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A modified pedigree method of selection

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Summary. A dismal 81% failure of newly bulked lines against checks was observed in Indian wheat material evolved by the pedigree method. This is considered to be the consequence of selection in space planting in early generations followed by yield tests in a competitive environment which did not allow any scope of selection for competitive ability. Thus, most of the homozygous lines, which were until now raised and carried forward under space planting, failed to compete with the checks for yield in close planting. It is, therefore, necessary to modify the method to combine both the competitive ability and identity of selected plants. The proposed modified procedure involves raising the population under spaced planting as well as under drilling from F_2 onwards. Evaluation for tiller index marks an important step. On the basis of tiller index, single plants are isolated from spaced populations. Steps of the modified procedure are outlined in detail. The modified method, which economises on breeders' workload and other physical inputs, besides having other advantages, can also be used for certain other grain crops. Preliminary results based on the modified method during the past two seasons have indicated its utility.

Key words: Wheat – Tiller index – Competitive ability – Interplant competition – Modified pedigree method of selection

Introduction

The pedigree method of selection is the most widely practised by breeders because it enables control in selection to a greater degree than any other method for self-pollinated species. This procedure involves visual selection of desirable single plants from F_2 onwards through several generations of space-planted segregating populations, before finally testing the homozygous lines for yield at the recommended density of commercial planting. The effective selection, thus, is dependent upon the expression of the trait under selection being consistent in different densities of crop stands. If genotypes respond differentially to changes in plant density, the ones selected for their superior performance under low density might not give similar performance when tested under high density of commercial production.

It is known that genotype-environment interaction plays a key role in the overall performance of a genotype, which becomes more important for yield because of its low heritability. The problems caused by selection and testing in differential planting densities are, thus, more pronounced for yield. The present communication is an attempt to overcome such problems of testing in differential crop stands after selecting from the segregating population, using a large number of derived lines of wheat in a wide range of agro-climatic zones.

Materials and methods

Six-hundred-and-thirty wheat strains developed under the National Wheat Program following the pedigree method of selection by 46 breeding centres were tested at 271 locations spread over nine agro-climatic wheat zones of India from 1983–1984 to 1986–1987. Multilocational data over seasons on yield, including those of 2–3 checks at each location, were utilized.

Results and discussion

The yield results of Uniform Regional Trials (timely sown), the test of elite Indian material pertaining to 630

Table 1. Performance analysis of elite Indian wheat material from 1983–84 to 1986–87 developed by various breeding centres. Source: Adapted from the results of Uniform Regional Trials (timely sown), conducted by the All-India Coordinated Wheat Improvement Project

Zone	No. of locations	No. of cultures[a]	Cultures compared to the best check			Ratio between		
			Significantly superior	Numerically superior	Equal or inferior	Col. 3:4 (%)	Col. 3:5 (%)	Col. 3:6 (%)
Northern Hills	30	50	–	16	34	–	32.0	68.0
Northern Plains	49	115	–	9	106	–	7.8	92.1
Northwestern Plains	31	76	4	11	61	5.2	14.4	80.2
Northeastern Plains	44	79	4	9	66	5.0	11.3	83.5
Far Eastern	18	73	–	11	62	–	15.0	84.9
Southeastern	10	55	5	13	37	9.0	23.6	67.2
Central	40	64	–	–	64	–	–	100.0
Peninsular	45	72	6	12	54	8.3	16.6	75.0
Southern Hills	4	46	8	12	26	17.3	26.0	56.5
Total	271	630	27	93	510	44.8	146.7	707.4
Mean						4.9	16.3	78.6
Overall ratio						4.2	14.7	80.9

[a] Includes cultures and checks other than the best check

cultures at 271 locations from 1983–1984 to 1986–1987, are presented in Table 1. The table reveals that out of 630 cultures, only 27 significantly outyielded the best check in the respective test, 93 were numerically superior and as many as 510 were equal to or inferior to the best check. The mean ratio between the number of cultures and those significantly superior to the best check, those numerically superior to the best check and those equal or inferior to the best check was found to be 4.9%, 16.3% and 78.6%, respectively. The corresponding values averaged over the 4 years were 4.2%, 14.7% and 80.9%. This implies that at the all-India level with such a wide testing, merely 4.2% of the breeders' material was effective, while a large component of over 80% did not meet the objective. Such waste calls for some modification in selection methodology which may reduce it substantially.

The reasons for this are obvious in the selection procedure. For nearly six generations, the space planting in progeny testing allowed a more congenial environment for individual plant expression with little or no interplant competition. The sudden change in advanced yield trials to a highly competitive environment, which the plants had not been selected for, provided the crucial test of realistic environment. In fact, they were never allowed any opportunity to express their competitive ability during their several earlier generations. After attaining high homozygosity, the progenies were in an entirely new environment of stiff interplant competition in yield tests. Thus, the failure of a large percentage of these lines could be expected. If the plants were evaluated under a competitive environment also from earlier generations and selection pressure was applied for competitive ability (which can be measured in terms of tiller index, the ratio between maximum and effective number of tillers expressed in percentage), one could expect better results. Kelkar and Briggs (1979) concluded that selection within segregating population in wheat should be carried out in a more closely spaced plant population. Skorda (1973) observed significant correlation between yield from F_2 and F_3 lines with an interplant distance of 5 cm within the rows.

Fasoulas (1984) favoured selection in isolation for obtaining higher yield. He based his conclusion upon a study of only two wheat crosses in F_2 planted 90 cm apart in a honeycomb design followed by selection. His results have several limitations. He did not clearly spell out the methodology for selection and testing, and the experiment was not replicated with standard checks and with adequate degrees of freedom for valid statistical comparison. Furthermore, the honeycomb design with very wide spacing, as studied by Fasoulas (1984), is impractical for large-scale breeding programs. Wider spacing between plants reduces interplant and intraplant competition, which affects tillering and vigour (Bunting and Drennan 1966). Such vigourous plants, which are more due to favourable environment, tend to be visually impressive and thus tend to be selected. The relative ineffectiveness of single plant selection in F_2, as observed by Mc Ginnis and Shebeski (1968) and Knott (1972), may partly be explained by the adoption of wider rather than narrow spacing. The plants selected from sparsed population, when brought to a different environment, as under commercial planting, have drastic reduction in both effective tillers and vigour. Even when the number of early tillers at the commercial density of planting is high, it declines

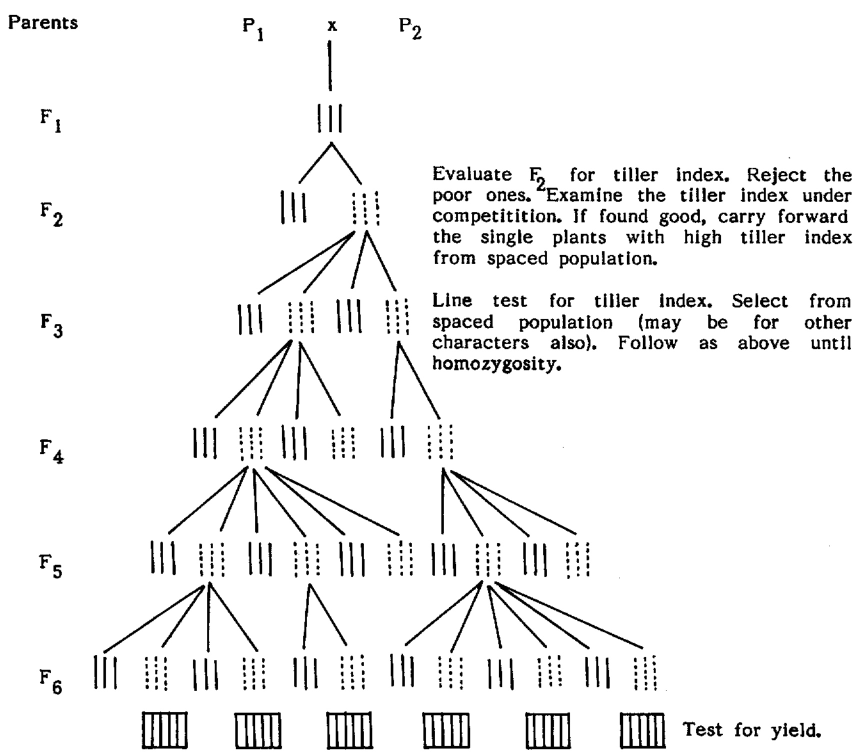

Fig. 1. Schematic representation of modified pedigree method of selection

gradually (Ishag and Taha 1974; Saini et al. 1980; Kulshrestha and Chowdhury 1987) under natural field conditions, mainly due to inter- and intraplant competition (Simmons et al. 1982), availability of water or natural precipitation (Begg and Turner 1976), interception of sunlight (Aspinall and Paleg 1964; Friend 1965) and other variables, such as humidity and temperature (Rawson 1971; Aspinall and Paleg 1964) under crop canopy. Chaturvedi et al. (1981) recorded 1,077 average maximum number of tillers per m^2 and the average effective tillers at 525 per m^2. Taking a variety of 40 g per 1,000 kernels, this works out to an average of 4.3 tillers produced by each seed, of which only 2.1 ($<50\%$) were effective. Genetic variability both for the capacity to produce early tillers and for their survival has been amply demonstrated in wheat (Saini et al. 1980; Chaturvedi et al. 1981; Ishag and Taha 1974; Kulshrestha and Chowdhury 1987), which could be selected.

The pedigree method of selection in its present form, which is so widely practised, would not allow any selection for competitive ability. The space planting, generally at about 15 cm between plants, could ensure effective single plant selection rather than its performance as a population. Selection of single plants at commercial density of planting would be difficult due to fewer tillers, intermingling with those of the others. Even single-head selection would not be feasible because, firstly, it gives little indication of tillering capacity of a recombinant and, secondly, one head does not give sufficient seed for yield test. It is, therefore, necessary to have a method which would ensure selection of a single plant and at the same time allow enough interplant competition.

A slight modification in the standard pedigree mehtod of selection may be usefully applied to achieve the above objective by greater emphasis on tiller index under competition and evaluation both under space planting and under near drilled conditions. The proposed modified steps are outlined below and are diagramatically shown in Fig. 1.

Methodology

1. Choose desirable parents and make crosses.
2. Grow F_1 spaced about 8 cm plant-to-plant. Bulk harvest at maturity.
3. Grow part of F_2 under competition and part spaced about 8 cm plant-to-plant. Evaluate for tiller index (ratio between maximum and effective tillers in percentage) under competition and mark such crosses which exhibit high tiller index. Of the selected crosses, examine the spaced single plants for competitive ability in terms of tiller index. Select desirable plants. Other desirable characters may also be taken into consideration.

4. Grow part of the plant-to-line F_3 under competition and part spaced about 8 cm. Evaluate for tiller index under competition and in spacing as well. If tiller index status is desirable, isolate the recombinants (perhaps for other desirable traits too) from the spaced population to carry on to further generation. This practice may be carried on until homozygosity is achieved, after which yield test may be conducted.

Evaluating lines of the same family at two densities and selecting from the spaced one ensures a high probability that the right plants are being isolated. This enables a breeder to apply optimum amount of selection pressure for tiller index throughout the course of evaluation. The ratio between the strains tested and those equal or inferior to the check (Table 1) is likely to decline considerably by adopting this modified method.

This proposed modified method of pedigree selection has the following advantages: (1) It enables a breeder to test for competitive ability (tiller index) in early generations, without allowing the same to be delayed until preliminary yield tests, as is the present practice. (2) It is possible to reject the cross(es) that show(s) poor tiller index in F_2 itself. This would lessen the work load of the breeder and reduce pressure on land, labour and other inputs. (3) Other desirable characters can also be taken care of simultaneously so that a special breeding program for competitive ability need not necessarily be taken up.

Preliminary results based on this modified methodology in wheat during the past two seasons have proved its usefulness. A greater rejection leading to steady decline in the volume of the material has been observed. In F_2, 17.3% of material and in F_3, 9.0% of families were retained as compared to 62.5% in F_2 and 27.3% in F_3 by using conventional pedigree selection method.

This modified methodology of pedigree selection may also be effectively used for other cereal crops such as barley, triticale and oat.

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