SELECTION FOR GRAIN YIELD & YIELD COMPONENTS IN EARLY GENERATIONS FOR TEMPERATE RICE

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The study aimed to determine the response to selection for high and low grain yields and yield components, estimate the heritabilities of these traits, and compute for any correlation of grain yield with yield components in different generations of rice. The research was conducted at Thrace Agricultural Research Institute, Edirne, Turkey in 1995 and 1996. Two segregating populations for each generation were used in F3, F4, and F5. The results indicated that selections for grain weight and number of grains per panicle were effective in early generations. There were positive and significant associations between grain yield and number of grains per panicle in all populations in both years. High heritabilities were estimated for the 1,000-grain weight. The estimated narrow-sense and realized heritabilities were similar in magnitude. The selection for grain weight was effective inasmuch as direct grain yield selection and number of grains per panicle followed it. The selection results for low and high progenies of the yield components, correlations between grain yield and yield components and heritability values, indicated that the number of grains per panicle and desired grain size could be used as selection criteria in early generations.

Keywords 1,000-grain weight, early generation, heritability, rice, selection, yield components

INTRODUCTION

Rice breeders are interested in developing cultivars with improved yield and other desirable agronomic characters. To achieve this goal, breeders have the option of selecting desirable genotypes in early generations or delaying intense selection until advanced generations are reached, when progenies are now nearly homozygous. In the early stages of breeding programs, direct estimates of yield are quite difficult, so plant breeders commonly select for yield components that indirectly increase yield. Yield-component breeding to increase grain yield would be most effective if the components involved were highly heritable and genetically independent or positively correlated.

The selection criterion for production may be yield, or one or more of the morphological components of yield, i.e., number of panicles per unit area, number of grains per panicle, or grain weight.

On one hand, Woodworth (1931) suggested that yield might be increased in small grains by selecting for the component of yield and that parental varieties should be selected on the basis of component attributes. On the other hand, Frankel (1935) and Adams (1967) reported that the components of yield are influenced greatly by the environment and that negative correlations among them are common. Thus, selection for one of the components may fail to result in yield increase because of negative associations among the components. In contrast, Grafius (1960) suggested that individual yield components may contribute valuable information in breeding for yield. McNeal (1960) determined correlation between six plant characteristics and grain yield.
per plant in the F₂ and F₃ generations of a ‘Lemhi/Thather’ cross and observed that only kernels per plant was highly associated with yield in both generations. Knott & Talukdar (1971) suggested that wheat yield could be increased by selecting for increased kernel weight.

Rasmusson & Cannell (1970) selected lines for low and high yields and yield components in the F₃ generation of barley. They observed that selection for number of heads resulted in changes in yield that were similar to those when selection was for yield itself. Selection for kernel weight was highly effective in altering yield. They postulated that the optimum genotypic level for kernels per head and number of heads per plant would vary depending on environment, but that the optimum for kernel weight would be near its genetic maximum.

Strokopf & Reinbergs (1966) reported that grains per spike accounted for 50.4%, tiller per plant 28.3% and grain weight 21.3% of the variation in the yield of barley. In oats, grains per panicle was of even greater importance than in barley, accounting for a mean of 76.6% of the total variability, while tillers per plant accounted for a mean of only 2.9%.

Selection index for grain yield and contributing characters to yield in rice were studied by Talwar (1976). It was concluded that the selection pressure based on grain yield, total tillers and grain per panicle could be advantageous in the breeding program.

Venkateswarlu et al (1986) examined the effect of the high density grain on grain yield. They suggested that increasing the proportion of high density grains would enhance the potential yield. An estimated 30% increase in grain yield was possible by increasing the number of high density grains. Kato (1990) reported that selection for grain size of rice was effective even in early generations after crossing.

On one hand, Gravais & McNew (1993) suggested that the selection for increased yield via selection for either panicle weight or panicle number alone would be ineffective. However, a selection index that included selection for both increased panicle weight and panicle number to increase yield was estimated to be 91% as effective as selecting for yield directly.

On the other hand, Feil (1992) reported that among the components of grain yield of a cereal crop, the number of spikelets per panicle appeared to be the predominant or key character to the development of high-yielding cultivars. Morales (1986) suggested that the number of grains/panicle and the 1,000-grain weight might be considered important criteria for increasing yield/unit area. Moeljopawiro (1989) and Reuben & Katuli (1989) reported that grains/panicle was the yield-determining component with the greatest effect. In another study, Ibrahim et al (1990) found that the number of productive tillers was the most reliable character to use in selecting genotypes, while Mehetre et al (1994) reported that the filled grains/panicle was an important yield-contributing character.

The relationship between rice yield and yield components has been studied extensively at the phenotypic level. Subramanian & Rathinam (1984) observed highly significant associations of grain yield with the 1,000-grain weight and number of tillers per plant. Deosarkar et al (1989) and Mehetre et al (1994) reported significant positive associations between grain yield per plant and number of grains per panicle. Sharma & Choubey (1985) and Dhanraj & Jagadish (1987) reported that yield/plant was positively correlated with the number of productive tillers, panicles and spikelets/plant and the 1,000-grain weight, while Prasad et al (1988) observed positive correlations between grain yield/plant and yield components: total spikelets/panicle, fertile grains/panicle and the 1,000-grain weight. Bai et al (1992) reported positive correlations of yield with number of productive tillers, and number of grains/panicle. Ram (1992) reported significant positive associations of yield with number of grains per panicle and number of productive tillers per plant. Sürek et al (1998) reported that grain yield/plant was significantly correlated with

Selection For Temperate Rice
number of panicles per plant and the 1,000-grain weight. Surek & Bejer (2003) observed significant associations of grain yield with number of productive tillers per square meter and number of filled grains per panicle.

Heritability ($h^2$) of a trait is important in determining a cultivar’s response to selection. Grain yield is known to have low heritability and is highly influenced by environment. Rasmusson & Cannel (1970) estimated realized heritabilities in barley for yield ranging from 0.18 to 0.26, number of heads 0.12 to 0.22, kernels per head 0.09 to 0.57, and kernel weight 0.43 to 0.68. Gravais & McNew (1993) estimated 0.45 realized heritability in rice for panicle number and 0.31 for panicle weight. Takeda & Saito (1983) reported highly realized heritability for grain weight in rice, ranging from 0.63 to 0.90. Kato (1997) estimated 0.16 realized heritability for number of panicles per plant in rice and 0.20 to 0.33 for number of spikelets per panicle. Surek & Korkut (1998) estimated high narrow-sense heritability in rice for grain weight, moderate for the number of spikelets per panicle, and low for the number of panicles per plant.

The objectives of this study were to determine the response to selection for high and low yields and yield components, estimate the heritability of yield and yield components, and determine the correlation of grain yield with any of the yield components in the different generations of rice.

### MATERIALS & METHOD

Two cross populations were used for each generation in the F3, F4, and F5 for this study. The crosses and the number of lines utilized in the experiment are given in Table 1.

Within each population, the lines were randomly selected by taking one panicle from each plant in 1994, in the F2, F3, and F4 generations. They were grown together with parents in 2-meter long single plant rows spaced 25 cm. The rice was drill-seeded on 27 May 1995. When the seedlings reached the 4- or 5-leaf stage, the hills were thinned to a uniform density. Harvested area was 1.5 x 0.25 = 0.37 m²; to avoid border effects, the 25-cm distance from both sides in each row was excluded from the sampling. After harvest and evaluation of data, the lines that had 10 high and 10 low values for the traits, grain yield, number of productive tiller, number of filled grains and the 1,000-grain weight were selected for each generation. Also, 10 lines were randomly selected from each population to represent a random sample. These selected lines in each population were grown together with their parents in a randomized complete block design with three replications. Each entry was drilled in a plot which consisted of 2-meter rows spaced 25 cm apart on 30 May 1996; 400 seeds/m² were used in planting. When the seedlings reached the 4- or 5-leaf stage, the hills were thinned to a uniform density.

#### Table 1. The cross populations and the number of lines used in the experiment.

<table>
<thead>
<tr>
<th>No</th>
<th>Cross</th>
<th>Generation</th>
<th>Number Of Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trakya x Lido</td>
<td>F3</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>Trakya x M-102</td>
<td>F3</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>Ípsala x N1-41T-1T-0T</td>
<td>F4</td>
<td>52</td>
</tr>
<tr>
<td>4</td>
<td>Altinyazi x Titanio</td>
<td>F4</td>
<td>52</td>
</tr>
<tr>
<td>5</td>
<td>Krasnodarsky-424 x Europa</td>
<td>F5</td>
<td>52</td>
</tr>
<tr>
<td>6</td>
<td>Baldo x Balilla-28</td>
<td>F5</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>304</td>
</tr>
</tbody>
</table>
harvesting area was $0.5 \times 1.8 = 0.9 \text{ m}^2$. In both years, fertilizers were applied at the rates of 150 kg N/ha and 80 kg P/ha. All phosphorus and 1/3 part of N were applied at pre-planting, 1/3 at tillering and the remaining at panicle initiation.

The data were recorded for grain yield, number of productive panicle per square meter, number of filled grains per panicle, and the 1,000-grain weight.

Analysis of variance was carried out to study the variation among lines for examined traits. Phenotypic correlations were computed following the procedures described by Steel & Torrie (1960), to study the associations of yield components with yield. The statistics program MSTAT-C was used for ANOVA and correlation analysis. Narrow-sense heritabilities of grain yield and yield components were estimated from the regression ($r^2$) of $F_{g2}$ on $F_{g1}$ values ($g_1$ for the initial generation and $g_2$, following generation). Realized heritability ($h^2$) was estimated according to Falconer (1960):

Realized heritability ($h^2$) = ($\Delta G^+ - \Delta G^-)/(G^+ - G^-)$ where $G^+$ and $\Delta G^+$ are the means of the highest lines in the initial generation and of their progeny lines in the following generation, respectively, and $G^-$ and $\Delta G^-$ are the means of lowest progeny lines in the initial generation and of their progeny lines in the following generation, respectively.

The paired t-test was used to compare the mean differences of the traits for the lines selected for high and low values. The selection gain from selection for high yield components and grain yield were computed as the difference between the mean of the high lines and the mean of random selected lines for these traits (Bhatt 1977).

**RESULTS & DISCUSSION**

The results of variance analysis showed that there were significant differences among the lines for examined traits, except the productive tiller per square meter, as there were no significant differences for this trait in two populations, one in $F_4$ (Trakya x Lido cross) and one in $F_5$ (Ipsala x N1-41T-1T-O7T cross). Tables 2, 3, and 4 show significant differences between the lines selected for high and low values of the traits, grain yield, number of productive panicles per square meter, number of grains per panicle, and the 1,000-grain weight. These differences continued in the following generations for the 1,000-grain weight in all generations, $F_4$, $F_5$, and $F_6$. Also, the differences continued for the number of grains per panicle, except in an $F_4$ generation (Trakya x Lido cross).
Table 3. Mean performance of the selected lines, the ten highest and the ten lowest in the F4 generation for each character.

<table>
<thead>
<tr>
<th>Character</th>
<th>Cross</th>
<th>Altinyazi x Titanio</th>
<th>Ipsala x N1-41T-1T-0T</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>873</td>
<td>494</td>
<td>379**</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>454</td>
<td>283</td>
<td>171**</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>77</td>
<td>40</td>
<td>37**</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>36</td>
<td>30</td>
<td>6**</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level.

The results indicated that selections for grain weight and number of grains per panicle were effective in early generations (Tables 5, 6, 7, 8, 9, and 10). Selection for high and low number of productive panicles per square meter was not effective in all generations. The reason for this is that the optimum genotypic level for this component varies with the environment. Rasmusson & Cannell (1970) observed similar results in barley. In contrast, Benbelkacem et al (1984) reported significant differences between high and low progeny groups for tiller number in barley.

Selection for high and low grain yield groups was not effective in early generations; however, it was effective in two F5 populations (Baldo x Balilla-28 and Krasnodarsky-424 x Europa).

In general, the values of random selected lines were between low and high progeny groups for all characters.

The selection gains for the 1,000-grain weight were high in all generations, followed by the number of grains per panicle. High selection gain was obtained for grain yield in one generation of two F6 crosses.

**Increasing Yield by Selecting for Components of Yield**

The mean yields of the progenies of lines selected for high number of grains per panicle exceeded the mean yield of the progenies selected for low number of grains per panicle, except one population of F4 (Trakya x Lido cross) (Tables 11, 12 and 13).

The yield response obtained by selecting for grain weight was very large. This was larger than the selection for yield itself, except for two populations in F5 (Altinyazi x Titanio cross and Ipsala x N1-41T-1T-0T). These results are in agreement with the findings of Rasmusson & Cannell (1970) in barley.

There were negative yield responses to selection for number of productive panicles per square meter in four populations. Positive yield differences were observed only in two populations between low and high number of productive panicles per square meter in one F4 population (Trakya x Lido) and in one F5 population (Ipsala x N1-41T-1T-0T).

The selection for grain weight was effective as much as direct grain yield selection in most populations and number of grains per panicle followed it.

There were positive and significant associations between grain yield and grains per panicle in all populations in both years (Table 14). Similar results had been reported by Prasad et al (1988), Baia et al (1992), Ram (1992), Mehetre et al (1994) and Sürek & Beşer (2003).

The correlations between grain yield and the number of productive panicle per square meter were not important in all populations in both years. In contrast, Sharma & Choubey (1985), Dhanraj & Jagadish (1987) observed positive correlation with grain yield of this trait. The
correlations with grain weight were positive and significant in three of the six populations in different generations in both years. Similarly, Subramanian & Rathinam (1984), Sharma &

**CONCLUSION**

The selections for grain weight and number of grains per panicle were effective in early

Table 4. **Mean performance of the selected lines, the ten highest and the ten lowest in the F5 generation for each character.**

<table>
<thead>
<tr>
<th>Character</th>
<th>Krasnodarsky-424 x Europa</th>
<th>Baklo x Balilla-28</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>765</td>
<td>256</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>440</td>
<td>271</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>72</td>
<td>23</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>38</td>
<td>28</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level.

Coubey (1985), Dhanraj & Jagadish (1987), and Prasad et al (1988) observed positive and significant associations between grain yield and the 1,000-grain weight.

Narrow-sense and realized heritabilities were estimated in all populations (Table 15). High heritabilities were estimated for the 1,000-grain weight; it was medium to low for grain yield. The lowest heritabilities were estimated for the number of productive panicles per square meter. Similar results for realized heritabilities were observed for yield components by Rasmusson & Cannell (1970) in barley and for number of panicles per plant and number of spikelets per panicle in rice by Kato (1997). Also, Tekada & Saito (1983) reported high realized heritability for grain weight in rice.

Results for yield components, correlations between yield and yield components, and heritability values showed that grains per panicle as well as grain weight could be used as selection criterion in early generations.

**LITERATURE CITED**


Bhatt GM. 1977. Response to two-way selection for harvest index in two wheat (Triticum aestivum L.)
Table 5. Mean performance of the parental varieties, the selected and random lines, and selection gain in F4 generation of Trakya x Lido cross

<table>
<thead>
<tr>
<th>Character</th>
<th>Parent</th>
<th>Response To Selection</th>
<th>Selection Gain (%)</th>
<th>Random Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>926.8</td>
<td>666.0</td>
<td>675.2</td>
<td>660.7</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>362.0</td>
<td>415.0</td>
<td>369.7</td>
<td>357.3</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>72.0</td>
<td>70.0</td>
<td>66.9</td>
<td>60.3</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>35.5</td>
<td>25.3</td>
<td>33.6</td>
<td>27.4</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level

Frankel OH. 1935. Analytical yield investigation on New Zealand wheat. II. Five years analytical variety trials. *Journal of Agriculture Science Cambridge* 25: 466-509
Table 6. Mean performance of the parental varieties, the selected and random lines, and selection gain in F4 generation of Trakya x M-102 cross

<table>
<thead>
<tr>
<th>Character</th>
<th>Parent</th>
<th>Response To Selection</th>
<th>Selection Gain (%)</th>
<th>Random Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trakya</td>
<td>M-102</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Grain yield g/ m^2</td>
<td>926.8</td>
<td>599.4</td>
<td>607.8</td>
<td>563.5</td>
</tr>
<tr>
<td>Number of productive panicles per m^2</td>
<td>362.0</td>
<td>407.0</td>
<td>350.6</td>
<td>326.6</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>72.0</td>
<td>53.0</td>
<td>62.3</td>
<td>50.7</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>35.5</td>
<td>28.0</td>
<td>34.2</td>
<td>28.6</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level.

Reuben SOWM & SD Katuli. 1989. Path analysis of components and selected agronomic traits of upland rice breeding lines. *IRRN* 14: pp 4
Table 7. Mean performance of the parental varieties, the selected and random lines, and selection gain in F5 generation of Altinyazi x Titanio cross.

<table>
<thead>
<tr>
<th>Character</th>
<th>Parent</th>
<th>Response To Selection</th>
<th>Selection Gain (%)</th>
<th>Random Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Altinyazi</td>
<td>Titanio</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>644.3</td>
<td>634.8</td>
<td>678.4</td>
<td>632.4</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>363</td>
<td>353.0</td>
<td>347.4</td>
<td>321.0</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>50.0</td>
<td>63</td>
<td>61.1</td>
<td>52.4</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>33.1</td>
<td>32.1</td>
<td>33.5</td>
<td>30.5</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level.

Table 8. Mean performance of the parental varieties, the selected and random lines, and selection gain in F5 generation of Ípsala x Ni-41T-1T-0T cross.

<table>
<thead>
<tr>
<th>Character</th>
<th>Parent</th>
<th>Response To Selection</th>
<th>Selection Gain (%)</th>
<th>Random Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ípsala</td>
<td>Ni-41T-1T-0T</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>727.1</td>
<td>750.4</td>
<td>756.0</td>
<td>669.7</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>332.0</td>
<td>320.0</td>
<td>352.9</td>
<td>329.5</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>50.0</td>
<td>65.0</td>
<td>59.4</td>
<td>50.9</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>40.1</td>
<td>29.2</td>
<td>39.1</td>
<td>33.2</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level.
Table 9. Mean performance of the parental varieties, the selected and random lines, and selection gain in F6 generation of Krasnodarsky-424 x Europa cross.

<table>
<thead>
<tr>
<th>Character</th>
<th>Parent</th>
<th>Response To Selection</th>
<th>Selection Gain (%)</th>
<th>Random Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Krasno-</td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
</tr>
<tr>
<td>Grain yield g/m2</td>
<td>940.2</td>
<td>609.2</td>
<td>571.9</td>
<td>37.6*</td>
</tr>
<tr>
<td>Number of productive panicles per m2</td>
<td>352.0</td>
<td>348.5</td>
<td>323.1</td>
<td>25.4</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>90.0</td>
<td>68.8</td>
<td>53.7</td>
<td>15.1**</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>29.7</td>
<td>34.3</td>
<td>27.3</td>
<td>7.0**</td>
</tr>
</tbody>
</table>

*, ** Significant at 0.05 and 0.01 level, respectively.

Table 10. Mean performance of the parental varieties, the selected and random lines, and selection gain in F6 generation of Baldo x Balilla-28 cross

<table>
<thead>
<tr>
<th>Character</th>
<th>Parent</th>
<th>Response To Selection</th>
<th>Selection Gain (%)</th>
<th>Random Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baldo</td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
</tr>
<tr>
<td>Grain yield g/m2</td>
<td>800.6</td>
<td>720.7</td>
<td>630.4</td>
<td>90.0**</td>
</tr>
<tr>
<td>Number of productive panicles per m2</td>
<td>365.0</td>
<td>331.4</td>
<td>313.4</td>
<td>18.1</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>72.0</td>
<td>63.8</td>
<td>54.3</td>
<td>9.5*</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>39.0</td>
<td>36.7</td>
<td>30.2</td>
<td>6.5**</td>
</tr>
</tbody>
</table>

*, ** Significant at 0.05 and 0.01 level, respectively.
Table 11. Mean yield (g/m²) of lines selected for high and low grain yield, number of panicles per square meter, number of grains per panicle and the 1,000-grain weight in F₄ generation

<table>
<thead>
<tr>
<th>Character Selected</th>
<th>Cross</th>
<th>Trakya x Lido</th>
<th>Trakya x M-102</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>675.0</td>
<td>660.7</td>
<td>14.5</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>738.8</td>
<td>677.7</td>
<td>61.1</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>694.4</td>
<td>700.1</td>
<td>-5.7</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>747.7</td>
<td>678.8</td>
<td>68.9</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level.

Table 12. Mean yield (g/m²) of lines selected for high and low grain yields, number of panicles per square meter, number of grains per panicle and the 1,000-grain weight in F₅ generation

<table>
<thead>
<tr>
<th>Character Selected</th>
<th>Cross</th>
<th>Altınyazı x Titanio</th>
<th>İpsala x N1-41T-1T-0T</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>678.4</td>
<td>632.4</td>
<td>46</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>579.4</td>
<td>634.6</td>
<td>-55.2</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>651.2</td>
<td>577.6</td>
<td>73.2**</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>613.8</td>
<td>621.8</td>
<td>-7.7</td>
</tr>
</tbody>
</table>

** Significant at 0.01 level.
Table 13. Mean yield (g/m²) of lines selected for high and low grain yield, number of panicles per square meter, number of grains per panicle and the 1,000-grain weight in F₆ generation.

<table>
<thead>
<tr>
<th>Character Selected</th>
<th>Cross</th>
<th>Krasnodarsky-424 x Europa</th>
<th>Baldo x Balilla-28</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
<td>Difference</td>
</tr>
<tr>
<td>Grain yield g/ m²</td>
<td>609.7</td>
<td>572.5</td>
<td>37.2*</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>564.6</td>
<td>613.2</td>
<td>-48.6</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>591.0</td>
<td>575.1</td>
<td>15.9</td>
</tr>
<tr>
<td>1,000-grain weight (g)</td>
<td>626.8</td>
<td>569.0</td>
<td>57.8</td>
</tr>
</tbody>
</table>

*, ** Significant at 0.05 and 0.01 level, respectively

Table 14. Correlations between grain yield and yield components in the different generations.

<table>
<thead>
<tr>
<th>Character</th>
<th>Crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trakya x Lido</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>F3  0.272</td>
</tr>
<tr>
<td></td>
<td>F4  0.132</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>F3  0.465*</td>
</tr>
<tr>
<td></td>
<td>F4  0.608*</td>
</tr>
<tr>
<td>1,000-grain weight</td>
<td>F3  -0.029</td>
</tr>
<tr>
<td></td>
<td>F4  0.063</td>
</tr>
</tbody>
</table>

*, ** Significant at 0.05 and 0.01 level, respectively.
Table 15. Estimated narrow-sense ($h^2$) and realized ($r^2$) heritabilities for the traits

<table>
<thead>
<tr>
<th>Character</th>
<th>Trakya x Lido</th>
<th>Trakya x Titanio</th>
<th>Altinyazi x Titanio</th>
<th>Ipsala x Europa</th>
<th>Krasno-424 x Europa</th>
<th>Baldo x Balilla-28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield g/ m²</td>
<td>h²  36</td>
<td>r²  37</td>
<td>h²  43</td>
<td>r²  13</td>
<td>h²  18</td>
<td>r²  34</td>
</tr>
<tr>
<td></td>
<td>h²  18</td>
<td>r²  34</td>
<td>h²  28</td>
<td>r²  51</td>
<td>h²  17</td>
<td>r²  21</td>
</tr>
<tr>
<td></td>
<td>h²  28</td>
<td>r²  51</td>
<td>h²  17</td>
<td>r²  21</td>
<td>h²  15</td>
<td>r²  11</td>
</tr>
<tr>
<td></td>
<td>h²  17</td>
<td>r²  21</td>
<td>h²  15</td>
<td>r²  11</td>
<td>h²  18</td>
<td>r²  18</td>
</tr>
<tr>
<td>Number of productive panicles per m²</td>
<td>h²  20</td>
<td>r²  15</td>
<td>h²  10</td>
<td>r²  10</td>
<td>h²  8</td>
<td>r²  17</td>
</tr>
<tr>
<td></td>
<td>h²  10</td>
<td>r²  17</td>
<td>h²  13</td>
<td>r²  13</td>
<td>h²  13</td>
<td>r²  13</td>
</tr>
<tr>
<td></td>
<td>h²  13</td>
<td>r²  13</td>
<td>h²  15</td>
<td>r²  12</td>
<td>h²  15</td>
<td>r²  11</td>
</tr>
<tr>
<td></td>
<td>h²  15</td>
<td>r²  12</td>
<td>h²  11</td>
<td>r²  18</td>
<td>h²  18</td>
<td>r²  18</td>
</tr>
<tr>
<td>Number of grains per panicle</td>
<td>h²  14</td>
<td>r²  29</td>
<td>h²  3</td>
<td>r²  17</td>
<td>h²  24</td>
<td>r²  26</td>
</tr>
<tr>
<td></td>
<td>h²  24</td>
<td>r²  26</td>
<td>h²  18</td>
<td>r²  23</td>
<td>h²  27</td>
<td>r²  30</td>
</tr>
<tr>
<td></td>
<td>h²  27</td>
<td>r²  30</td>
<td>h²  25</td>
<td>r²  22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,000-grain weight</td>
<td>h²  78</td>
<td>r²  76</td>
<td>h²  75</td>
<td>r²  88</td>
<td>h²  41</td>
<td>r²  50</td>
</tr>
<tr>
<td></td>
<td>h²  84</td>
<td>r²  81</td>
<td>h²  69</td>
<td>r²  66</td>
<td>h²  69</td>
<td>r²  66</td>
</tr>
<tr>
<td></td>
<td>h²  66</td>
<td>r²  66</td>
<td>h²  54</td>
<td>r²  51</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>