often include one or more components of grain number per unit area (panicle number, length, compactness, etc.).

The experiment reported in this paper was designed to test the effectiveness of indirect selection for increased grain number in the S_0 generation. In comparison to the normal procedure of visual selection for yielding ability. Two indirect selection criteria for grain number per unit land area were used: number of panicles per plant and panicle

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surface area (an estimate of panicle size). Both traits have been reported to be correlated to grain yield in pearl millet (Burton, 1983; ICRISAT, 1986; Jindla and Gill, 1984; Pokhryal, Mangath and Gangal, 1967).

MATERIAL AND METHODS

The experiment was conducted with a dwarf, open-pollinated pearl millet synthetic variety, ICMS 7901, formed by intermating selected dwarf progenies derived from a backcross program designed to produce dwarf versions of seven standard height millet composites (Rai, 1990).

Approximately 1200 plants spaced 0.75 x 0.75 m apart were grown in 1980 rainy season (June-September) at ICRISAT Center, Patancheru. The main shoot panicle of each plant was left for open-pollination and panicle size measurement. One tiller panicle on each plant was selfed to produce S_1 seed. At maturity, off-type plants were discarded, and the panicle number per plant counted and the main shoot panicle length and diameter measured, on each remaining plants. Panicle surface area (hereafter called panicle size) was calculated as π x panicle length x panicle diameter assuming the panicle to be a perfect cylinder. At the same time, plants were visually evaluated for yielding ability by the breeder of the original synthetic (KNR). The three selection criteria were used individually to choose approximately 40 plants representing the best expression of each criterion. A total of 114 selfed tiller panicles were harvested. Several of those selected on the basis of visual evaluation were also selected on the basis of one or both of the other two criteria.

In the 1981 rainy season S_1 progenies (from each selected S_0 plant) were yield-tested in a trial replicated three times. Plots were two rows of 4.0 m length with 0.75 m inter-row spacing, and a plant population of 11 plants per m^2. Grain yield and the expression of the trait for which the original S_0 was selected were measured on all plots. Panicle number was counted for the harvested area of the plot (1.5 x 3.0 m) and the main shoot panicle surface area was measured on five random plants.

On the basis of ranking for both grain yield and expression of the original selection criterion, the 10 best progenies in each selection criterion category were chosen (except for the visual assessment criterion, in which progenies were chosen on the basis of yield alone). Remnant S_1 seed of each set of the selected progenies was sown in the 1981-1982 dry season. The lines in each set were recombined to form three subsynthetics, representing the three selection criteria.

The three subsynthetics plus the original synthetic were yield-tested at normal plant populations in plots of 4 rows (gross plot size = 3.0 x 4.0 m; harvest area of two centered rows = 4.5 m^2) replicated four times, in the 1982 and 1984 rainy seasons at ICRISAT Center. At harvest, data were gathered on grain yield and all yield components in order to compare the effects of the different selection criteria on yield and yield component expression. Error variances were homogeneous between the two years, and there was an entry x year interaction only for individual grain mass, so data are presented as the means of both years.

RESULTS AND DISCUSSION

S_0 plant selection

There was considerable variation among the original S_0 spaced plants for the two components of grain number per unit land area. Panicle number per plant ranged from 3 to 12, with a mean of 6.4, and main shoot panicle size

TABLE 1. Grain yield and yield components of S_1 progenies (1981) trial and subsynthetics (mean of 1982 and 1984 trials)

Material	No. of panicles m^{-2}	Grains Panicle^{-1}	Grains m^{-2} ($x10^{-3}$)	Grain mass (mg grain^{-1})	Grains yield (g m^{-2})
All S_1s tested (114)[1]					
mean	28	1250	33.3	6.2	201
range	17-43	390-2530	12.0-56.2	3.4-9.4	105-315
SED	± 3.7	± 202	± 5.7	± 0.57	± 29.9
Selected S_1s (10)					
panicle no.	36	1110	39.5	6.3	243
panicle size	25	1630	39.5	7.0	274
visual rating	27	1550	40.8	6.5	256
Subsynthetics					
panicle number	32	1310	40.4	5.9	237
panicle size	23	1910	41.9	6.5	269
visual rating	22	1740	35.9	6.4	226
original ICMS 7901	26	1550	39.8	5.7	225
SED	± 1.7	± 239	± 3.36	± 0.26	± 18.8

[1] Number of S_1 progeny.

ranged from 90 to 330 cm^2, with a mean of 149 cm^2 (data not presented). The mean panicle number per plant of those selected on the basis of a high panicle number was 8.9, and the mean panicle size of those selected on the basis of a large panicle size was 249 cm^2.

S_1 progeny evaluation

There were significant differences among the 114 S_1 progenies tested for all variables measured (Table 1). The range in grain number per unit land area was broad (12 000 to 56 000 grains m^{-2}) and was accompanied by an equally broad range in grain mass (3.4 to 9.4 mg grain $^{-1}$). As expected, variation in grain yield was related primarily to variation in grain number per m^{-2} ($r= 0.72$, $P < 0.001$). Grain mass had a weak, although significant relationship to grain yield ($r=0.27$, $P < 0.01$).

The mean of the 10 S_1 progenies selected for recombination on the basis of panicle number had 29% more panicles than the mean of the 114 S_1 progenies tested. (This is not, strictly speaking, a selection differential as the 114 lines are not a random sample of the original synthetic, but it does provide some idea of the results of selection for a sepcific grain number component). This difference in panicle number was accompanied by a 19% greater grain number m^{-2} and a 21% greater grain yield (Table 1). The panicle size selections had a 19% greater grain number m^{-2} and 36% greater grain yield than the whole S_1 population. The larger difference in grain yield in the panicle size selections was due to a difference in grain mass as well as in grain number per unit area. The 10 best visually selected progenies had a 23% greater grain number and a 27% greater grain yield, than the population mean.

Based on these results it appears that there was little difference among the three selection criteria used on S_0 plants in their ability to identify S_1 progeny with increased grain numbers. The panicle size criterion identified slightly higher yielding S_1 progenies than the other two selection criteria, but the reason was related to changes in grain mass rather than to changes in grain number.

Subsynthetic evaluation

The results of the subsynthetic evaluation confirmed the observations from the S_1 progeny evaluation. Both grain number component selection criteria resulted in positive changes in the component that was the object of selection, but these positive changes were accompanied by compensating negative changes in the other component of grain number (Table 1). The increase in panicle number in the panicle number subsynthetic was significant ($P < 0.05$); the increase in grains per panicle in the panicle size subsynthetic was not. In neither case, however, did grain number per unit area differ significantly from that of the original synthetic.

The panicle size subsynthetic outyielded the original synthetic ($P < 0.05$) by 20% due to a significantly ($P < 0.05$) larger grain mass (Table 1). The visually selected subsynthetic also produced a higher grain mass than the original synthetic ($P < 0.05$) but this was accompanied by a slight (non-significant) reduction in grain number per unit area, such that the grain yield did not differ significantly from that of the original synthetic.

Implications for selection

There was a general inverse relationship between panicle number per unit area and grain number per panicle among synthetics (Fig.1). For example, selection for panicle number resulted in a corresponding decrease in panicle size, with little effect on grain number per unit area. Such inverse relationships are common in other cereals and are related to the sequential nature of the development of yield components in crop plants (Shankar, Ahluwalia and Jain, 1963).

There was also evidence of an inverse relationship between grain number per unit area and grain mass, for all the subsynthetics except the panicle size subsynthetic (Fig. 2). Selection for increased panicle size appeared to have resulted in a larger grain mass than that predicted from the relationship of grain number and grain mass common to the original synthetic and the other two subsynthetics. It was this change that resulted in the increased grain yield in the panicle size subsynthetic.

Why selection for larger panicle size should result in a change in the relationship of grain number and grain mass is not known, although a positive correlation of grain mass and panicle diameter has been reported previously (Singh and Ahluwalia, 1970). Greater panicle length and/or diameter are often associated with a loose arrangement of spikelets at the surface of the panicle, which may allow more space for grain growth. There is no direct evidence that graoin growth in pearl millet is affected by the space available for grain expansion, although an increase in the density of grains per unit of panicle surface area has been reported to be associated with a decrease in grain size (Waddignton *et al.*, 1986). An alternative explanation could lie in the commonly observed relationship between panicle diameter and stem diameter (authors, unpublised), which might suggest a greater reserve of carbohydrates in the stem for grain filling in genotypes with a larger panicle diameter.

Whatever the reason, the subsynthetic produced by selection for panicle size deviated from the grain number - grain mass relationship characteristic of the other subsynthetics, with a resulting increase in grain yield. Whether this phenomenon is specific to the synthetic used in this experiment or is a

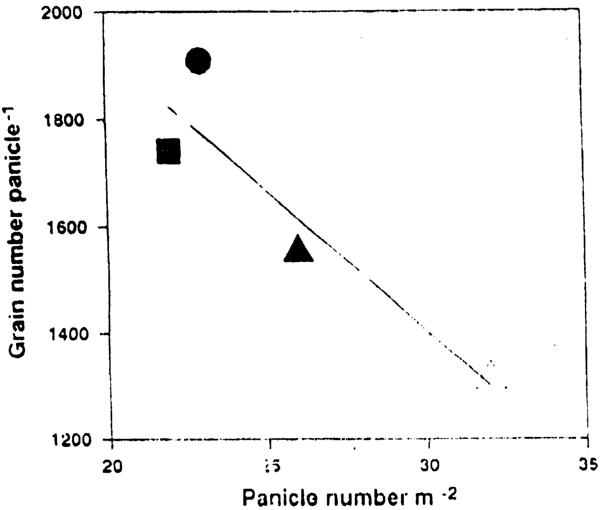

Fig. 1. Grain numbers per panicle in relation to panicle numbers per unit land area. (▲), original synthetic; (△), panicle number subsynthetic; (●), panicle size subsynthetic; (■), visually selected subsynthetic.

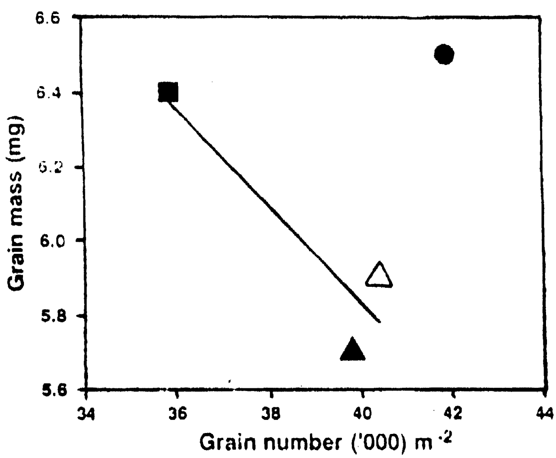

Fig. 2. Individual grain mass in relation to grain number per unit area (Symbols as in Fig. 1). Line fitted by eye, excluding panicle size subsynthetic.

general one for the crop is not known, and can only be determined by repeating this study on other synthetics of different genetic backgrounds. The large gain in yield made in a single cycle of selection on the basis of this criterion merits further investigation.

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