Food Legume Improvement and Development

Proceedings of a workshop held at The University of Aleppo, Syria, 2-7 May 1978

Geoffrey C. Hawtin and George J. Chancellor, Editors

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Broomrape (*Orobanche crenata*) Resistance in Broad Beans:
Breeding Work in Egypt

Abdullah M. Nassib, Ali A. Ibrahim, and Hamdy A. Saber

Agricultural Research Institute, Giza, Orman, Egypt

The parasitic weed broomrape (*Orobanche* sp.) is a severe pest of all legume crops in Egypt. Infestations, particularly of broad beans (*Vicia faba*), which are the most widely cultivated grain legume in the country, cause very high annual crop losses. At present there is no truly effective method for controlling this damaging parasite, and current emphasis is being placed on the development of resistant varieties as the most effective and economic control measure. Four branched and four unbranched species of *Orobanche* have been identified in Egypt. Although all the species infest legume plants, *Orobanche crenata* is without doubt the most serious pest, attacking the important broad bean crop and causing considerable damage.

Comparatively resistant cultivars have been reported in broad beans in Italy, melons in the USSR, and hemp in France and grafting experiments have shown the decisive characters determining resistance to be in the root. In sorghum, which is infested by parasitic plants of *Striga* spp., two forms of resistant mechanism have been found: firstly, resistance arising from the low production of *Striga* germination stimulant by the root, resulting in low infestations due to reduced germination of the parasite; and secondly, resistance based on barriers to the successful establishment of the parasite on the host, either through mechanical obstruction, involving thick-walled endodermis or heavy deposits of silica in the endodermis, or by physiological barriers preventing adequate haustorial nourishment. In addition, research on *Striga* resistance in sorghum has revealed that different strains of the parasite exist and that these differ in their virulence on different hosts. This presents further complications in attempting to achieve a good and stable resistance. A similar situation should be expected in *Orobanche* species.

**Screening and Selection for *Orobanche* Resistance in Broad Bean**

This program was initiated in 1972 at Giza Research Station. A collection of germ plasm, comprising land strains (families) and hybrid derivative lines, were subjected to selection for three seasons in a heavily infested plot; 315 lines of *Orobanche*-free and less-infected plants selected from this material were then tested against a new unselected population of 121 entries. This investigation showed the percentage of tolerant lines in the selected population to be 44.5, in comparison with 21.0 in the unselected material, thereby illustrating the effectiveness of selection in raising the resistance level in populations.

**Evaluation of Promising Tolerant Families**

Twenty-two families derived through a 3-year cycle of individual plant selection in an F$_2$ line of the cross Rebaia 40 (commercial variety) × F 216 (land strain) were evaluated with seven commercial varieties and land strains for *Orobanche* tolerance. Results (Table 1) indicated the family F 402 to have a higher level of tolerance than either the other selected families or the check varieties. Further tests on this family have shown that on average it had 57.5% less *Orobanche* spikes per hill and nearly four times more *Orobanche* free hills (each hill with two bean plants) than the commercial variety Giza 2.

F 402 has also proved to have a high level of field resistance to root rot and wilt
Table 1. A comparison of the tolerance of selected families and unselected populations of broad bean to *Orobanche crenata*, Giza Research Station, 1974-75.

<table>
<thead>
<tr>
<th>Broad bean material</th>
<th>No. <em>Orobanche</em> spikes/infected plant</th>
<th>% <em>Orobanche</em>-free plants</th>
<th>Visual ratinga</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Selected families</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F 402</td>
<td>1.1</td>
<td>22.2</td>
<td>1.3</td>
</tr>
<tr>
<td>F 408a</td>
<td>3.3</td>
<td>0.0</td>
<td>2.7</td>
</tr>
<tr>
<td>F 403a</td>
<td>4.0</td>
<td>9.1</td>
<td>2.3</td>
</tr>
<tr>
<td>F 401</td>
<td>4.3</td>
<td>2.6</td>
<td>3.7</td>
</tr>
<tr>
<td>F 410c</td>
<td>4.9</td>
<td>7.5</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Unselected populations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L 53/536/63</td>
<td>5.9</td>
<td>2.2</td>
<td>5.0</td>
</tr>
<tr>
<td>F 216</td>
<td>6.6</td>
<td>0.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Giza 2</td>
<td>7.4</td>
<td>0.0</td>
<td>3.3</td>
</tr>
</tbody>
</table>

a Visual rating using 1-5 scale: 1, vegetative growth and pod setting almost normal, due to very low infestation; 5, plants stunted and dried out before maturity with few pods set, due to heavy infestation.

diseases caused by species of the genera *Rhizoctonia* and *Fusarium*, in contrast to the commercial varieties Giza 2 and Giza 4, which are severely affected under field conditions. The tolerance of F 402 to both *Orobanche* and root rot/wilt diseases has resulted in seed and straw yields 16.9 and 4.4 times higher respectively than those obtained from Giza 2.

An evaluation of families selected for *Orobanche* tolerance at Giza and Sids, in Middle Egypt, and Shandaweel, in Upper Egypt, conducted at the Shandaweel Station has shown selections originating from Giza to be considerably more tolerant than selections originating from either of the other two sites. This probably reflects the light selection pressure brought to bear on the material from Sids and Shandaweel (one season only), compared to the more intensive selection, over three to five seasons, carried out at Giza. The investigation also revealed that *Orobanche* infestation on F 402 selections was about four times higher than at Giza, where the selections originated. This result suggests that the virulence of the parasite varies with location, or that different physiological races exist.

**Evaluation under Controlled Conditions**

Screening for tolerance to *Orobanche* under field conditions introduces a number of errors due to the fluctuating parasite population, its distribution around the plants, and other soil and management factors. To enable better estimates to be made of host resistance and to facilitate studies of the nature and mode of inheritance of resistance, the reaction of catch and trap crops, and the variations in virulence of parasite collections from different locations, a technique for creating artificial infestations has been evolved at Giza. This involves inoculating the root mass of a 25-day-old plant in a soil core of 5 cm in diameter with sufficient *Orobanche* seed and then growing the plant under irrigation in a 25-cm pot.

Using this technique, an estimation of *Orobanche* infestation of F 402 and Giza 2 has revealed highly significant reductions in *Orobanche* populations both above and below the surface in the case of F 402 (Table 2). Based on these findings the resistance of F 402 may be ascribed both to reduced production of a germination stimulant and the erection of mechanical and physiological barriers to the successful establishment of the parasite. This resistance is associated with slower tap root growth, less production of lateral roots, and an altogether more compact root mass in F 402 than in other more susceptible varieties, such as Giza 2.

**Toward More Resistant Broad Bean Lines**

The research efforts to date have primarily involved screening and selection from within the available indigenous germ plasm and from a number of hybrid lines, not
specially bred for *Orobanche* resistance. Although this selection program has proved to be fairly successful in increasing the level of resistance in populations, the rather narrow genetic base and geographical spread of the screening nurseries inherent in the work means that a ceiling will soon be reached in improvement achievements.

For the future, a truly effective breeding program must combine a massive amount of screening of a wide range of material over a large number of locations with studies of a wide collection of parasite seed under artificial infestation conditions. This will enable the identification of sources of resistance to the suspected different races of the parasite as well as the clarification of the different resistance mechanisms. Once defined, this resistance can be introduced into adapted lines by multiple hybridization followed by recurrent selection to obtain lines that are both highly productive under a variety of environmental conditions and resistant to *Orobanche*.

In this way the highly destructive effect of this parasite on the very important broad bean crop in Egypt can, it is hoped, be greatly reduced, if not completely eliminated.

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**Table 2. *Orobanche crenata* infestations of F 402 and Giza 2 under artificial infestation conditions, Giza Research Station, 1977-78 season.**

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Above soil surface</th>
<th>Below soil surface</th>
<th>Total</th>
<th>% of total above soil surface</th>
<th>Max. spike height</th>
<th>% <em>Orobanche</em>-free plants above surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>F402</td>
<td>2.2</td>
<td>13.4</td>
<td>15.6</td>
<td>14.1</td>
<td>1.8</td>
<td>53.9</td>
</tr>
<tr>
<td>Giza 2</td>
<td>11.4</td>
<td>26.1</td>
<td>37.5</td>
<td>30.8</td>
<td>10.6</td>
<td>0.0</td>
</tr>
</tbody>
</table>