TRAITS ASSOCIATED WITH BEST PERFORMANCE OF WINTER WHEAT IN A SEMI-HUMID AREA OF TRANSYLVANIA

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ABSTRACT

Data from winter wheat cultivar yield trials grown at Brasov during 22 years were used to analyze the relationship between grain yield on one hand and the yield components (spikes/m², grains/spike, weight of 1000 grains) and disease scores on the other hand, in order to define the wheat ideotype for the region. Grain number spike was most often associated with grain yield, of all yield components. This suggests that the winter wheat ideotype for the area should have large, fertile spikes, even if this trait might sometimes be associated with a smaller number of spikes and smaller grains. There is a risk in building yield based on large number of spikes per unit area, as this trait is sometimes associated with lodging and lower yields. Powdery mildew scores were frequently associated with lower yields, while leaf rust scores never correlated with yield. Though less frequent, stripe rust (*Puccinia striiformis*), *Septoria* and *Fusarium* scores significantly correlated with yield in some years. A successful cultivar for the semi-humid area of Brasov should not be susceptible to powdery mildew (*Blumeria graminis*), stripe rust (*Puccinia striiformis*), *Septoria* and *Fusarium*.

Key words: winter wheat, ideotype, yield components

INTRODUCTION

Progress in plant breeding could be accelerated by defining an ideal plant type, based on optimizing physiological processes involved in yield building (Donald, 1968a, 1968b). The wheat ideotype suggested by Donald, based on reducing competition among plants through reduced height, erect leaves and no tillering has not been widely accepted, but the usefulness of defining ideotypes has been almost generally recognized.

Mc Kay (1966) stated that, taking into consideration the complexity of the interactions inside the system plant-soil-weather, a different ideotype should be defined for each specific set of environmental conditions. Taking also into account the variation of conditions from one year to another, defining ideotypes, even for a specific area, should include identification of traits most often associated with highest yield and best yield stability (Saulescu and Jinga, 1990).

One possible approach is to analyze the performance of diverse genotypes in multi-year yield trials and to correlate the yields with several morphological and physiological traits. Saulescu et al. (1989) used this approach to suggest optimum wheat plant height for several areas of Romania.

This paper is an attempt to define optimum values for several traits of the wheat plant, based on multi-annual data from yield trials with wheat cultivars, performed in Transylvania at Brasov – Romania.

MATERIAL AND METHODS

Data from wheat cultivar yield trials, performed at Brasov during 22 years (1982-2003), were used to analyze the relationship between grain yield, on one hand, and the yield components (spikes/m², grains/spike, weight of 1000 grains) and disease scores, on the other hand. Diseases observed were:

- powdery mildew (*Blumeria graminis*);
- leaf rust (*Puccinia recondita*);
- stripe rust (*Puccinia striiformis*);
- scab (*Fusarium graminearum*);
- leaf blotch (*Septoria* sp.).

Correlation analysis was used to establish the significance of trait association for each year of study.

RESULTS AND DISCUSSION

The same yield level can be achieved by various combinations of yield components. However, one can expect that some combinations might have an advantage in certain environmental conditions. Based on this hypothesis, we analyzed the correlations between each yield component and yield, for each of the 22 years of study.

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The correlation between the number of spikes/m² and yield was significantly positive in only one year, with normal rainfall, while correlation was negative in two years, one normal and another deficient in rainfall (Table 1). Obviously, in contrast with the situation reported in other areas, cultivars with higher number of spikes do not have an yielding advantage in the area, and even present risks in some years.

The correlations between the number of grains per spike and yield was significantly positive in six of the years and never negative (Table 1). This suggests that, in the environment of Brasov, cultivars with large heads frequently produce higher yields.

The correlations between the weight of grain and yield was significant and positive in only two years, but never significant and negative (Table 1). Although large grained cultivars might not have an advantage in most years, they do not have a disadvantage.

Table 1. Correlations between yield and yield components in wheat cultivar yield trials grown at Brasov

Year	Coefficients of correlation between yield and		
	number of spikes/m²	number of grains/spikes	grain weight
1982[1]	0.36	0.07	0.03
1983	0.25	-0.21	0.26
1984	0.84*	-0.31	0.01
1985	-0.04	0.36	0.29
1986	0.26	0.30	-0.04
1987	0.01	0.42*	-0.01
1988	-0.03	-0.03	0.39
1989	0.23	0.04	0.47*
1990	-0.38	0.52*	0.20
1991	-0.18	0.18	-0.02
1992	0.18	-0.12	0.18
1993	-0.50º	0.36	0.47*
1994	-0.30	0.22	-0.04
1995	0.07	0.53*	0.06
1996	-0.21	0.43*	0.15
1997	0.08	0.64*	0.21
1998	-0.67º	0.32	-0.09
1999	0.25	0.40*	0.17
2000	0.57	n.a.	n.a.
2001	0.09	0.23	-0.13
2002	-0.22	-0.09	0.27
2003	0.10	0.35	0.05

[1] Years written with bold figures had normal rainfall.
*) and º) - positive and negative correlation coefficients significant at $P < 0.05$ level
n.a. - data not available

The number of spikes per unit area was negatively and significantly correlated with the number of grains per spike in nine of the years (Table 2), suggesting frequent competition for resources between developing spike primordia. The fact that significant correlations were found both in years with normal and reduced rainfall suggests that water was not the only resource involved.

Table 2. Correlations between yield components and other plant traits in wheat cultivar yield trials grown at Brasov

Year	Correlation coefficients between number of spikes/m² and:			Correlation coefficients between number of grains/spike and:	
	number of grains/spike	grain weight	lodging scores	grain weight	lodging scores
1982[1]	-0.44º	-0.15	-0.22	-0.21	-0.17
1983	-0.64º	-0.28	-0.11	0.08	0.25
1984	-0.52º	-0.13	-0.30	-0.52º	-0.47º
1985	-0.43º	-0.39	n.a.	0.01	n.a.
1986	-0.67º	-0.33	-0.08	0.17	-0.07
1987	-0.57º	-0.48º	0.52*	-0.18	-0.40º
1988	0.03	-0.54º	-0.05	-0.43º	-0.44º
1989	-0.62º	-0.15	-0.33	0.03	0.02
1990	-0.41º	0.01	0.54*	0.18	-0.09
1991	-0.27	0.10	0.12	-0.07	-0.09
1992	0.02	-0.10	n.a.	-0.42º	n.a.
1993	-0.50º	-0.28	0.29	0.03	-0.34
1994	0.13	-0.38	-0.01	-0.53º	-0.06
1995	-0.37	-0.14	0.36	-0.31	-0.10
1996	0.20	-0.24	n.a.	-0.41º	n.a.
1997	0.36	-0.20	0.11	0.18	0.12
1998	-0.42º	-0.68º	0.43*	0.10	-0.27
1999	0.34	-0.30	0.41*	0.17	0.04
2000	n.a.	n.a.	n.a.	n.a.	n.a.
2001	-0.24	0.06	0.01	-0.46º	-0.09
2002	-0.19	0.07	0.31	-0.57º	-0.15
2003	0.06	0.11	n.a.	-0.14	n.a.

[1] Years written with bold figures had normal rainfall.
*) and º) - positive and negative correlation coefficients significant at $P < 0.05$ level
n.a. - data not available

A high number of spikes/m² was associated with smaller grains in three years. In two of these

years, higher canopy density was correlated with more severe lodging.

The number of spikes correlated with lodging scores in four years. As suggested before, in the semi-humid climate of Southern Transylvania, cultivars that form a high number of spikes might produce lower yields, because of lodging and because of reduced spike size.

Spike size, as reflected by the number of grains per spike, was associated with smaller grains in seven of the years, suggesting relatively frequent competition for assimilates between developing grains. In two of these years the association might have been related with lodging. Larger spike size was associated with more severe lodging in three years.

Correlation between disease attack scores and grain yield. In the absence of special trials in which cultivars are treated and non-treated with fungicides, a convenient way to estimate the impact of various diseases on yield is by correlating disease scores with yield in regular cultivar trials.

Visible genotypic differences in powdery mildew (*Blumeria graminis*) attack were observed in all but one year. In 5 out of the 22 years (23%) powdery mildew scores the negative coefficients of the correlation with grain yield were significant (Table 3). Powdery mildew resistance seems to be frequently essential for obtaining high yields in the area.

In contrast, leaf rust (*Puccinia recondita)* attacks were only observed in about half of the years of study. Correlation with grain yield was never significant. Leaf rust resistance does not seem to be a condition for a successful cultivar in the Brasov region (Table 3).

Fusarium scab was observed in 9 years, but negative correlation with grain yield was significant in only one year. Nevertheless, taking into account the risk of mycotoxin contamination, the winter wheat ideotype for the region must include a certain degree of scab resistance.

Genotypic differences in leaf blotch (*Septoria* sp.) attacks were noted in more than half of the years (Table 3). In two years negative correlations with grain yield were significant. *Septoria* resistance seems desirable for winter wheat yield stability in the Brasov area.

Stripe rust (*Puccinia striiformis*) was observed on susceptible cultivars in 13 of the study years, but disease scores were signific antly correlated with yield in only one year. This apparent underestimation of the effect of stripe rust on yield might be explained by the fact that most cultivars in the trial showed resistance. Taking into account the high frequency of cool humid springs, favorable to stripe rust development, and also the fact that susceptible cultivars, such as Fundulea 29, gave very low yields in years with early disease development, we conclude that stripe rust resistance is necessary for cultivars recommended to the area.

Table 3. Coefficients of correlation between disease scores and grain yield in wheat cultivar yield trials grown at Brasov

Year	Correlation between grain yield and:				
	Blumeria graminis attack	*Puccinia recondita* attack	*Fusarium* scab attack	*Septoria* sp. attack	*Puccinia striiformis* attack
1982	-0.13	n.a.	n.a.	n.a.	n.a.
1983	-0.45º	0.17	n.a.	n.a.	n.a.
1984	-0.57º	n.a.	n.a.	n.a.	n.a.
1985	-0.07	0.11	n.a.	n.a.	n.a.
1986	n.a.	n.a.	n.a.	n.a.	n.a.
1987	-0.23	n.a.	n.a.	n.a.	n.a.
1988	-0.74º	n.a.	0.09	-0.08	0.06
1989	0.06	n.a.	n.a.	0.12	0.13
1990	-0.64º	n.a.	-0.42º	-0.37	-0.42º
1991	-0.17	n.a.	n.a.	0.16	-0.16
1992	0.28	n.a.	n.a.	0.07	-0.36
1993	-0.26	-0.35	n.a.	-0.35	-0.35
1994	-0.62º	-0.20	n.a.	0.29	-0.04
1995	-0.10	-0.05	-0.36	-0.08	-0.09
1996	-0.32	0.35	n.a.	-0.08	0.05
1997	0.38	0.37	-0.22	-0.09	0.08
1998	-0.08	-0.12	-0.09	-0.20	-0.01
1999	-0.13	-0.12	-0.18	-0.14	-0.16
2000	-0.06	-0.18	n.a.	-0.44º	n.a.
2001	-0.38	-0.09	0.03	-0.19	0.03
2002	0.19	0.31	0.15	-0.42º	n.a.
2003	-0.37	n.a.	-0.30	0.15	n.a.

[1] Years written with bold figures had normal rainfall.

*) and º - positive and negative correlation coefficients significant at P<0.05 level

n.a. - data not available

CONCLUSIONS

Spike size, as described by the number of grains per spike, was most often associated with grain yield, of all yield components. This suggests that the winter wheat ideotype for the area should have large, fertile spikes, even if this trait might sometimes be associated with a smaller number of spikes and smaller grains.

The fact that in two years we found negative correlation between the number of spikes per m² and yield, as well as the relatively high association of high spike number with lodging, illustrate the risks of building high yields based on large number of spikes.

Correlation of disease atack scores with yield suggest that a successful cultivar for the semi-humid area of Brasov should not be susceptible to powdery mildew (*Blumeria graminis*), stripe rust (*Puccinia striiformis*), *Septoria* and *Fusarium*. Leaf rust resistance does not seem to be as important.

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