Crossability of tetraploid and hexaploid wheats with ryes for primary triticale production

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Summary

Crossability of wheat and rye was investigated during thirteen crop cycles in two contrasting locations to 1) evaluate tetraploid and hexaploid wheat parents in crosses with rye, 2) identify genotypes with high crossability and 3) assess the impact of environment on seed development. The majority of the tetraploid wheats crossed with rye had seed set around 20%, but very low embryo viability. Several wheat genotypes with seed set above 50% were identified. The hexaploid wheats crossed with rye showed poor seed set, but plant recovery was relatively high. The majority of the hexaploid wheats with highest seed set (20–30%) were from China. The results suggest differences in crossability between the rye populations, and wheat species by rye interactions. The crossability of the tetraploid and hexaploid wheats was affected by climate in the two locations.

Introduction

Triticale (× Triticosecale Wittmack), as a synthetic crop, is genetically not as diverse as naturally evolved crops. Wheat-rye crosses expand the genetic base of triticale particularly by exploiting the tetraploid wheat (Triticum durum Desf.) and rye (Secale cereale L.) gene pools, which are otherwise difficult to access. Octoploid primary triticales, derived from crossing hexaploid wheat (Triticum aestivum L.) and rye, are used for introgressing D genome genes into triticale (Łukaszewski, 1986). Wheat-rye crosses also contribute to the improvement of bread wheat (Żeven, 1987).

Crossability between wheat and rye (seed set) is controlled by genes Kr1 and Kr2 (Lein, 1943) on wheat chromosome 5B and 5A (Riley & Chapman, 1967). When dominant these genes prevent hybrid seed formation by active inhibition (Lange & Wojciechowska, 1976; Falk & Kasha, 1981). Kr1 has a greater effect than Kr2. An additional gene, Kr3, on chromosome 5D, was indicated to have a weak effect on crossability (Krolow, 1970; Snape et al., 1979; Fedak & Jui, 1982).

In a triticale breeding programme, the progenitors of primary triticales are chosen according to their agronomic qualities. Crossability of the parents varies and is frequently unpredictable. Crossability could be improved prior to making the intergeneric cross if lines with high crossability could be identified.

This study uses data from thirteen cycles of primary triticale production in the CIMMYT (International Maize and Wheat Improvement Center) triticale breeding programme. The objectives were to 1) evaluate tetraploid and hexaploid wheat par-
ents in crosses with rye, for assessing specific problems occurring with each type of cross, 2) evaluate crossability of wheat and rye progenitors of triticale to identify genotypes with high crossability and 3) assess the impact of environment on seed set and caryopsis development.

**Materials and methods**

During thirteen crop cycles (1984–1991), 1440 tetraploid wheat × rye and 550 hexaploid wheat × rye crosses were made in the field. The crosses included 374 tetraploid wheat and 200 hexaploid wheat cultivars. With some cultivars crosses were made with several sister lines. The wheat lines were mainly semi-dwarf durum and bread wheats of CIMMYT origin, but wheats of South-American, Indian and East-Asian origin were included. Open pollinated rye populations were used as pollen parents. The most frequently used ryes included populations from Canada, Europe, West Asia, China, Morocco and Brazil.

The crosses were made in winter at Cd. Obregon in northwestern Mexico (27°N 109°W 39 masl) under irrigated conditions, and during the summer cycle at El Batan in the central Mexican highlands (19°N 98°W 2249 masl) under rainfed conditions with supplementary irrigation. During the cycles studied, mean temperature during the pollination time at Cd. Obregon was about 1.5°C higher than at El Batan. Daily temperature varied more at Cd. Obregon than at El Batan. The El Batan cycles were characterized by frequent rains and less sunshine than the Cd. Obregon cycles.

About 24 florets were emasculated per spike. Pollination was done 4–6 days after emasculation. Immature caryopses were collected 18–22 days after pollination and embryos were rescued immediately into TL medium (Taira & Larter, 1978). The cultures were kept at +8°C for two weeks and then incubated in daylight at room temperature until germination. The plants were transferred into peat pots when roots and shoots had developed. Plants were treated with 0.1% colchicine supplemented with 2% dimethyl sulfoxide (DMSO) at the 2–4 tiller stage.

Measures of crossability included seed set (seeds per pollinated floret), seeds with embryo, plant set (plants per pollinated floret) and embryo viability (plants per rescued embryo). Average number of haploid plants per cross and doubling rate (amphidiploids per amphihaploid) were noted. Data from all crosses were included for the summary analysis. However, for estimation of the distribution of the wheat lines in different crossability classes, the highest seed set of each line, indicating the potential crossability, was used. Data from hexaploid wheat–rye crosses during El Batan cycle 1989 were omitted due to total failure of seed set. Frequency data were analysed using the χ² test. Correlation between climatic parameters and crossability parameters were calculated.

To evaluate the rye parent in the crosses, only ryes used in crosses with ten or more wheats were studied. The performance of each rye population, measured as seed set, was compared with that of other rye populations crossed with the same wheat genotypes. The average difference in seed set between each rye population and the other rye populations was used to evaluate the relative performance of each rye studied. To compare the rye performance between tetraploid and hexaploid wheats, the average differences were transformed into a normalised index. This was calculated by dividing the value for average difference in seed set of

<table>
<thead>
<tr>
<th>Wheat species</th>
<th>Tetraploid</th>
<th>Hexaploid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed set (%)</td>
<td>15.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Seeds with embryo (%)</td>
<td>55.9</td>
<td>73.8</td>
</tr>
<tr>
<td>Embryo viability (%)</td>
<td>11.2</td>
<td>46.4</td>
</tr>
<tr>
<td>Plant set (%)</td>
<td>0.99</td>
<td>1.54</td>
</tr>
<tr>
<td>Crosses with plants (%)</td>
<td>43.8</td>
<td>53.6</td>
</tr>
<tr>
<td>Plants per cross</td>
<td>1.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Doubling rate (%)</td>
<td>31.9</td>
<td>26.8</td>
</tr>
</tbody>
</table>

* Seeds per pollinated floret
* Plants per embryo
* Plants per pollinated floret
* Amphidiploids per amphihaploids

Table 1. Crossability for tetraploid and hexaploid wheats in crosses with ryes