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BREEDING FOR ADAPTATION IN WINTER WHEATS FOR THE GREAT PLAINS[1]

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SUMMARY

General adaptation has been considered important in the breeding of winter wheat varieties for the highly variable Great Plains of central North America. Yield improvement has been substantial—35% over the long-time check variety. Regression analyses have been used to compare stability of the new varieties with that of the check varieties. In general, the new, higher yielding varieties are more responsive in the better environments than the long-time check variety, Kharkof, however, their stability is good and their performance relative to nursery mean highly predictable.

Regression analyses have aided in obtaining better performance descriptions of promising new lines at an earlier testing stage. These are useful both in encouraging the rapid introduction of some new lines and, also, in alerting breeders to possible deficiencies in other lines.

INTRODUCTION

The Great Plains region of Central North America contains an area of extensive hard red winter wheat production with highly variable and often precarious environmental conditions. The continental climate fluctuates greatly from year to year and within seasons. Precipitation ranges from 300 to 1000 mm and elevation from 150 to 1500 m, with the higher elevations receiving the lower precipitation. In this region, the success of a new variety is as dependent on its capacity for performing well over a range of environments as on its yield potential. This was demonstrated by the production of the Turkey variety introduced from southern Russia about 100 years ago. By 1919, this variety accounted for 21.6 million of the 80 million acres of wheat in production in the United States at that time and continued to be grown until about 1940. This would suggest that the variety had fairly wide adaptation.

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Some 40 years ago the U.S. Department of Agriculture and the state experiment stations of the Great Plains region recognized the importance of wide adaptation in hard red winter wheat varieties for that area and initiated a cooperative testing program to identify higher yielding but widely adapted varieties. That program is still active today in the form of two nurseries, the Southern (SRPN) and the Northern Regional Performance Nursery (NRPN). Data presented in this paper will pertain to the Southern Regional Performance Nursery and its utilization by the Nebraska wheat-breeding project. This nursery is grown annually at about 25 locations in the region. Testing sites range from central Texas (32° N lat) to southern South Dakota (44° N lat) and from Illinois (88° W long) to the Rocky Mountains (105° W long).

The effectiveness of the program can be measured by the success of the varieties identified through this nursery. Pawnee wheat, one of the first varieties identified as a widely adapted but productive variety through this nursery, was released in 1942-43 and by 1949 occupied over 11 million acres (13% of the U.S. wheat acreage). Scout wheat and its derivative Scout 66 were identified through this program and in 1972 were estimated to occupy 8-9 million (15-17%) of the 53 million acres of wheat in the United States. More recently, the Centurk variety was released in 1971 by most of the states in the region, and in 1973 is already being grown on about one million acres. It has a 5-year yield advantage of 35 percent over Kharkof in the regional nursery.

The above varieties were identified as superior varieties largely because of their high average yield over the wide environmental array. It was assumed that they were therefore widely adapted. However, FINLAY and WILKINSON (1963) pointed out that high mean yield alone is not necessarily indicative of wide adaptation. They suggested that the desired genotype is one that produces a high mean yield over all environments and has average yield stability in comparison with other genotypes in the same test. They suggested that each nursery mean yield is a measure of an environment, and thus an array of low- to high-yielding environments is available from such regional tests. The response of a particular variety to this array of environments can be estimated by the regression of the variety mean yields on the nursery mean yields. FINLAY (1963) suggests that varieties with average stability would have a regression coefficient of 1, those with values above 1 would be less stable but have high yield potential, while those with values below 1 would be very stable over a range of environments.

The statistics mean yield, regression coefficient ($by.x$), and coefficient of determination (r^2, varietal predictability in relation to the nursery mean performance) are currently being used to evaluate data obtained from regional tests. These will be used in this paper to evaluate varieties under test in the Nebraska variety nursery (NEVN) and the regional nursery (SRPN).

EVALUATION OF VARIETAL ADAPTATION IN THE GREAT PLAINS

Evaluation of the Check Varieties in Regional and Nebraska Tests

The Kharkof wheat variety is used as the long-time check in the SRPN, while Turkey serves the same purpose in the Nebraska tests. Breeders in the hard red winter wheat region have considered these two varieties as very similar. Data in Table 1 and the 3-year regression lines for Kharkof (SRPN) and Turkey (NEVN) would

TABLE 1. Yield performance data for selected entries from the 1970-72 Southern Regional Performance Nursery (SRPN) and the Nebraska Variety Nursery (NEVN)

		SRPN				NEVN			
Entry	Year	No. of tests	Mean yield (kg/ha)	Regr. coef. *(by.x)*	Coef. of determ. (r^2)	No. of tests	Mean yield (kg/ha)	Regr. coef. *(by.x)*	Coef. of determ. (r^2)
Centurk	1970	23	3057	1.24	.92	15	3490	1.10	.87
	1971	24	3367	1.16	.97	14	3800	1.16	.91
	1972	23	3628	1.08	.95	11	3336	1.16	.88
	1970-72	70	3351	1.14	.95	40	3558	1.17	.89
Scout 66	1970	23	2951	1.02	.92	15	3383	1.07	.92
	1971	24	3285	1.00	.95	14	3571	1.10	.91
	1972	23	3390	.87	.93	11	3302	.93	.64
	1970-72	70	3210	.95	.93	40	3430	1.04	.85
Kharkof	1970	23	2298	.71	.74	15	2596	.78	.70
(SRPN) or	1971	24	2588	.80	.87	14	2724	.70	.63
Turkey	1972	23	2709	.81	.84	11	2347	.83	.60
(NEVN)	1970-72	70	2533	.78	.83	40	2576	.76	.63

substantiate this. If Kharkof and Turkey can be considered to have had fairly wide and satisfactory adaptation to the Great Plains, then the data for the two new check varieties, Scout 66 and Centurk, would suggest that there has been considerable improvement for yield without great loss of average stability. However, Centurk is consistently responsive to the better environments in Nebraska and regional tests (Fig. 1).

It is generally accepted that testing over a wide range of environments is essential if widely adapted varieties are to be identified. Often it is assumed that this requires testing over a large geographical area. However, the regional or the Nebraska data presented in Table 1 and that portion graphed in Figure 1 would lead one to very similar conclusions in evaluating these varieties. Thus it would appear that the geographically restricted Nebraska testing locations are fairly representative of the more extensive regional locations.

To examine this relationship further, data for Centurk, Scout 66 and two Nebraska experimentals were reviewed. These data are presented in Table 2. The evaluation of these two experimentals in relation to the two check varieties would not be materially different regardless of the nursery used.

Performance Repeatability

The decision to increase and release a certain variety used to be based on rather extensive tests spanning a number of years. Today those decisions are being made on diminishing numbers of tests and tests over years. Yet an estimate of a variety's worth based on mean yields from a limited number of tests and one year's data is of dubious value. Therefore, the regressive values over years were examined for repeatability by use of t tests. For Centurk, in the SRPN (Table 1), the comparison of regressive values between years produces t values with

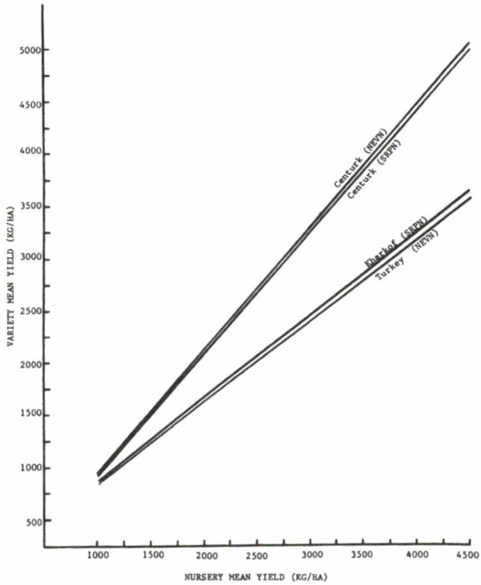

FIGURE 1. Comparison of regressions of Centurk yields on mean yields in the Nebraska Variety Nursery (NEVN) and Southern Regional Nursery (SRPN) and for Turkey (NEVN) versus Kharkof (SRPN), 1970-1972.

non-significant probabilities from .40 to .10; for Scout 66, from .10 to .05; and for Kharkof, from .50 to .40. In the Nebraska tests (NEVN, Table 1 and Fig. 2), the comparison of regressive values between years for both Centurk and Turkey produced t values with probabilities above .50. Thus it would appear that varietal response to environments is predictable to a considerable degree. If in addition, the varietal response is highly correlated with mean nursery performance (coefficient of determination, r^2, approaching 1), then considerable confidence can be placed on one year's measurement of a variety's performance and adaptation.

ANALYSIS BY ENVIRONMENTS

Twelve entries in the 1972 SRPN were being grown for the second year. When regression coefficients and coefficients of determination were calculated for the combined 1971-72 data, five of the 12 entries had r^2 values ranging from .85 to .90 and substantially lower then the others, which ranged from .94 to .96. REITZ and SALMON (1959) showed that SRPN data from some of the locations were more closely correlated with certain others in the region and that ecological regions existed. One such region probably included Lincoln, Nebraska; Ames, Iowa; Manhattan, Kansas; Stillwater, Oklahoma; and Denton, Texas. All of these are in the lower-elevation, high-precipitation region. Following this lead, we divided the SRPN testing region into a "low-plains" environment having an elevation of 600 m or below and above 600 mm precipitation, and a "high-plains" region with elevation above 600 m but below 600 mm precipitation. Irrigated nurseries were not included in further computations. Data for these entries according to this classification are presented in Table 3. The number of observations is considerably higher for the "high-plains" environment and may account in part for the better predictability for all entries in the "high-plains" environment, but it is also obvious that most of the variability was associated with performance in the "low-plains" environment. On the whole, varietal performance was highly predictable in the "high-plains" environment. Interestingly, the main agricultural stations of Nebraska, Kansas, and Oklahoma are located in what is designated as "low-plains" environment, yet the largest wheat acreage in each of these states is really in the "high-plains" environment! However, all have testing locations within the "high-plains" environment. The data do suggest that careful evaluation of the information obtained from regional nurseries is important.

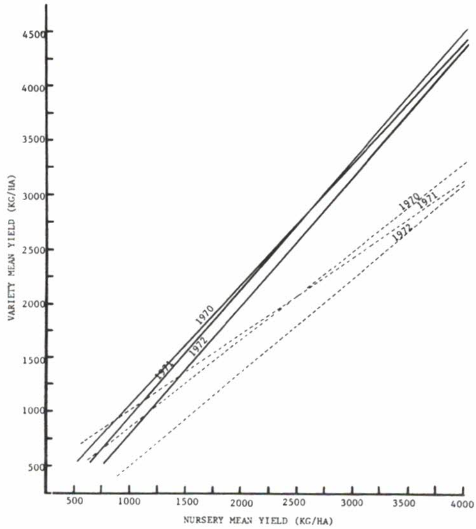

FIGURE 2. Comparisons of regression for Centurk and Turkey wheats on mean Nebraska Variety Nursery yields for 1970-1972 (solid lines, Centurk; broken lines, Turkey).

TABLE 2. Comparative yield performance data for two check varieties and two experimentals in the SRPN and NEVN, 1971-72

Entry	Nursery	No. tests	Mean yield (kg/ha)	Regr. coef. (*by.x*)	Coef. of determ. (r^2)
Centurk	NEVN	25	3598	1.20	.89
Centurk	SRPN	47	3495	1.12	.96
Scout 66	NEVN	25	3457	1.04	.82
Scout 66	SRPN	47	3337	.93	.94
NE68435	NEVN	25	3517	1.12	.88
NE68435	SRPN	47	3427	1.04	.96
NE68437	NEVN	25	3349	1.07	.86
NE68437	SRPN	47	3282	1.00	.96

TABLE 3. Comparative yield performance of 12 entries in two environments[1] in the SRPN in 1971-72

Entry	Mean yield (kg/ha) Low plains	High plains	Regr. coef. *(by.x)* Low plains	High plains	Coef. of determ. (r^2) Low plains	High plains
Kharkof	2878	2176	1.03	.81	.65	.91
Scout 66	3898	2681	1.05	.96	.87	.97
Pronto	3306	2525	.72	.94	.58	.92
Centurk	3971	2750	1.31	1.10	.82	.98
Bezostaya 1	3740	2591	1.23	.94	.81	.93
NE68435	3942	2757	1.24	1.01	.91	.99
NE68437	3764	2534	1.10	.88	.91	.96
Exp. A	3731	2521	.92	.99	.77	.96
Exp. B	3736	2621	1.44	1.14	.90	.95
Exp. C	3346	2682	.95	1.06	.59	.95
Exp. D	3944	2719	.99	1.06	.88	.97
Exp. E	3529	2632	1.09	.93	.63	.92

[1]Environments

Low plains:Below 600 m elevation, above 600 mm precipitation (14 observation

High plains:Above 600 m elevation, below 600 mm precipitation (23 observations)

CONCLUSIONS

Progress in increasing wheat yields in the Great Plains hard red winter wheat region has been considerable without substantial loss of yield stability. Improved evaluation techniques should aid in early identification of those lines having high potential yield and good general adaptation in a highly variable environment. Data obtained through these same techniques should alert breeders to possible deficiencies in a new line or its adaptation to a limited area.

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