CORRELATIONS OF YIELD AND GRAIN YIELD COMPONENTS OF WINTER WHEAT VARIETIES

Rade Protić¹, Goran Todorović² and Nada Protić³

Abstract: Mean positive correlation ($r = 0.47^{**}$) between grain yield and number of plants per m² and strong correlation between grain yield and number of spikes per m² were established ($r = 0.55^{**}$). Weak correlation was established between grain yield and productive tillering ($r = 0.24^{**}$). Strong positive correlation ($r = 0.51^{**}$) is between the number of spikes per m² and productive tillering, as well as between the number of plants per m² and number of spikes per m² ($r = 0.68^{**}$). Very weak negative correlation ($r = -0.12^*$) is between productive tillering and the number of plants per m².

Regression equations of grain yield and other investigated traits, on the level of significance 5% and 1%, have linear form. By increasing one plant per m², the number of spikes for one per m², productive tillering for one, grain yield will be increased for 0.006 t/ha, 0.005 t/ha and 1.174 t/ha on the average. The other regression equations between the number of spikes per m², number of plants per m² and productive tillering have linear form. By increasing one plant per m² and productive tillering for one, the increase of number of spikes per m² is 1.087 and 312.21 on the average. By increasing the number of plants per m², productive tillering is reduced for 47.59 on the average.

Key words: wheat, correlations, regression, yield and grain yield components.

Introduction

In the last few decades, the following conception has been adopted and practice has been introduced that high grain yields of wheat are achieved with the great number of plants per area unit and in the intensive cultural conditions.

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In the large populations, competition between plants is getting bigger, so they have to be reduced in order to use water more efficiently, mineral nutrients and sunlight. It is necessary that optimal structure is determined in order to maximally use genetic potential for grain yield. One more reason is that new wheat genotypes are continually made which are different according to their stem height, lodging resistance, and intensity of tillering, arrangement of leaves, structure form, and use of nutrients from soil and water, photosynthetic rates and the other.

Optimal population size and structure of wheat, regarding the ability for tillering and self-regulation, is constant subject for researches. More intensive investigations started in Serbia in 1960s. According to the greater number of experiments, carried out in our institutes with various varieties and planting density, it was concluded that by planting from 500 to 600 germinated grains per m², which insures structure from 700 to 800 spikes per m², high grain yields are achieved with good nutrient supply (Borojević et al., 1961; Jeftić, 1967, 1974; Jeftić and Spasojević, 1973; Borojević, 1980; Protić, 1980, 1988, 1999; Šćepanović, 1979).

Material and Methods

In order to determine dependability between traits investigated in this work, the method of common correlation and regression method are applied. Correlation analysis method helps to determine dependability between investigated phenomena which have to be included in regression analysis by means of common correlation coefficient (r).

Within regression analysis, linear function form was applied and it facilitates determination of yield changes depending on yield components. In order to adopt their values for investigated phenomenon on the whole, evaluation of regression coefficient significance was derived by means of t-test. Zero hypothesis and risk level of 5 % and 1 % were used for evaluation of regression coefficient significance. This work shows correlations and regressions between wheat grain yields as dependant variables on the one hand, and yield components as independent variables on the other hand (the number of plants per m², the number of spikes per m² and productive tillering).

The results show triennial testing average (2003/04—2005/06).

Statistical data analysis was done by the MSTAT – C program, Michigan State University, Version 1.

Results and Discussion

The number of plants per m²

If grain yield dependability on investigated indicators is observed, mean positive (r = 0.47**) correlation can be noticed between grain yield and the number of plants per m² (Table 1).
Strong positive correlation is determined between the number of plants per m² and number of spikes per m² \((r=0.68**)\). Very weak negative correlation \((r=-0.12*)\) is between the number of plants per m² and productive tillering (Table 1).

By establishing optimal structure in the case of winter wheat, Borojević et al. (1961) concluded that the number of plants per m² is not of crucial importance for yield, because the wheat just as the other similar varieties has the ability to autoregulate the structure.

Sarić, (1965) states that the yield, in great measure, depends upon the number of plants per unit area.

In the researches of grain yield and some yield components in the case of various wheat genotypes, and during different planting density, Protić et al. (1988) establish strong positive correlation between grain yields and number of plants per m² \((r = 0.88**)*\).

Regression equation shows how one trait, dependent variable, changes if an independent variable changes for one unit. In that way, regression equation between grain yield and number of plants per m² was established. It was evaluated as highly important on the level of 5 % and 1 % and it had linear equation form,

\[ y = 4.07 + 0.006 x_1 \]

and it shows to us that by increasing one plant per m², the grain yield will increase on the average for 0,006 t/ha (Table 2 and Figure 1).

Tab. 1 - Simple correlation coefficients between investigated traits in the case of wheat

<table>
<thead>
<tr>
<th>Investigated traits</th>
<th>(X_1)</th>
<th>(X_2)</th>
<th>(X_3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(X_1) - number of plants per m²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(X_2) - number of spikes per m²</td>
<td>0.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(X_3) - productive tillering coefficient</td>
<td>-0.12</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>(Y) - grain yield</td>
<td>0.47</td>
<td>0.55</td>
<td>0.24</td>
</tr>
</tbody>
</table>

The number of spikes per m²

Strong positive correlation was established between grain yields and the number of spikes per m² \((r = 0.55 **)*\). Strong positive correlation \((r = 0.51**)*\) is between the number of spikes per m² and productive tillering as well as the number of plants per m² and number of spikes per m² \((r = 0.68**)*\).

Linear regression equation was established between the number of spikes per m² and grain yields and was of significant regression coefficient on the level of 5% and 1%, having the following form:

\[ y = 4.00 + 0.005 x_2, \]

which shows that by increasing the number of spikes per m² for one, grain yield increases for 0,005 t/ha on the average (Table 2 i Figure 2).
By researches of Borojević et al. (1973) and Protić (1980, 1988), it was concluded that optimal structure in the case of semi dwarf winter wheat varieties, with good disease resistance, with average leaf blade, with apical erected position of leaf blade, amounts from 700 to 800 spikes per m² in the intensive agronomy practices for maximal grain production. A leaf blade area index (LAI) is around 6, leaf index (LAI) is about 9 and the long duration of green area after the milk stage phase.

Sarić (1965) found out that smaller number of spikes can hardly be compensated by the number and grain weight per spike, and that realization of structure from 500 to 700 spikes per m² should be aimed at in the production conditions. Drezgić (1971), in his researches, concluded that the highest yield is realized with 600 to 700 spikes per m² and that smaller number of spikes do not manage to compensate unused vegetative space by the increased yield per spike. Larger number of 700 spikes per m² does not provide adequate yield increase, but it, due to competition, leads to yield decrease. Đokić (1975) and Lešnik (1977) came to the same results.

Borojević (1972) said that there is a strong positive correlation between the number of spikes per m² and wheat grain yield, while Protić (1980, 1988 and 1999) established mean to strong highly significant positive correlation (r=0.48**, 0.87**, 0.87**).

**Productive tillering coefficient**

Weak correlation (r = 0.24**) was established between grain yield and productive tillering. Linear regression equation of significant regression coefficient on the level of 5 % and 1 %, was established between productive tillering coefficient and grain yield, which has the following form:

\[ y = 5.22 + 1.174x_3 \]

and it shows that by increasing productive tillering for one, grain yield increases for 1,174 t/ha (Table 2 and Figure 3).

The other regression equations between the number of spikes per m², number of plants per m² and productive tillering have linear form. By increasing one plant per m² and productive tillering for one, increase of the number of spikes per m² is 1,087 and 312,21 on the average. By increasing productive tillering for one, the number of plants per m² is reduced for 47,59 on the average (Table 2, Figure 4, 5, 6).

In the researches of grain yield and some yield components in the case of various wheat genotypes during different planting density, Protić et al. (1988, 1999) established strong positive correlation between grain yield and productive
Correlations of wheat yield and grain yield

tillering \( (r=0.87**) \), then between productive tillering and number of plants per m² \( (r=0.90**) \), number of spikes per m² and productive tillering \( (r=0.80**) \), weak correlation between productive tillering and 1000-kernel weight and hectoliter weight.

Borojević and Ćupina (1969), by testing yield components in the case of different wheat genotypes, concluded that the greater number of various traits have more decisive role in yield making in the case of various genotypes. It is the result of interaction between traits within one genotype as well as between genotype and environmental factor.

Swedish scientist Mac Key (1966) pointed out that the yield is very relative term and it is always determined by variety, ecological conditions and level of the sole production.

Tab. 2. - Regression equation, standard error of regression between grain yield and yield components for wheat

<table>
<thead>
<tr>
<th>Investigated traits</th>
<th>Regression equation ( (y) )</th>
<th>( T )-value</th>
<th>Significance</th>
<th>( \text{Syr} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of plants per m² and grain yield</td>
<td>( y = 4.07 + 0.006x_1 )</td>
<td>8.417</td>
<td>**</td>
<td>0.001</td>
</tr>
<tr>
<td>No. of spikes per m² and grain yield</td>
<td>( y = 6.82 + 0.001x_2 )</td>
<td>10.465</td>
<td>**</td>
<td>0.000</td>
</tr>
<tr>
<td>Productive tillering coefficient and grain yield</td>
<td>( y = 6.78 + 0.400x_3 )</td>
<td>3.845</td>
<td>**</td>
<td>0.353</td>
</tr>
<tr>
<td>No. of plants per m² and no. of spikes per m²</td>
<td>( y = 142.66 + 1.087x_4 )</td>
<td>14.626</td>
<td>**</td>
<td>0.074</td>
</tr>
<tr>
<td>No. of spikes per m² and productive</td>
<td>( y = 196.45 + 312.206x_5 )</td>
<td>9.474</td>
<td>**</td>
<td>32.954</td>
</tr>
<tr>
<td>tillering coefficient and no. of plants per m²</td>
<td>( y = 522.37 - 47.589x_6 )</td>
<td>1.998</td>
<td>*</td>
<td>23.820</td>
</tr>
</tbody>
</table>

\[ y = 4.07 + 0.006X_1 \\ r=0.47** \]

Fig. 1. - Regression analysis between the number of plants per m² and grain yield for wheat
Fig. 2. - Regression analysis between the number of spikes per m$^2$ and grain yield for wheat

Fig. 3. - Regression analysis between productive tillering coefficient and grain yield for wheat

Fig. 4. - Regression analysis between the number of plants per m$^2$ and number of spikes per m$^2$ for wheat
Correlations of wheat yield and grain yield

\[ y = 196.45 + 312.206X^5 \]
\[ r = 0.51^{**} \]

Fig. 5. - Regression analysis between the number of spikes per m² and productive tillering coefficient for wheat

\[ y = 522.37 - 47.589X^6 \]
\[ r = -0.12^* \]

Fig. 6. - Regression analysis between productive tillering coefficient and the number of plants per m² for wheat

**Conclusion**

According to the research results about the relationship between grain yields and some grain yield components, the following conclusion can be brought:

- mean positive correlation was established between grain yield and number of plants per m² \((r = 0.47^{**})\) and strong correlation between grain yield and number of spikes per m² \((r = 0.55^{**})\);
- weak correlation \((r = 0.24^{**})\) was established between grain yield and productive tillering;
- strong positive correlation \((r = 0.51^{**})\) is between the number of spikes per m² and productive tillering as well as between the number of plants per m² and number of spikes per m² \((r = 0.68^{**})\);
very weak negative correlation \( r = -0.12^* \) is between productive tillering and the number of plants per m²;

- regression equations of grain yield and the other investigated traits, on the level of significance of 5% and 1%, have linear form. By increasing one plant per m², the number of spikes per one per m², productive tillering for one, grain yield will increase for 0.006 t/ha, 0.005 t/ha and 1.174 t/ha on the average;

- by increasing one plant per m² and productive tillering for one, the increase of the number of spikes per m² is 1.087 and 312.21 on the average. By increasing productive tillering, the number of plants per m² is reduced for 47.59 on the average.

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KORELACIJE PRINOSA I KOMPONENATA PRINOSA ZRNA SORTI OZIME PŠENICE

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Rezime

Ustanovljena je srednja pozitivna (r=0,47**) korelacija između prinosa zrna i broja biljaka po m² i jaka korelacija između prinosa zrna i broja klasova po m² (r=0,55**). Između prinosa zrna i produktivnog bokorenja utvrđena je slaba korelaciona veza (r=0,24**). Jaka pozitivna korelacija (r=0,51**) je između broja klasova po m² i produktivnog bokorenja, kao i između broja biljaka po m² i broja klasova po m² (r=0,68**). Jako slaba negativna korelacija (r=-0,12*) je između produktivnog bokorenja i broja biljaka po m².

Jednačine regresije prinosa zrna i drugih ispitivanih osobina, na nivou značajnosti 5% i 1%, imaju linearni oblik. Povećanjem jedne biljke po m², broja klasova za jedan po m², produktivnog bokorenja za jedan prinos zrna će se uvećati za 0,006 t/ha, 0,005 t/ha i 1,174 t/ha u proseku. Ostale jednačine regresije između broja klasova po m², broja biljaka po m² i produktivnog bokorenja imaju linearni oblik. Povećanjem jedne biljke po m² i produktivnog bokorenja za jedan dovodi do uvećanja broja klasova po m² u proseku za 1,087 i 312,21. Povećanjem broja biljaka po m² produktivno bokorenje umanjuje se za 47,59 u proseku.