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Breeding strategy for wheat improvement based on exploitation of varietal responsiveness towards phosphorus levels : A proposed method

D. Singh*

G. B. Pant University of Agriculture and Technology, Western Campus, Modipuram, Meerut 250 110

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Abstract

Fifteen commercially released varieties of bread wheat were grown in 48 artificially created micro-environments. The varieties were evaluated for diversity and similarity for adaptive reactions towards different levels of fertilizers over a range of practically feasible environments following correlation method. Eighteen pairs of wheat varieties were found diverse with respect to their response pattern towards environmental variation and therefore, the genotypes of each pair could be crossed with each other in order to obtain improved genotypes. Only four pairs of wheat varieties (CPAN 1676, HD 2285; UP2113; HD2329; PBW 34, C 235 and PBW 34, HD 2204) exhibited isoresponsiveness over the same series of environments.

Key words : *Triticum aestivum*, strategy, Isoresponsive varieties, correlation coefficient

The improvement of bread wheat on scientific lines started in India at the beginning of the present century soon after the rediscovery of the Mendelian laws of heredity. The wheat breeding work for first 30 years involved major emphasis on single plant selections taking advantages of the enormous variability present in the land races selected by farmers over the past centuries. Since 1930 to the introduction of dwarf genes, breeders exercised intensive hybridization in order to improve the wheat for grain quality, disease resistance and higher grain yield. However, in India, up-gradation of productive genetic potential of wheat was not significantly large and wheat yield on farmer's field remained stagnant for a long period extended over 3 decades prior to the introduction of dwarf varieties, i.e. Sonora 63, Sonora 64 and Lermo Rojo.

There were two reasons for the slower yield improvement in wheat, firstly Indian scientists were working with limited gene pools. Secondly, the Indian farmers were working within the framework of traditional agriculture. On the other hand, the western scientists during the same decades were able to achieve a sustained and significant grain yield increase in the wheat varieties developed by them. There is no real evidence that the genetic diversity in their breeding programmes was much larger. Perhaps, the success of the wheat breeding efforts in the western countries during these earlier decades was function of the fact that their selections were made under improved levels of agronomical management. Presently, since the introduction of dwarf varieties and modern farm inputs in the agriculture, break through has been achieved in wheat improvement. But, beyond this, breeders once again feel difficulty to improve it further by following the conventional breeding technology. Therefore, a need of resorting new premises of research is felt. In this context agronomic manipulations merit special considerations to improve the productivity.

In the present paper, an attempt has been made to screen the newly developed varieties of bread wheat for adaptive reactions with respect to their yielding ability under a wide range of agronomical manipulations with major emphasis on application of phosphorus. Diversity of varieties with respect to adaptive reactions and its speculative application in further breeding programmes to improve the productivity by using different levels of agronomical management is also discussed.

Materials and methods

The present experiment was undertaken in order to evaluate newly released wheat varieties for commercial cultivation for their response towards different levels of phosphate fertilizers, particularly in view of phosphorus deficient soils of the region (1). In this experiment, Nitrogen, Phosphorus and Potassium were supplied in the form of urea, single super phosphate and murate

*Present address: Sardar Vallabh Bhai Patel University of Agriculture and Technology, Modipuram, Meerut 250 110

of potash, respectively. Data of two years (1987-88 and 1988-89) were analysed in the present context. Fifteen wheat varieties including some standard old varieties suited for different agroclimatic conditions were evaluated in RBD for two years under 6 levels of P_2O_5 (O, 20, 40, 60, 80, 100 kg/ha) without and with application of recommended doses of N and K_2O for western plains of Uttar Pradesh both in irrigated (N, K_2O, 120, 40 Kg/ha) and rainfed (N, K_2O : 100, 40 kg/ha) conditions thus resulting in a total of 48 artificially created environments. Data were recorded on a plot basis in each of the three replications. Net plot consisted of 5 lines (23 cm apart) 4 meters long. Correlation coefficients between different pairs of 15 cultivars were estimated for deviations in grain yield from environmental mean. Environmental mean is the same as environmental index in Eberhart and Russell (2). Diverse and isoresponsive genotypes were selected following the methods suggested by Singh and Gupta (3) and Singh (4), respectively.

Results and discussion

Correlation coefficients for all pairs of 15 genotypes are given in Table 1. Average grain yield of each genotype is given in Table 2.

Statistically significant negative correlation between the deviations in grain yield of a pair of varieties from their respective mean over all the environments is suggested to be used as a measure of diversity between both the varieties of the pair with respect of their response towards agronomical manipulations. This may provide a measure of potential breeding value of the cross made between them and hence possibly the heterotic effect may be obtained in response of the hybrid to environmental variations. The crosses thus obtained will be screened for magnitude and direction of heterosis. Positive heterosis will be indicated by increased sensitivity of the hybrid towards environmental variation. As a matter of fact the genotypes exhibiting higher response towards rich environmental conditions will be equally responsive towards conditions of stress. Therefore the hybrid exhibiting positive heterosis in response will be more suitable for farming conditions where a farmer can economically afford to save the crop from the adverse effects of higher response causing more susceptibility towards pests and disease. However, some uncontrollable effects of such response may limit its utility for commercial purpose. Negative heterosis in response will be desirable under economically poor

Table 1. Correlation coefficients between fifteen wheat varieties for deviation in grain yield from environmental means

Varieties		2	3	4	5	6	7	8	9	10	11	12	13	14	15
UP 2121	(1)	–.355*	–.070	–.020	–.014	.175	.094	–.430**	.005	–.334*	.059	–.400**	–.079	.267	.025
UP 262	(2)		–.160	.284	–.240	.126	.161	.238	.023	.078	–.380**	.223	–1.107	–.025	–.106
CHAN 1676	(3)			–.221	–.292*	–.359**	–.526**	.004	.090	–.032	.498**	–.077	–.022	.190	–.269
UP 368	(4)				–.055	.110	.113	–.002	–.336*	–.255	–.166	–.136	.217	–.001	.068
PBW 154	(5)					.170	.062	–.299*	–.320*	–.069	–.150	–.321*	–.011	–.125	.221
C-306	(6)						.567**	–.263	–.281	–.065	–.589**	–.136	–.237	–.160	.261
PBW 34	(7)							–.037	–.107	.104	–.656**	–.231	–.295*	–.146	.288*
HD 2327	(8)								.129	.077	–.062	.335*	–.158	.111	–.250
HD2329	(9)									.192	–.032	.238	–.256	.220	–.464**
UP 115	(10)										–.180	.109	–.034	–.343*	–.032
HD 2285	(11)											–.070	.025	.105	–.240
UP 2113	(12)												–.143	–.024	–.295*
HD 2270	(13)													–.151	.026
HD 2428	(14)														–.151
HD 2204	(15)														1.00

*, **Significant at 5% and 1% levels of probability, respectively.

Table 2. Clustering of diverse genotypes based on response pattern

Varieties	Mean yield (q/ha)	Cluster of varieties showing diversity against variety given in column 1
UP 2121	28.00	UP 262, HD 2327, UP 115, UP 2113
UP 262	28.48	UP 2121, HD 2285
CPAN 1676	24.89	PBW 154, C 306, PBW 34
UP 368	27.28	HD 2329
PBW 154	31.34	CPAN 1676, HD 2327, HD 2329, UP 2113
C 306	26.85	CPAN 1676, HD 2283
PBW 34	28.77	CPAN 1676, HD 2285, HD 2270
HD 2327	30.54	UP 2121, PBW 154
HD 2329	29.06	UP 368, PBW 154, HD 2204
UP 115	29.06	UP 2121, HD 2428
HD 2285	24.27	UP 262, C 306, PBW 34
UP 2113	27.17	UP 2121, PBW 154, HD 2204
HD 2270	29.33	PBW 34
HD 2428	29.42	UP 115
HD 2204	26.78	HD 2329, UP 2113

farming conditions i.e. low input agriculture where scant use of agricultural chemicals and machinery limits the farmer's control over adverse effects of positive heterosis i.e./higher levels of responsiveness.

In Indian agriculture no heterosis is exploited in wheat cultivation, though it is feasible well in this crop. However, it is generally assumed that maximum improvement can be obtained through hybridization from the crosses which released maximum amount of variation

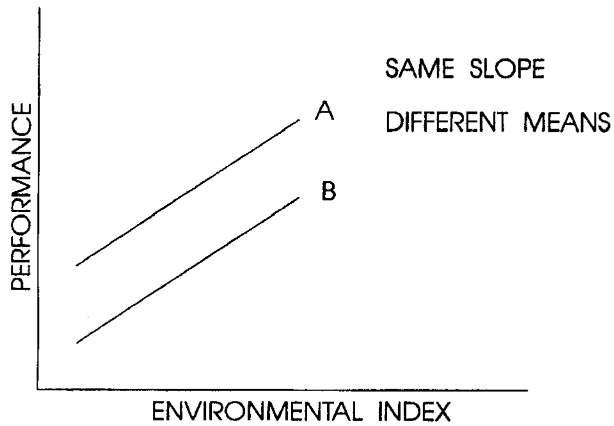

Fig. 1.

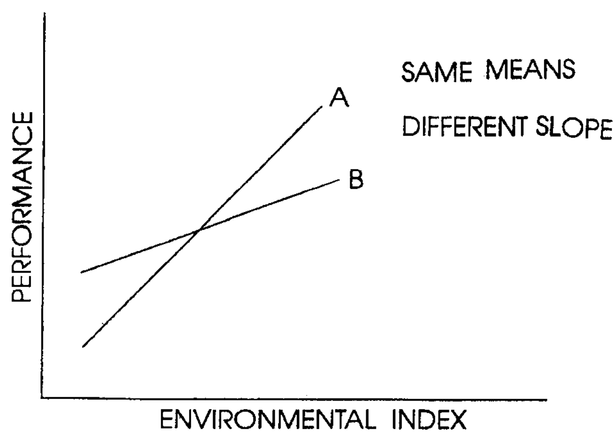

Fig. 2.

with the exception of those crosses specially designed to incorporate particular agronomical pathological or morphological characteristics. It is, therefore suggested that diverse cultivars/parents should be used in breeding programmes in order to breed the specific genotypes for different agro-economic conditions i.e. low input or high input agriculture.

It is also already established that the response of a genotypes towards environmental variations and its basic yield potential are governed by separate gene complexes (3, 5 and 6) as illustrated in figure 1 and figure 2. Therefore, when we plan to breed the genotypes for specific responsiveness, only those parents should be used, which are diverse for responsiveness as well as higher yielder. In the data presented in Table 1, it may be noticed that only 18 pairs of genotypes were diverse with respect to their response in varying agro-economic conditions with major emphasis on phosphorus application as given in Table 2. The genotypes of such a pair may be used for obtaining better segregants for further selections. But only those crosses which involve high yielding parents will be more valuable.

Four pairs has significant positive correlations reflecting almost similar response of the genotypes of the pair over environments used. The varieties CPAN 1676 and HD 2285 has almost similar response pattern and therefore, one variety of such a pair can be recommended for cultivation in agricultural conditions where the another is well suited. Likewise, UP 2113 and HD 2329 exhibited the similar response pattern. PBW34, C-306 and PBW 34, HD 2204 both these pairs were also found to be isoresponsive for the phosphatic levels used presently. Therefore both C-306 and HD 2204 wheat varieties could be recommended where PBW 34 variety is well suited for cultivation.

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