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YIELD COMPONENTS COMPENSATION IN WINTER WHEAT (*Triticum aestivum* L.) IS CULTIVAR DEPENDENT

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ABSTRACT

Compensations between yield components are important barriers to improve yield in wheat. Data about the number of spikes per m^2, the number of grains per spike and thousand of kernel weight (TKW) were obtained from 26 yield trials with winter wheat cultivars, performed in 10 locations in Romania, during 2016-2018. Grain yield showed most frequently positive correlations with the number of grains per spike. Correlation coefficients of grain yield with the number of spikes per unit area ranged from -0.3 to +0.7, with most of the trials showing low positive correlations. Most trials showed practically no correlation of grain yield with TKW. Most correlations among the yield components were negative, illustrating the difficulty of combining in the same cultivar high values of more than one component, because of compensation between yield components. The strongest negative correlation was found between the number of spikes per unit area and the number of grains per spike, and most correlations between number of grains/spike and TKW were also negative.

Significant differences between cultivars were found in deviations from both regressions between negatively correlated yield components (number of spikes per m^2 - number of grains per spike and number of grains per spike - TKW respectively). This suggests the existence of cultivar specificity in compensation between yield components. Cultivars showing positive or smaller negative deviations from the regressions between negatively correlated yield components might be useful in breeding for reducing compensations between yield components. Further studies are necessary to confirm if this could lead to genetic progress for yielding potential.

Keywords: number of spikes, number of grains per spike, weight of 1000 kernels, winter wheat, cultivar.

INTRODUCTION

Wheat yield has frequently been analysed in terms of yield components (spikes/m^2, grains per spike, grain size), and complementation of yield components has often been considered in breeding for higher yields. However, compensations between components are one of the main barriers to improve yield using this approach (Slafer et al., 2014). For example, in GA insensitive semidwarfs it was shown that a higher number of grains per ear was accompanied by a lower grain weight. Depending on the climatic conditions in a particular year, the increase in grain number could be sufficient to compensate for the reduction in grain size and result in higher yields (Börner et al.,

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1993). When high seed weight was transferred from ‘Selkirk’ to ‘Thatcher’ spring wheat *Triticum aestivum* L., by backcrossing, the yield of the progenies varied considerably depending on the degree of compensation in the other yield components. Weight per seed was negatively correlated with number of kernels per plot, and the number of kernels per spike showed a high negative correlation with the number of spikes per plot (Knott and Talukdar, 1971).

On the other hand, many studies indicated that environmental factors may have higher impact on the expression of yield components than genetic factors (Zecevic et al., 2010). This suggests that it is desirable to study the yield components, their correlations with grain yield and among themselves in various environments.

This paper reports the correlation between grain yield and the yield components, and the correlation between the yield components in a set of winter wheat cultivars tested in several locations in Romania, trying to identify differences among cultivars in the degree of yield components compensation.

MATERIAL AND METHODS

Yield trials with 25 winter wheat cultivars, using a balanced square lattice design with 3 replications were organized in the years 2015/2016, 2016/2017 and 2017/2018 at the National Agricultural Research and Development Institute Fundulea (44°30`N latitude and 24°10`E longitude), and in eight Agricultural Research Stations (ARDS) from different regions of the country: ARDS Teleorman (44°07`N - 25°45`E), ARDS Şimnic (44°36`N - 25°45`E), ARDS Secuieni (46°85`N - 23°82`E), ARDS Dobrogea (44°16`N - 28°48`E), ARDS Oradea (47°50`N - 21°93`E), RDSSEC “MM” Perieni (46°30`N - 27°61`E), ARDS Mărculeşti (44°40`N - 27°50`E), RDSB Târgu Mureş (46°58`N - 24°61`E) and ARDS Albota (44°78`N - 24°85`E).

Data were not available from all locations and years, so that the total number of analysed trials was only 26. These included a large variation of weather and soil conditions, as well as crop management. For example, rainfall during the wheat vegetation period varied in 2017-2018 from 455.5 mm at RDSSEC “MM” Perieni to 682.8 mm at ARDS Teleorman, soil conditions varied from chernozem to luvisol, and crop management included various preceding crops, sowing dates and fertilization. At Fundulea and Simnic, trials were performed with and without Nitrogen fertilization. All these were reflected in average yield, which varied from 3550 kg ha^{-1} at Teleroman in 2018 to 8169 kg ha^{-1} at Secuieni in 2017.

Grain yield was calculated per hectare at 14% moisture. Number of spikes/m² was counted after complete heading in three replications. Weight of 1000 kernels (TKW) was determined based on weighing three samples of 100 grains each, while the average number of grains per spike was computed as Grain yield/(TKW*Number of spikes*100).

All 25 entries of the yield trials were used to calculate correlation coefficients between grain yield and yield components, as well as among the yield components. Nine *Rht-B1b* semidwarf Romanian cultivars and the long term check cultivar Bezostaya 1 (*Rht8*) were common to all 26 analysed yield trials and were included in the regression analysis regarding cultivar specific compensation of yield components.

RESULTS AND DISCUSSION

Correlation coefficients of grain yield with yield components were very different for the 26 yield trials, depending on the particular yield component and on the environment (Figure 1). The yield showed the highest correlation, varying from 0.3 to 0.9, with the number of grains per m^2, most trials having significant correlation coefficients from 0.5 to 0.7. More than 96% of the trials showed significant correlations between the number of grains per spike and grain yield.

Correlation coefficients of grain yield with the number of spikes per unit area ranged from -0.3 to +0.7, with most of the trials showing low positive correlations (+0.1 to +0.3), and only one trial having significant positive correlation.

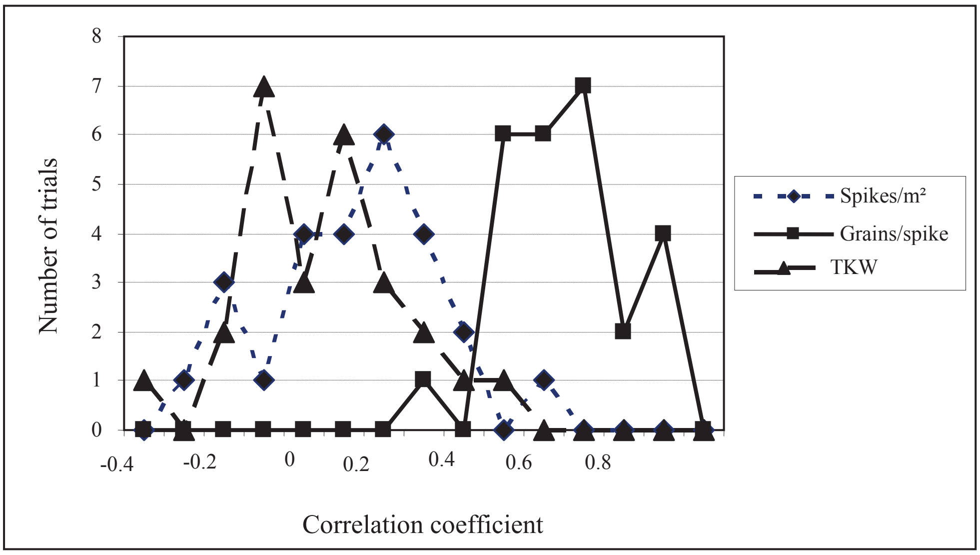

Figure 1. Frequency distribution of 26 yield trials according to correlation coefficients between grain yield and yield components (spikes/m^2, grains per spike and thousand kernels weight)

The correlation coefficient of grain yield with TKW ranged from -0.4 to +0.6, with most trials showing practically no correlation, and only one trial having significant positive correlation.

Most correlations among the yield components were negative, illustrating the difficulty of combining in the same cultivar high values of more than one component. The strongest negative correlation was found between the number of spikes per unit area and the number of grains per spike, with most trials showing correlation coefficients around -0.7 out of which 69% significant (Figure 2).

The correlation between the number of spikes per unit area and TKW was close to 0 in most trials, only less than 4% being significant, which was expected based on the fact that these two yield components are formed at some distance in time during the wheat plants development and as such are not directly connected.

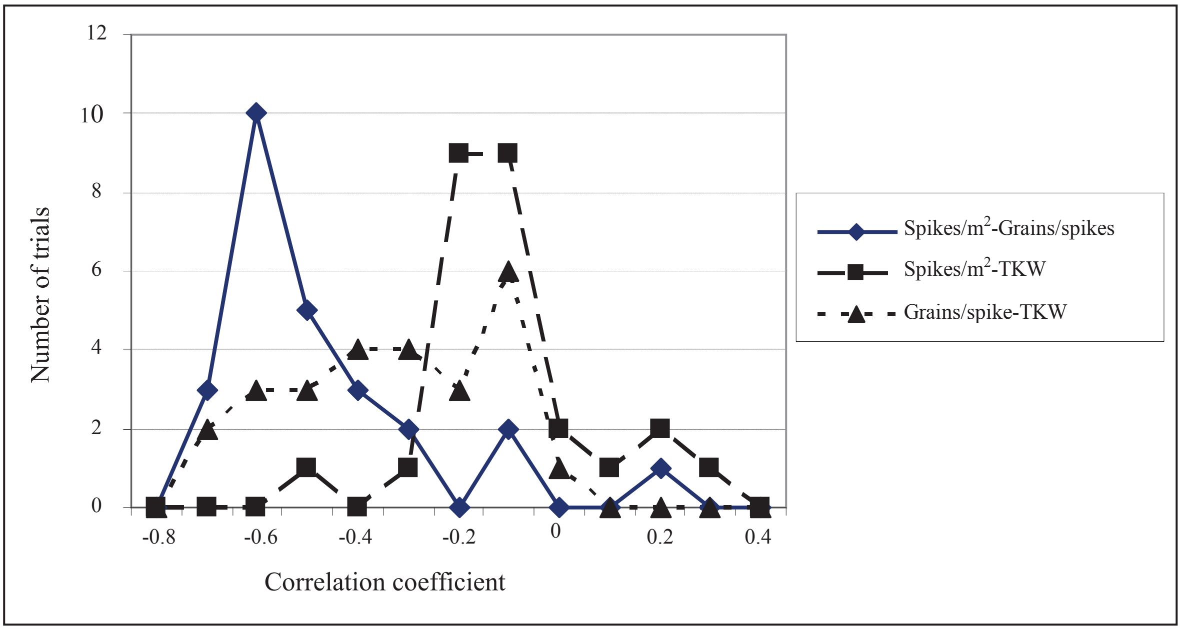

Figure 2. Frequency distribution of 26 yield trials according to correlation coefficients among yield components (spikes/m^2, grains per spike and thousand kernels weight)

The correlation between the number of grains per spike and TKW showed a larger variation, probably reflecting the effect of various environments on the competition for assimilates during grain filling. Most of the trials recorded quite high negative correlations and more than 30% of the correlations were significant, but in 10 trials the correlations were low, suggesting that in some cases the competition might be negligible.

A graphical representation of the relationship between the average values of the number of spikes/m^2 and the number of grains per spike in the ten cultivars that were tested in all 26 yield trials suggests that cultivars behave differently (Figure 3). Some cultivars, such as Otilia and Ursita, had significantly more grains per spike (3.2 to 4.7) than expected based on the regression on the number of spikes, while Bezostaya 1 had a much smaller number of grains than expected.

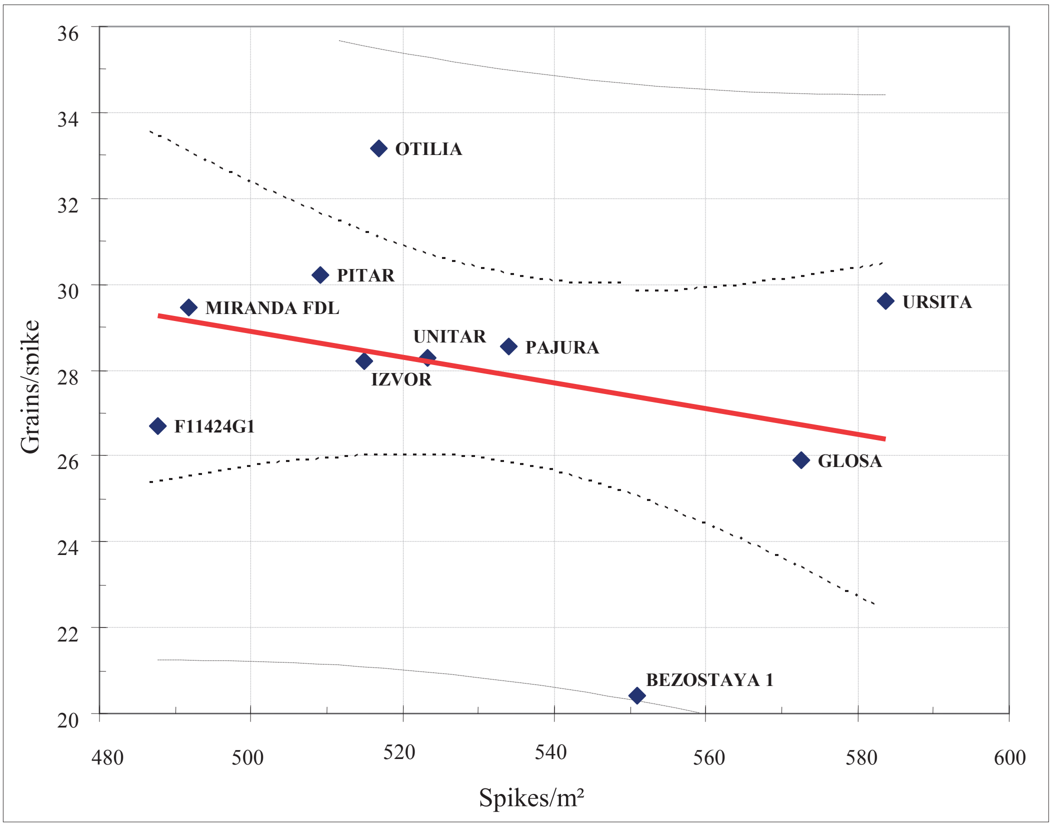

Figure 3. Relationship between Spikes/m^2 and Grains/spike averaged over 26 yield trials

As seen in Table 1, deviations from the regression were quite consistent in the three years of testing. ANOVA demonstrated that differences between cultivars in their deviations from the regression between the number of spikes per unit area and the number of grains per spike were significant (Table 2).

A similar situation was found in the case of regression between the number of grains per m^2 and TKW (Figure 4). Cultivars F11424G1 and Unitar formed significantly heavier grains (TKW higher by 2.6 to 3.5 g) than expected based on the regression on the number of grains, while Bezostaya 1, Izvor and Otilia formed smaller grains than expected.

Deviations were consistent in the three years of testing, some cultivars showing only positive deviations, while others had only negative deviations from regression (Table 3). ANOVA showed that cultivars were significantly different in their deviations from the regression between the number of grains/spike and TKW (Table 4).

Table 1. Deviations from the regression between the number of spikes/m² and the number of grains/spike, averaged for each year of testing

Cultivar	2016	2017	2018	Average
Number of yield trials	*5*	*10*	*11*	*26*
Otilia	2.68	4.28	6.71	4.76
Ursita	3.89	3.37	1.29	3.22
Pitar	0.85	0.89	-1.45	1.58
Pajura	0.17	-0.33	-2.07	0.66
Miranda FDL	5.11	-0.69	0.08	0.31
Unitar	-2.24	2.90	0.72	0.08
Izvor	-1.63	0.17	1.56	-0.26
Glosa	-1.68	-1.68	-2.41	-0.83
F11424G1	-0.07	-5.38	-3.37	-2.57
Bezostaya 1	-12.09	-5.05	-5.51	-6.94

Table 2. ANOVA for the deviations from the regression of grain number per spike on the number of spikes per unit area

Source of variation	SS	df	MS	F
Between cultivars	299.75	9	33.31	6.50**
Within cultivars	102.40	20	5.12	
Total	402.15	29		

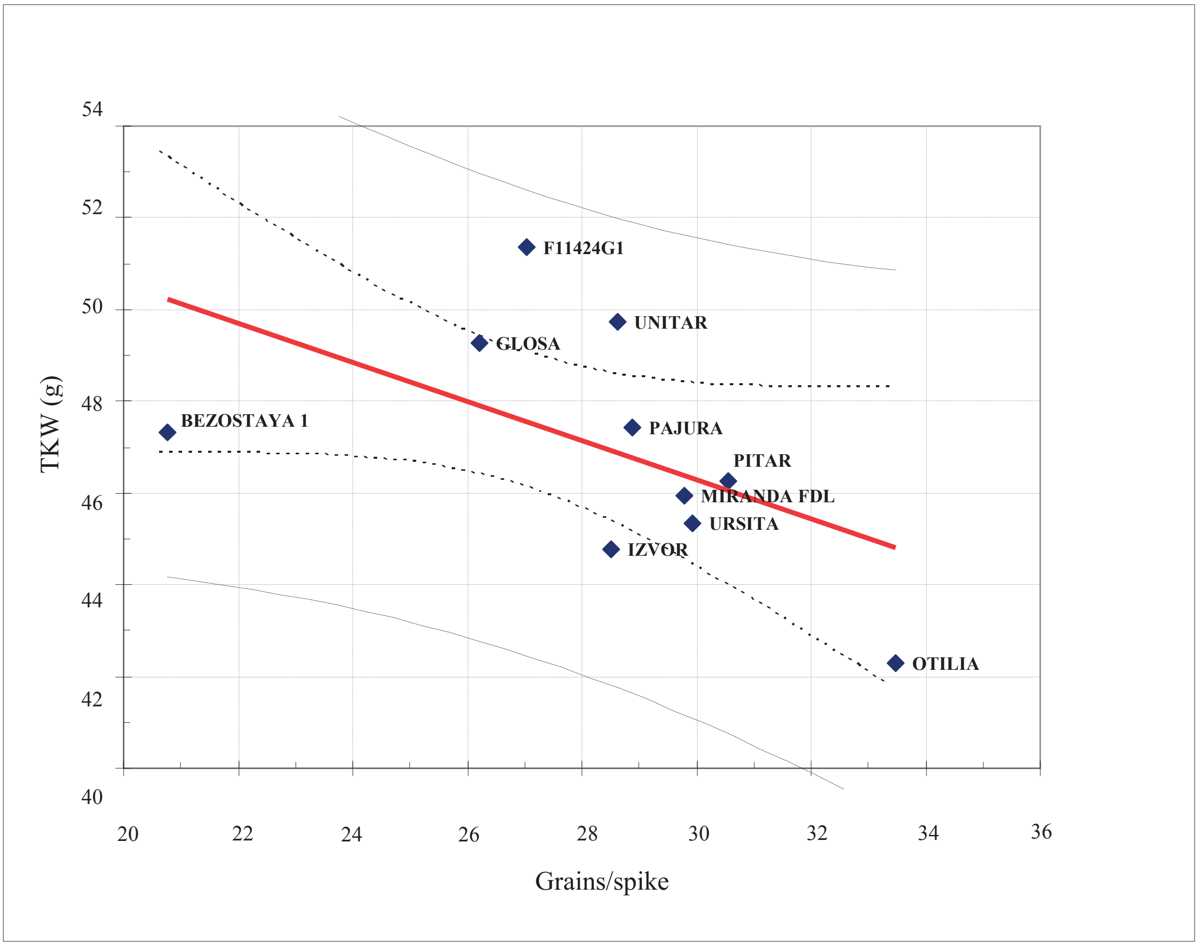

Figure 4. Relationship between Grains/spike and TKW averaged over 26 yield trials

Table 3. Deviations from the regression between the number of grains/spike and TKW

Cultivar	2016	2017	2018	Average
Number of yield trials	*5*	*10*	*11*	*26*
F11424G1	1.73	4.11	5.96	3.57
Unitar	2.92	2.37	4.08	2.68
Glosa	2.13	1.39	1.55	1.31
Pajura	0.35	0.24	2.09	0.62
Pitar	1.87	-0.13	-0.31	0.18
Miranda FDL	0.21	-0.83	1.22	-0.41
Ursita	-1.18	0.28	-0.33	-0.90
Izvor	-3.20	0.00	-1.06	-2.00
Otilia	-2.10	-2.60	0.09	-2.35
Bezostaya 1	-2.29	-1.70	-3.33	-2.69

Table 4. ANOVA for the deviations from the regression of TKW on grain number per spike

Source of variation	SS	df	MS	F
Between cultivars	112.84	9	12.54	8.40**
Within cultivars	29.85	20	1.49	
Total	142.69	29		

Some of the cultivars had contrasting behaviour regarding the relationship between different yield components. For example, Otilia showed the highest positive deviation from the regression number of spikes - number of grains and a large negative deviation from the regression number of grains - TKW. On the contrary, line F114242G1 had the highest positive deviation from the regression number of grains - TKW and one of the largest negative deviations from the regression of the number of grains per spike on the number of spikes. This suggests that the compensation of yield components should be considered together for all components.

On the other hand, other cultivars had similar behaviour regarding the deviations from regressions between different yield components. For example, Bezostaya 1, the only non *Rht-B1b* cultivar in the analysed set, showed large negative deviations from both studied regressions. This is in agreement with the higher competition for assimilates typical for this taller cultivar, in comparison with the semidwarf *Rht-B1b* cultivars.

Some of the semidwarf cultivars showed positive or small negative deviations from both regressions that describe the relationship between the negatively correlated yield components. Such cultivars as Pajura, Unitar, Ursita, Pitar, etc. might be useful in breeding for increased yields, based on reducing compensations between yield components.

CONCLUSIONS

In the 26 yield trials performed in various environments of Romania, grain yield showed most frequently positive correlations with the number of grains per spike. Correlation coefficients of grain yield with the number of spikes per unit area ranged from -0.3 to +0.7, with most of the trials showing low positive correlations. Most trials showed practically no correlation of grain yield with TKW.

Most correlations among the yield components were negative, illustrating the difficulty of combining high values of more than one component. The strongest negative correlation was found between the number of spikes per unit area and the number of grains per spike, but most correlations between number of grains/spike and TKW were also negative.

Significant differences between cultivars were found in deviations from both regressions between negatively correlated yield components (number of spikes per m^2 - number of grains per spike and number of grains per spike - TKW respectively).

We suggest that cultivars showing positive or small negative deviations from the regressions between negatively correlated yield components might be useful in breeding for reducing compensations between yield components. Further studies are necessary to confirm if this could lead to genetic progress for yielding potential.

REFERENCES

Börner, A., Worland, A.J., Plaschke, J., Schumann, E., Law, C.N., 1993. *Pleiotropic Effects of Genes for Reduced Height (Rht) and Day-Length Insensitivity (Ppd) on Yield and its Components for Wheat Grown in Middle Europe*. Plant Breeding, 111(3):177-264.

Knott, D.R. and Talukdar, B., 1971. *Increasing Seed Weight in Wheat and Its Effect on Yield, Yield Components, and Quality.* Crop Science, 11(2): 280-283.

Slafer, G.A., Savin, R., Sadras, V.O., 2014. *Coarse and fine regulation of wheat yield components in response to genotype and environment*. Field Crops Research, 157: 71-83.

Zecevic, V., Boskovic, J., Dimitrijevic, M. and Petrovic, S., 2010. *Genetic and phenotypic variability of yield components in wheat (Triticum aestivum L.)*. Bulg. J. Agric. Sci., 16: 422-428.