Structural variability amongst potato cultivars possessing varying grades of resistance to late blight

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Late blight caused by Phytophthora infestans (Mont.) de Bary is a highly destructive disease of potato and causes heavy yield losses under favourable weather conditions. This is the major cause of loss of tuber yield due to reduction in photosynthetic capacity of the plant through destruction of foliage and tuber infection (7). Host resistance is the most predominant component in late blight management. Central Potato Research institute has released over dozen potato cultivars carrying varying grades of resistance to late blight. The nature and basis of resistance in these cultivars have been studied which include factors like field resistance and host attribution components (4) and compatible and incompatible interaction at cellular level (5). However, structural basis of late blight resistance has so far not been investigated. Present studies were aimed at generating information on structural variability amongst potato cultivars carrying varying grades of resistance to late blight.

The seed tubers of four cultivars of potato viz. Kufri Jyoti, Kufri Badshah, Kufri Ashoka and Kufri Chandramukhi were raised under recommended agronomic practices in the experimental area of the Department of Plant Pathology, Punjab Agricultural university, Ludhiana during the year 2000-2001. For pathological work, the leaves were collected at random when the crop was 40 days old. The screening of varieties for disease reaction was done using detached leaf technique (7). Observations were recorded after 7 days (Kufri Ashoka, Kufri Chandramukhi) and 10 days (Kufri Jyoti, Kufri Badshah) of inoculation in terms of percentage of infected leaves and percent leaf area infected following the 0-5 disease rating scale (0=no symptom, 1=1 to 10%, 2=11 to 25%, 3= 26 to 50%, 4 = 51 – 75% and 5 = > 75% leaf area infected). Sporulation was determined by taking 5 leaf discs (15 mm diam.) from infected portion which were washed in 2 ml of water and the sporangia were counted with the help of haemocytometer.

To conduct anatomical investigations, the fourth leaf from the top of the main branch was harvested one each from five disease free plants of each variety 70 days after planting and preserved in F.A.A. (Formaline – acetic acid – alcohol) solution. Cross sections of 18 μm thickness were cut from the middle portion of the terminal leaflet and stained with erythrocyn crystal violet combination (3). The measurements of various tissues of the leaflet were taken at five different locations in the cross section of each leaflet (x 400). The palisade index was calculated by the method proposed by Godoy et al. (1) and the palisade proportion was calculated by the method of Tiwari et al. (9). The differences between the resistant and susceptible cultivars were evaluated by using statistical methods.

The results obtained from inoculation studies conducted to ascertain the disease reaction of the four test cultivars of potato revealed that the potato cultivars Kufri Chandramukhi and Kufri Ashoka exhibited 75 and 65% infection on leaves, depicting their degree of susceptibility. On the other hand, the cultivars Kufri Jyoti and Kufri Badshah showed only 10.0 and 8.5% leaf area infected demonstrating their degree of resistant response to P. infestans population prevalent in Punjab. However, cv. Kufri Jyoti which was earlier
considered to be resistant has now been reported to show susceptible reaction to late blight in hilly regions of Himachal Pradesh which could be due to (i) the presence of different races of *P. infestans* prevalent in H.P. (ii) heavy inoculum load and extended congenial weather conditions (6).

The internal leaf tissue plays a role in post penetration phase by restricting the growth of pathogen within the host tissues. Pathogen, if able to invade the epidermal layer, is encountered by the mesophyll tissue. Mesophyll tissue of potato leaf consists of palisade and spongy tissues. It comprises of 1-2 layers of palisade parenchyma. The cells of the spongy tissue are arranged in irregular fashion having intercellular spaces in between them. This loose arrangement of spongy tissue facilitates the rapid and easy spread of the pathogen. The thickness and compactness of the palisade and the spongy tissue has been correlated with the degree of disease resistance. The average values of various mesophyll characteristics are given in Table 1. The average thickness (μm) of the lamina was 245.1 (Kufri Jyoti), 214.6 (Kufri Badshah) in the resistant, and 207.1 (Kufri Ashoka) and 239.1 (Kufri Chandramukhi) in the susceptible cultivars. The difference in the thickness of lamina of resistant and susceptible cultivars was not statistically significant. These observations indicate that the thickness of lamina does not play any role in determining the degree of resistance against late blight infection in potato cultivars.

The average thickness (μm) of the palisade tissue was higher in Kufri Jyoti (118.5) and Kufri Badshah (110.8) as compared to Kufri Ashoka (83.0) and Kufri Chandramukhi (84.8). The difference in the thickness of palisade tissue of the resistant and susceptible cultivars was statistically significant and might be involved in assessing the invasion by the pathogen.

The average thickness (μm) of the spongy tissue was highest (123.5) in Kufri Chandramukhi and lowest (67.7) in Kufri Badshah. Almost similar trend was recorded for the resistant variety Kufri Jyoti and the susceptible variety Kufri Ashoka. The differences in the thickness of the spongy tissue of Kufri Jyoti and Kufri Ashoka were not significant. However, Kufri Badshah differed significantly from the other three varieties. Therefore, it seems that the lower thickness of spongy tissue, which indirectly indicated lesser intercellular spaces, may have some role in conferring relatively greater degree of resistance to late blight infection in Kufri Badshah cultivar of potato. The mean values of the length of palisade cell (just below the epidermis) in the resistant potato cultivars ranged between 72.3 (Kufri Jyoti) and 73.5 μm (Kufri Badshah), while in the susceptible cultivars these were 63.2 (Kufri Ashoka) and 72.2 μm (Kufri Chandramukhi). The differences in the mean values for the length of palisade cells in the resistant and the susceptible cultivars of potato were statistically non-significant.

The data presented in Table 1 also revealed

Table 1. Average values of leaf anatomical characteristics in different late blight resistant and susceptible cultivars of potato

<table>
<thead>
<tr>
<th>Anatomical characteristics</th>
<th>Resistant varieties</th>
<th>Susceptible varieties</th>
<th>C.D. (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kufri Jyoti</td>
<td>Kufri Badshah</td>
<td>Kufri Ashoka</td>
</tr>
<tr>
<td>Thickness of lamina (μm)</td>
<td>245.12</td>
<td>214.63</td>
<td>207.11</td>
</tr>
<tr>
<td>Thickness of palisade tissue (μm)</td>
<td>118.54</td>
<td>110.88</td>
<td>83.03</td>
</tr>
<tr>
<td>Thickness of spongy tissue (μm)</td>
<td>90.82</td>
<td>67.72</td>
<td>97.68</td>
</tr>
<tr>
<td>Palisade cells/mm</td>
<td>63.47</td>
<td>64.80</td>
<td>52.79</td>
</tr>
<tr>
<td>Length of palisade cells (μm)</td>
<td>72.34</td>
<td>73.52</td>
<td>63.23</td>
</tr>
<tr>
<td>Width of palisade cells (μm)</td>
<td>14.52</td>
<td>15.44</td>
<td>12.80</td>
</tr>
<tr>
<td>*Palisade proportion</td>
<td>48.36</td>
<td>51.64</td>
<td>39.88</td>
</tr>
<tr>
<td>**Palisade index (μm/mm)</td>
<td>922.93</td>
<td>999.85</td>
<td>673.88</td>
</tr>
</tbody>
</table>

Data are mean of 25 observations; * Palisade proportion = Palisade thickness/Lamina thickness x 100; ** Palisade index = Cells/mm x cell width
that the average number of palisade cells/mm was higher in the resistant varieties i.e. Kufri Jyoti (63.4) and Kufri Badshah (64.8); whereas comparatively lower values were observed in the susceptible varieties Kufri Ashoka (52.7) and Kufri Chandramukhi (51.0). The average palisade cell width was highest in Kufri Badshah (15.4 μm) and lowest in Kufri Ashoka (12.80 μm). Intermediate values were recorded in Kufri Chandramukhi (13.8 μm) and Kufri Jyoti (14.5 μm). The palisade cell width was significantly higher in Kufri Badshah as compared with both the susceptible cultivars, but the difference between Kufri Jyoti and Kufri Chandramukhi was statistically non-significant. The palisade index which is a numerical measure of compact arrangement of palisade tissue was significantly higher in the resistant as compared with the susceptible varieties. The higher values of index in the resistant varieties indicated that the arrangement of the palisade cells was relatively more compact in these varieties. Earlier, higher palisade index has been observed in tomato genotypes resistant to late blight infection as compared with the susceptible genotypes (2).

The values of palisade proportion (i.e. thickness of palisade tissue in comparison with the total thickness of lamina) was higher in resistant varieties as compared to susceptible ones. The palisade proportion values of both the resistant cultivars were significantly higher than the two susceptible cultivars. In the present study, the values of palisade index indicated that the palisade cell arrangement was more compact in the resistant varieties, whereas these were loosely arranged in the susceptible varieties and had large intercellular spaces. The presence of large intercellular spaces between the palisade cells in the susceptible varieties may facilitate the rapid spread of the pathogens.

The information generated in the present study indicates that the palisade index and palisade proportion in the leaf lamina may prove useful for rapid screening of various genotypes of potato for their resistance to late blight under field conditions.

REFERENCES


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