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Correlation-Regression Analysis of Morphological-Production Traits of Wheat Varieties

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ABSTRACT

The investigation of three wheat varieties (PKB Talas, BG Merkur and PKB Lepoklasa) carried out at experimental field and laboratory of Institute PKB Agroekonomik, during two years 2009 and 2010. Correlations between morphological and production traits of plants number of shoots, number of spikelets per spike, number of grains per spike, 1000 grain weight and grain weight per spike, were studied. Correlations were observed separately for three Institute PKB Agroekonomik varieties. The manner of preparing data for calculating correlations influences obtained correlation values, and these values can differ substantially. Correlations calculated based on aggregated data are higher than those based on all data. Correlations differ for different varieties, which is logical, because each variety has a different genotype and specific genes forming various interactions. Taking into account all three varieties, high and positive correlations were found between: number of grains per spike and grain weight per spike (>0.78), number of spikelets per spike and number of grains per spike (>0.79), and number of spikelets per spike and grain weight per spike (>0.73).

Key words: wheat, varieties, correlation-regression analysis, morphological-production traits.

1. Introduction

The creation of high yielding varieties of wheat is one of the main goals of breeding. Indirect selection based on one or more components of grain yield has proven to be efficient compared to direct selection for total grain yield (B. GORJANOVIC & M. KRALJEVIC-BALALIC [1]. Therefore, the study of the correlation between traits that determine yield can help in the indirect selection of components of yield (V. ZECEVIC & al. [2], N. HRISTOV & al. [3]).

The main reason making breeding for individual components of yield difficult is that the components of yield frequently have negative mutual correlations (B. GORJANOVIC & M. KRALJEVIC-BALALIC [1]).

Correlation analysis shows the intensity of dependence (correlation) between studied traits. From the genetic aspect, correlation indicates links between genes, or the appearance of pleiotropic effects of genes. Gene linkage pertains to their position on the same chromosome, while pleiotropy appears when one gene regulates the expression of several traits.

D.S. FALCONER [4] emphasizes that correlations in plant breeding are important for multiple reasons, and that one should know that an improvement of one trait is simultaneously reflected on the change of other traits.

D.E. THIRY & al. [5] have established that grain yield depends to a high degree on the number of plants contained on a certain surface area, the number of shootsper plant, number of grains per spike and grain weight per spike. A. J. KHAN & al. [6] state that the number of shoots, together with the number of spikelets per spike and 1000 grain weight, has the highest positive effect on yield. W. HAQ & al. [7] emphasize that, in addition to mentioned characteristics, the number of grains per spike also has a significant positive correlation with yield.

R. IFTIKHAR & al. [8] have established that the number of spikelets per spike, number of grains per spike, and 1000 grain weight have a positive and statistically significant correlation with grain yield, and emphasize that the number of grains per spike and 1000 grain weight have a direct effect on yield and that, therefore, they can be used as direct selection criteria.

B. BANJAC & al. [9] have established highly significant positive correlations between spike parameters and the number of grains per spike, where the strongest direct correlation in all three vegetation seasons was present between the weight of the number of grains per spike and grain weight per spike.

The goal of this investigation was to compare mutual relations via correlations based on aggregated data, with mutual relations of traits resulting from correlations implemented to data that encompass all observations during the two year trial.

2. Material and Methods

The material used were three divergent Institute PKB Agroekonomik wheat varieties (PKB Talas, BG Merkur and PKB Lepoklasa), investigated during two production years, 2009 and 2010. Three treatments were investigated for each of these varieties in relation to the implementation of selection and crop density, corresponding to requirements for producing three different categories of seeds: pre-basic seed, basic seed and seed for variety reproduction. Plants in each of the different production conditions were monitored, accompanied by the measuring of their phenotypic characteristics.

Field micro-trials were done at the Experimental Field of Institute PKB Agroekonomik, Padinska Skela. Micro-trials were done on humogley type soil. Each category of seed plants was produced by applying standard agro-technical measures.

Following morphological and production traits of plants were analyzed: number of shoots, number of spikelets per spike, number of grains per spike, 1000 grain weight, and grain weight per spike.

The degree and form of dependence between traits was established by applying correlation and regression coefficients. Correlation and regression analysis was done using the program Statistica for Windows 8.0. Correlations were observed separately for each variety. Correlation was done in two ways, first based on average values obtained by data aggregation, by taking into account only 18 values (3 varieties x 2 years x 3 seed categories), and second for all data on all 1800 plants belonging to the same varieties.

Differences between correlations calculated in two ways, in relation to the number of observations included in, indicate to wheat breeders and seed producers, that when analyzing results and planning their work, they must devote attention to what they have taken as the basis for assessing relations between traits. To date no major attention was devoted to this, so the relation between traits was established without a biological link to the investigation goal.

Regression analysis was done only as a supplement to correlation and is presented in graphs showing the relationship between investigated dependent and independent traits. The paper presents regression lines only for mutually highly dependent traits (grain weight per spike and number of grains per spike). In addition to regression lines, graphs also present distribution points for values of these traits for investigated plants.

3. Results and Discussion

Correlation is a pragmatic approach for developing a selection criterion to accumulate optimal combinations of traits contributing to yield within one genotype (M. MUNIR & al. [10]).

Table 1 contains correlation coefficients (r) for investigated traits of wheat variety PKB Talas. Correlation coefficients based on aggregated data were only positive, while those based on all data had positive and negative values.

Highly significant and significant positive correlations for aggregated data were established for the variety PKB Talas (Table 1).

The number of secondary shoots has a highly significant and positive correlation with grain weight per spike (0.71), and the number of grains per spike (0.62), while there is a significant positive correlation with the number of spikelets per spike (0.59) and the 1000 grain weight (0.54). KASIHF & KHALIQ [11] obtained similar results stating that the number of secondary shoots has a significant positive correlation with the number of grains per spike.

The number of spikelets per spikeis a very important trait because it directly influences the number of grains per spike and grain weight per spike with which it has a highly significant and positive correlations (0.91 and 0.77). Similar results were obtained by V. ZECEVIC & al. [2], [12] and O. BILGIN & al. [13], B. AHMAD & al. [14] and W. HAQ & al. [7] coming to similar conclusions and stating that genotypes with a higher number of spikelets per spike produce more grains per spike, and thus have a higher total yield.

Grain weight per spike plays an important role in yield because it directly influences the harvest index, thus directly influencing the final grain yield (R. PROTIC & al. [15]).

Grain weight per spike had highly significant and positive correlations with all investigated characteristics. B. JOCKOVIC & al. [16] established that grain weight per spike has significant positive correlations with the number of grains per spike and 1000 grain weight.

Table 1. Correlation coefficients (r) for traits for aggregated data (above the diagonal) and for all data (below the diagonal) for the variety PKB Talas

Investigated traits	**Number of secondary shoots**	**Number of spikelets per spike**	**Number of grains per spike**	**1000 grain weight (g)**	**Grain weight per spike (g)**
Number of secondary shoots	1.00	0.59*	0.62**	0.54*	0.71**
Number of spikelets per spike	0.53*	1.00	0.91**	0.12	0.77**
Number of grains per spike	0.49*	0.90**	1.00	0.30*	0.92**
1000 grain weight (g)	-0.01	-0.04	-0.04	1.00	0.65**

Grain weight per spike (g)	0.42*	0.76**	0.85**	0.50*	1.00

*** p<0.01; p<0.05**

Based on all data, correlation coefficients for the variety PKB Talas demonstrate significant and highly significant correlations between investigated characteristics (Table 1).

The number of secondary shoots has a significant positive correlation with the number of spikelets per spike (0.53), number of grains per spike (0.49) and grain weight per spike (0.42), while there is no statistically significant correlation with the 1000 grain weight.

As with the aggregated data, the number of spikelets per spike had a statistically highly significant correlations with the number of grains per spike (0.90) and grain weight per spike (0.76), which is in agreement with results stated by Z. AKRAM & al. [17].

The number of grains per spike has a highly significant positive correlation with grain weight per spike (0.85). Many scientists are of the opinion that an increase of the number of grains per spikelet ads to increase in wheat yield (M. GUOHUA & al. [18], P. DE VITA & al. [19], N. ZAFARNADERI & al. [20]).

The 1000 grain weight had a significant and positive correlation only with the grain weight per spike (0.50).

Based on performed investigations, it can be noted that mutual correlations between investigated characteristics are stronger for aggregated data compared to correlations based on all data.

Deviations were more pronounced between correlation coefficients calculated in one way or the other, especially for traits that vary discontinuously, which is especially true for correlations between the number of shoots and other traits.

Regression lines illustrate the form of dependence (Fig 1 and 2) between traits of PKB Talas varieties that had the highest coefficients of simple correlation (0.92 and 0.85): number of grains per spike and grain weight per spike. This was done on two graphs, to clearly show their dependence together with distribution points for aggregated data and for all data.

The regression line (Fig 1) shows that in plants of the PKB Talas variety, with the increase of the number of grains per spike by 1, grain weight per spike increases by 0.039 g.

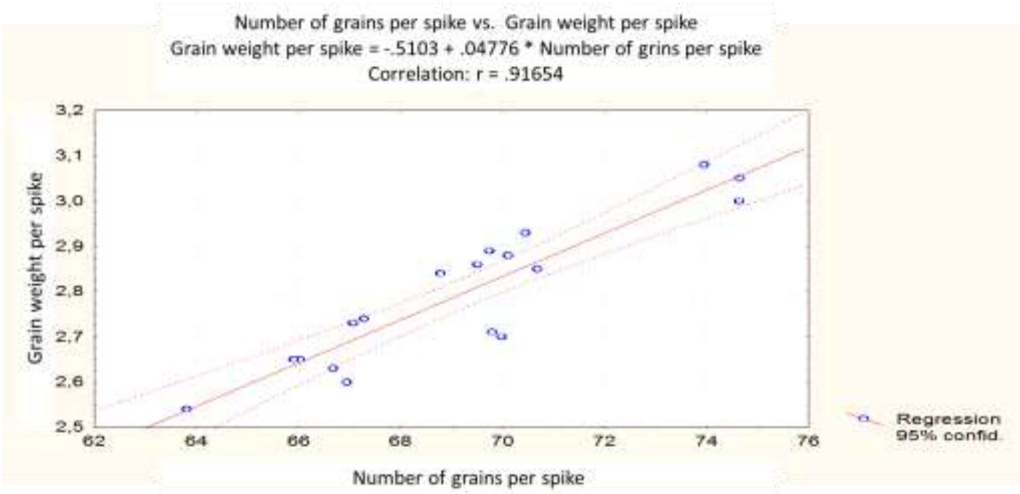

Figure 1. Regression between grain weight per spike (y) and number of grains per spike (x), for the variety PKB Talas for aggregated data

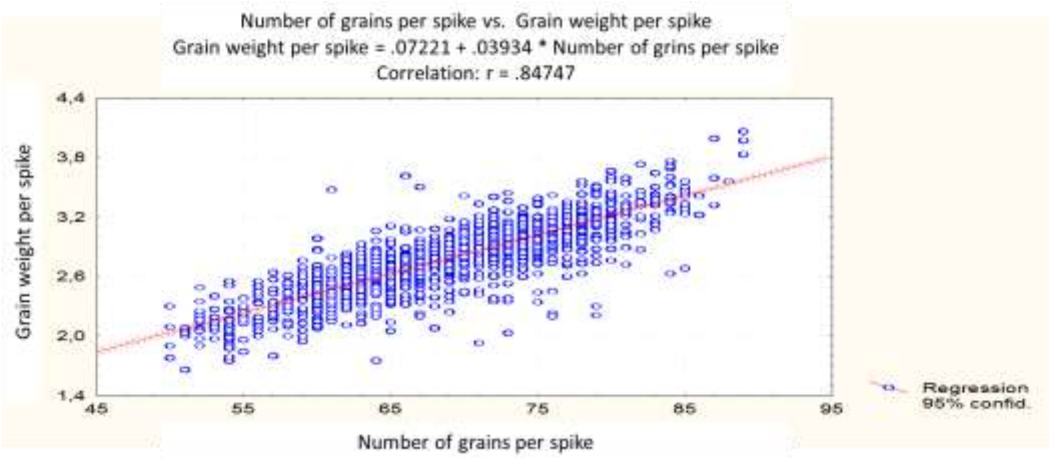

Figure 2. Regression between grain weight per spike (y) and number of grains per spike (x), for the variety PKB Talas for all data

Table 2 contains correlation coefficients (r) between investigated traits for the wheat variety BG Merkur. A highly significant and significant correlation for investigated traits for the variety BG Merkur was established for aggregated data (Table 2).

The number of secondary shoots has a highly significant and positive correlation with grain weight per spike (0.84) and 1000 grain weight (0.78), and the number of spikelets per spike (0.74), while it has a significant positive correlation with the number of grains per spike (0.49). Similar correlations for this investigated trait were also established for the genotype PKB Talas.

The number of spikelets per spike has a highly significant positive correlation with the number of grains per spike (0.79) and grain weight per spike (0.91), while the correlation with 1000 grain weight is significant (0.56).

Grain weight per spike had highly significant positive correlations with all investigated characteristics.

Table 2. Correlation coefficients (r) for traits for aggregated data (above the diagonal) and for all data (below the diagonal) for the variety BG Merkur

Investigated traits	**Number of secondary shoots**	**Number of spikelets per spike**	**Number of grains per spike**	**1000 grain weight (g)**	**Grain weight per spike (g)**
Number of secondary shoots	1.00	0.74**	0.49*	0.78**	0.84**
Number of spikelets per spike	0.43*	1.00	0.79**	0.56*	0.91**
Number of grains per spike	0.35*	0.82**	1.00	0.11	0.78**

1000 grain weight (g)	0.05	-0.03	-0.11	1.00	0.71**
Grain weight per spike (g)	0.35*	0.73**	0.85**	0.43*	1.00

***p<0.01; *p<0.05*

Correlation coefficients for the variety BG Merkur based on all data show significant and highly significant correlations between investigated characteristics (Table 1).

Grain weight per spike has a highly significant correlation with the number of grains per spike (0.85) and number of spikelets per spike (0.73). In addition, a highly significant and positive correlation was established between the number of grains per spike and the number of spikelets per spike (0.82).

The number of secondary shoots has a statistically significant positive correlations with the number of spikelets per spike (0.43), the number of grains per spike (0.35), and grain weight per spike (0.35). Thousand grain weight had a significant correlation only with the grain weight per spike (0.43).

Results obtained for the variety BG Merkur correspond to data obtained for the variety PKB Talas and show that correlations based on aggregated data are mainly higher than those based on all data. Also for the variety BG Merkur, deviations between the two ways of determining correlations are higher when the correlation pertains to traits that vary discontinuously.

As an example of regression analysis for the variety BG Merkur, dependence of grain weight per spike (y) on the number of grains per spike (x) was also used. The regression line for aggregated data is presented in Fig 3, and for all data in Fig 4. Taking into account all plants, it is evident (Fig 4) that the increase of the number of grains per spike by 1, increases grain weight per spike by 0.036 g.

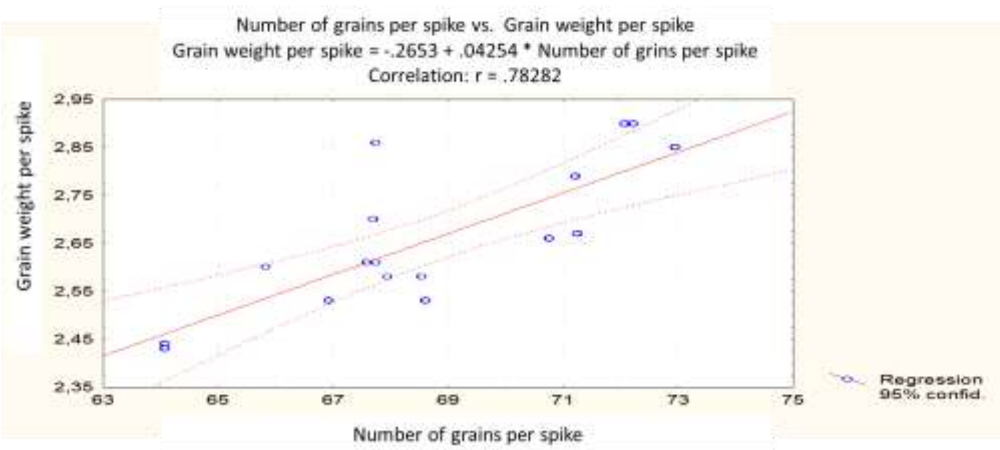

Figure 3. Regression between grain weight per spike (y) and number of grains per spike (x), for the variety BG Merkur for aggregated data

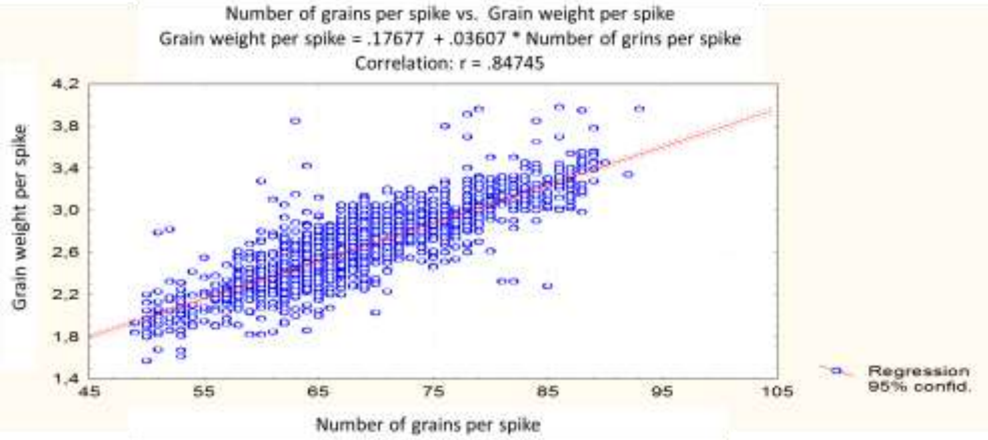

Figure 4. Regression between grain weight per spike (y) and number of grains per spike (x), for the variety BG Merkur for all data

Table 3 contains correlation coefficients (r) between investigated traits for wheat varieties PKB Lepoklasa. A highly significant positive correlation between all investigated characteristics of the variety PKB Lepoklasa for aggregated data is established (Table 3).

The number of secondary shoots has a highly significant positive correlation with the number of grains per spike (0.96), grain weight per spike (0.93), number of spikelets per spike (0.88), and 1000 grain weight (0.73).

The number of spikelets per spike and the number of grains per spike have a mutual highly significant correlation (0.93), as well as the 1000 grain weight and the number of grains per spike (0.76). Grain weight per spike has a highly significant positive correlation with all investigated characteristics.

Correlation coefficients for the variety PKB Lepoklasa based on all data (data about each analyzed plant) were reviewed (Table 3).

A highly significant positive correlation was established between the number of grains per spike and the number of spikelets per spike (0.90). Grain weight per spike had a highly significant positive correlation with grain weight per spike (0.80) and the number of grains per spike (0.92), while it had a significant correlation with 1000 grain weight (0.59).

Table 3. Correlation coefficients (r) for traits for aggregated data (above the diagonal) and for all data (below the diagonal) for the variety PKB Lepoklasa

Investigated traits	Number of secondary shoots	Number of spikelets per spike	Number of grains per spike	1000 grain weight (g)	Grain weight per spike (g)
Number of secondary shoots	1.00	0.88**	0.96**	0.73**	0.93**
Number of spikelets per spike	0.14	1.00	0.93**	0.63*	0.87**
Number of grains per spike	0.17	0.90**	1.00	0.76**	0.97**
1000 grain weight (g)	0.09	0.15	0.23	1.00	0.90**
Grain weight per spike (g)	0.17	0.80**	0.92**	0.59*	1.00

$**p<0.01$; $*p<0.05$

All ten comparisons show that correlation is higher when it is calculated based on aggregated values than when it is based on all values, and this between following traits: number of shoots and number of spikelets per spike (0.88>0.14), number of shoots and number of grains per spike (0.96>0.17), number of shoots and 1000 grain weight (0.73>0.09), number of shoots and grain weight per spike (0.93>0.17), number of spikelets per spike and number of grains per spike (0.93>0.90), number of spikelets per spike and 1000 grain weight (0.63>0.15), number of spikelets per spike and grain weight per spike (0.87>0.80), number of grains per spike and 1000 grain weight (0.76>0.23), number of grains per spike and grain weight per spike (0.97>0.92), and 1000 grain weight and grain weight per spike (0.90>0.59).

The example used for the regression line for the variety PKB Lepoklasa was the one showing the form of dependence between grain weight per spike (y) and number of grains per spike (x), for aggregated data (Fig 5) and for all data (Fig 6). As with other varieties, here also the regression line also shows an upward trend. For each unit of increase of the number of grains per spike for PKB Lepoklasa plants, grain weight per spike increases by 0.05 g.

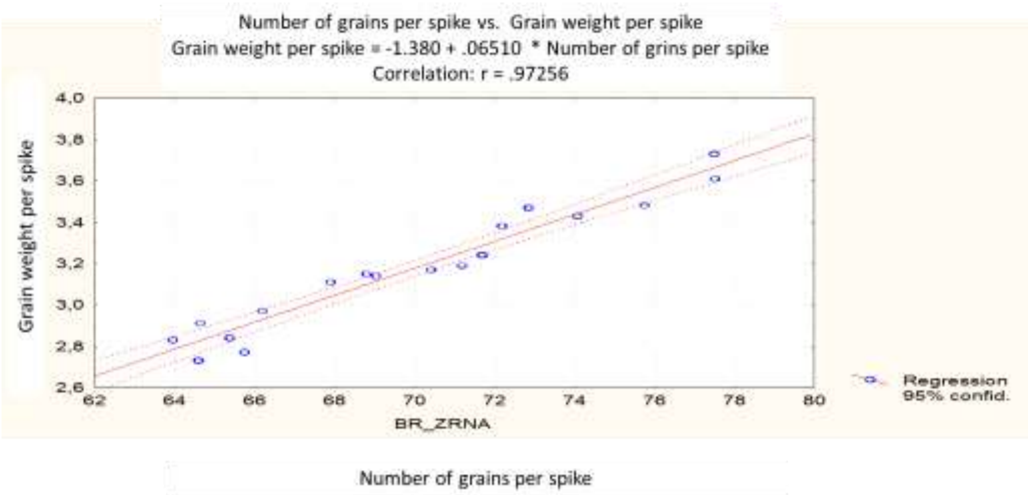

Figure 5. Regression between grain weight per spike (y) and number of grains per spike (x), for the variety PKB Lepoklasa for aggregated data

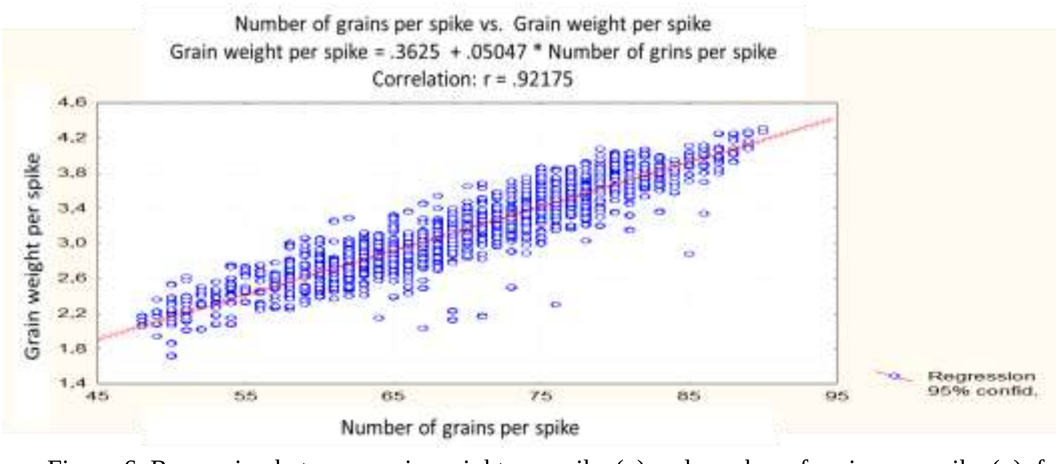

Figure 6. Regression between grain weight per spike (y) and number of grains per spike (x), for the variety PKB Lepoklasa for all data

4. Conclusions

Obtained results show that the manner of preparation of data for calculating correlation influences obtained values for correlations and that these values can substantially differ. Correlations calculated based on aggregated data are higher than those based on all data.

Deviations are greater between coefficients of correlation calculated in one manner or the other, especially for traits with discontinuous variation. This especially pertains to correlations between the number of shoots and other traits (variety PKB Talas), although changes of correlation between different varieties are not in the same direction. Certain varieties have a more pronounced, and others a weaker correlation between traits.

If the desire is to achieve an increase of the value of traits and their interrelationship by selection, then the parents should be the variety where these traits are more pronounced, with a higher dependence between desirable traits. For example, the variety PKB Talas has more shoots (3.26) and spikelets (21.66) than other varieties. If the goal is to increase the number of spikelets and to have stronger clustering, PKB Talas should be used, because it has a higher correlation between these traits ($r = 0.53$), not the variety BG Merkur which has a lower correlation between these traits ($r = 0.43$).

Correlations differ for different varieties. This is logical, because each variety has a different genotype and specific genes forming various interactions. Taking into account all three varieties, high and positive correlations were found between: the number of grains per spike and grain weight per spike (>0.78), number of spikelets per spike and number of grains per spike (>0.79), and between the number of spikelets per spike and grain weight per spike (>0.73).

The number of shoots is the trait with the strongest correlation with the majority of other traits, as shown during correlation-regression analysis of aggregated data. However, the strength of these relationships considerably decreases when all data are analyzed, which can be attributed to a discontinuous variability of this trait. This tells wheat breeders and seed producers that when analyzing data they need take care whether they are using traits with continuous or discontinuous variability.

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