HETEROSIS IN CROSSES BETWEEN WHEAT GENOTYPES WITH DIFFERENT SPIKE ARCHITECTURE

ABSTRACT: In order to estimate hybrid vigor, wheat genotypes differing in spike architecture (normal, tetrastichon and branched) were crossed and the F₁ and F₂ generations analyzed for the number of fertile spikelets/spike, number of grains/spike and grain weight/spike. The parents used for crossing were Sava (normal spike), Forlani (normal spike), ZG T 171/1 (tetrastichon spike) and ZG 172 (branched spike). The F₁ and F₂ progenies, except those from the cross Sava x Forlani, had a lower number of fertile spikelets/spike compared with the better parent. In the crosses between genotypes with normal and branched spikes, the F₁ and F₂ progenies formed significantly fewer grains/spike. On the other hand, the F₁ of the crosses between genotypes with normal and tetrastichon spike showed a significant level of heterosis with respect to the number of grains/spike, particularly the cross Forlani x ZG T 171/1. In regard to grain weight/spike, significant heterosis was detected in all crosses except Sava x ZG 172.

The crosses between genotypes with normal and tetrastichon spikes that exhibited significant heterosis for two main yield components were most promising in the context of hybrid wheat development. Such crosses deserve further attention and investigation.

KEY WORDS: heterosis, spike architecture, yield components, wheat

INTRODUCTION

Research aimed at the development of F₁ hybrid wheat varieties proceeded intermittently over last 50 years. The interest in this topic seems to be gaining momentum again. So far, varieties with normal spikes have typically been used as parents in hybrid wheat development programs. The research presented in this paper explored the possibility of exploiting hybrid vigor in wheat by crossing wheat genotypes with different spike architectures. We crossed wheat varieties and lines differing in spike architecture as parents, and compared F₁ and F₂ performance with that of the better parent for three critical determinants of grain yield (number of fertile spikelets/spike, number of grains/spike and grain weight/spike) in order to see a) whether genotypes with branched and tetrastichon spike may successfully serve as parents of wheat hy-
bridges and b) whether the F₁ and F₂ generations of such crosses could be used for commercial production.

**MATERIALS AND METHODS**

1. **Genotypes with normal spike:** a) Sava — a semidwarf (Rht 8), early (Ppd 1), winter wheat cultivar, derived from a cross Fortunato*2 / Red Coat at the Institute of Field and Vegetable Crops, Novi Sad (Yugoslavia) and b) Forlani — a tall Italian cultivar, susceptible to lodging but having a very productive spike (4—5 grains per spikelet), derived from a cross Villa Glori / Grano del Miracolo.

2. **Genotype with tetrastichon spike:** ZG-T-171/1 — a winter wheat line with 4-row (tetrastichon) spike, developed at the Institute for Breeding and Production of Field Crops (Croatia), from a cross Granata x Ranka.

3. **Genotype with branched spike:** ZG-172 — a tall winter wheat line with the branched spike developed at the Institute for Breeding and Production of Field Crops (Croatia), from a cross H 303 / Granatka // Granatka / Ranka.

The various spike types were crossed as follows:

a) **normal / branched** — (Sava x ZG-172 and Forlani x ZG-172)

b) **normal / tetrastichon** — (Sava x ZG-T-171/1 and Forlani x ZG-T-171/1)

c) **normal / normal** — (Sava x Forlani)

The F₁ and F₂ generations and their parents were grown in the 1992/93 season at the experiment field at the Institute of Field and Vegetable Crops, Novi Sad, Yugoslavia. The experiment was established in a randomized complete block design with three replicates. About 150 F₁ and 2000 F₂ plants were grown per combination. The sets of crosses and their parents were planted in rows 20 cm apart, with plants 6 cm apart within the row.

The spikes from the F₁ and F₂ generations were analyzed and compared with those of their contributing parents for the number of fertile spikelets / spike, number of grains / spike and grain weight / spike.

The F₂ progenies, except those from the cross Sava x Forlani, featured three or two types of spike structures e.g. normal, branched and (or) tetrastichon. The modes of inheritance for the spike architecture and the other traits have been presented in an earlier paper (Deňičić, 1988).

**RESULTS AND DISCUSSION**

*Number of fertile spikelets / spike*

In the crosses normal x branched spike, all F₁ and F₂ progenies showed a lower number of fertile spikelets / spike (from 50.2% to 64.7%) compared with the better parent (ZG 172). In the normal x tetrastichon crosses Sava x
ZG-T-171/1 and Forlani x ZG-T-171/1, all F1 and F2 progenies showed a lower number of fertile spikelets / spike (more than 30% below that of the better parent (Table1). Those results were expected since, in general, genotypes with branched and tetrastichon spikes have a large number of spikelets/spike. Furthermore, the results for the crosses between branched or tetrastichon x normal spikes showed that no heterotic effect could be achieved for the number of fertile spikelets/spike in either F1 hybrids (which consisted of plants with normal spikes) or F2 progenies (which consisted of plants with normal, tetrastichon and branched spikes). This may be explained by differences in the dispersion of dominant alleles for the number of fertile spikelets / spike of the parents, corresponding to the hypothesis of heterosis given by Jinks (1983).

Table 1. — Number of fertile spikelets and grains per spike and grain weight per spike in the crosses of wheat genotypes with different spike architectures

<table>
<thead>
<tr>
<th>Parent and hybrid</th>
<th>No. of fertile spikelets / spike</th>
<th>No. of grains / spike</th>
<th>Grain weight / spike (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \overline{x} ) (%)*</td>
<td>( \overline{x} ) (%)*</td>
<td>( \overline{x} ) (%)*</td>
</tr>
<tr>
<td>Sava (normal spike)</td>
<td>17.8</td>
<td>47.0</td>
<td>1.46</td>
</tr>
<tr>
<td>Sava/ZG 172</td>
<td>F-1 16,9 35,3</td>
<td>50,5</td>
<td>71,0 1.92 81,7</td>
</tr>
<tr>
<td></td>
<td>F-2 21,0 43,9</td>
<td>53,8</td>
<td>75,7 1.67 71,1</td>
</tr>
<tr>
<td>Forlani/ZG 172</td>
<td>F-1 19,8 41,4</td>
<td>63,0</td>
<td>88,6 2.75 117,0</td>
</tr>
<tr>
<td></td>
<td>F-2 23,8 49,8</td>
<td>62,9</td>
<td>88,5 2.61 111,1</td>
</tr>
<tr>
<td>ZG 172 (branched spike)</td>
<td>47.8</td>
<td>71.1</td>
<td>2.35</td>
</tr>
<tr>
<td>Sava/ZG-T-171/1</td>
<td>F-1 19,5 66,8</td>
<td>59,4</td>
<td>121,0 2.25 154,1</td>
</tr>
<tr>
<td></td>
<td>F-2 18,5 63,4</td>
<td>50,9</td>
<td>103,7 1.90 130,1</td>
</tr>
<tr>
<td>Forlani/ZG-T-171/1</td>
<td>F-1 19,8 67,8</td>
<td>69,6</td>
<td>141,8 2.95 146,0</td>
</tr>
<tr>
<td></td>
<td>F-2 17,7 60,6</td>
<td>50,4</td>
<td>102,6 2.72 134,7</td>
</tr>
<tr>
<td>ZGT-T-171/1 (tetrastichon spike)</td>
<td>29.2</td>
<td>49.1</td>
<td>1.44</td>
</tr>
<tr>
<td>Sava/Forlani</td>
<td>F-1 17,4 97,7</td>
<td>58,0</td>
<td>121,1 2.53 125,2</td>
</tr>
<tr>
<td></td>
<td>F-2 16,4 92,1</td>
<td>50,1</td>
<td>104,6 1.95 96,5</td>
</tr>
<tr>
<td>Forlani (normal spike)</td>
<td>15.5</td>
<td>47.9</td>
<td>2.02</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>5.46</td>
<td>10.11</td>
<td>0.27</td>
</tr>
<tr>
<td>LSD 1%</td>
<td>6.17</td>
<td>12.57</td>
<td>0.49</td>
</tr>
</tbody>
</table>

* — compared with better parent

Number of grains per spike

In the crosses Sava x ZG 172 and Forlani x ZG 172, the F1 and F2 progenies formed a significantly lower number of grains / spike than the better par-
ent, ZG 172 (Table 1). In contrast, in the crosses between genotypes with normal and tetrastichon spikes, pronounced and significant heterosis in F₁ was observed in both Sava x ZG-T-171/1 and Forlani x ZG-T-171/1 (21% and 41.8% respectively). In both crosses, the mean values for this trait in F₂ were lower but still heterotic. In the cross Sava x Forlani (both normal spikes), the F₁ hybrid was superior (21.1%) to the better parent (Forlani).

Grain weight / spike

The F₁ and F₂ plants of the cross Sava x ZG 172 achieved on average a significantly lower grain weight / spike than the better parent. In the cross Forlani x ZG 172 significant heterosis was observed in both F₁ and F₂ (17.0% and 11.1%, respectively) (Table 1).

In both crosses involving genotypes with normal and tetrastichon spikes, heterosis was highly pronounced in both F₁ and F₂ (Table 1), ranging from 30.1% up to 54.1% (Table 1).

In the F₁ plants of the cross Sava / Forlani, heterosis was demonstrated for both, the number of grains / spike and grain weight / spike, 21.1% and 25.2%, respectively (Table 1).

Most wheat crossing programs conducted in various countries have involved crosses between normal spike forms. Based on the results of this research, it seems that, concerning the development of hybrid wheat, the most promising crosses are those between genotypes with normal and tetrastichon spikes.

Potential heterosis of hybrid wheat must compensate for additional costs of F₁ seed production. Consequently, the required level of heterosis needs to be at least 6% (Pickett and Galwey, 1997). In this experiment, the levels of heterosis achieved for two of the main yield components in the crosses normal x tetrastichon spike were as high as 54.1%. Some open questions remain to be answered before a proper solution can be offered, such as the effect on the remaining yield component (number of spikes per unit area), as well as the testing of yield “per se” in regular field performance trials. Also, the low seeding rates used in the experiment should be reconsidered since some authors (Briggle et al., 1967a, b; Boland and Walcott, 1985) reported that heterosis in wheat increases with density. At any rate, we believe that crossing genotypes with normal and tetrastichon spike forms may be a good strategy for the production of hybrid wheat, as well as that this line of research deserves further attention and investigation.

REFERENCES


ХЕТЕРОЗИС У УКРШТАЊИМА ГЕНОТИПОВА ПШЕНИЦЕ СА РАЗЛИЧИТОМ АРХИТЕКТУРОМ КЛАСА

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Резиме

Са циљем процене хибридног вигора, т. ј. хетерозиса укрштени су генотипови пшенице са различитом архитектуром класа (нормални, тетрастихон и гранати), и у Ф₁ и Ф₂ генерацији су анализирани број плодних класића по класу, број зрна по класу и маса зрна по класу. Родитељи за укрштања су били сорта Сава (нормални клас), сорта Форлани (нормални клас), линија ЗГ T 171/1 (тетрастихон клас) и линија ЗГ 172 (гранати клас). У Ф₁ и Ф₂ генерацији је, сем код укрштава Сава/Форлани, утврђен мањи просечан број плодних класића по класу у односу на бољег родитеља. У укрштавањима генотипова са нормалним и гранатим класовима пшенице, у Ф₁ и Ф₂ генерацији је формиран значајно мањи број зрна по класу. Насупрот овим резултатима, у Ф₁ генерацији укрштања генотипова нормалних и тетрастихон класова утврђен је високо значајан позитиван хетерозис за својство број зрна по класу, а наарко у укрштању Форлани/ЗГ T 171/1. За својство маса зрна по класу, значајан позитивни хетерозис је утврђен код свих укрштава, са изузетком комбинације Сава/ЗГ 172.

Потенцијално добра укрштања за производњу хибридног семена пшенице, а код којих је утврђен значајан хетерозис за две компоненте принос, су укрштања између генотипова са нормалним и тетрастихон класовима, и зато овај тип укрштања заслужује додатну пажњу и даља истраживања.