Late blight caused by the oomycete (*Phytophthora infestans* (Mont.) de Bary) is the most dreaded disease of potato production worldwide, which caused Irish potato famine in the mid-1840s. Consequently, given its significant importance, there has been concerted global effort for more than 100 years to develop durable resistant cultivars. However, evolution of new races of *P. infestans* conquered the past resistance genes of the Mexican *S. demissum*. Although, common potato lacks significant resistance source, many of the wild *Solanum* species are rich sources of resistance genes, which may be exploited in potato breeding (Bradshaw *et al.*, 2006).

Many useful genes derived from wild sources cannot be transferred through conventional technique because sexual incompatibilities are primarily due to difference in ploidy and endosperm balance number (EBN). It is extremely difficult to cross wild species of 1 EBN directly with common cultivated potato of 4 EBN (Jackson and Hanneman, 1999). However, modern research and new techniques have made it possible to expand considerably the genetic resources available for use in breeding programme. A few methods have now become available to overcome this problem like bridge/ reciprocal crosses, embryo rescue, hormone treatment, somatic hybridization and many more. Among them, somatic hybridization, which removes prezygotic and some postzygotic barriers, can likewise surmount the barrier between cultivated and wild species. Somatic hybridization can provide a means of bypassing sexual incompatibility between *Solanum* species, leading to fertile plants that can be used directly in breeding programs. Despite these crossing-barriers, many researchers have used this technique and subsequently produced somatic hybrids with cultivated potato (Tiwari *et al.*, 2010; Sarkar *et al.*, 2011). In the present study, we report on the multiple evaluations of the potato somatic hybrids of dihaploid of *S. tuberosum* ‘C-13’ (+) *S. pinnatisectum* for durable resistance to late blight for two years in the field tests (2011 and 2012) and *in vitro* assays (2012 and 2013) in the controlled conditions for their future exploitation in the potato breeding programme.

Interspecific potato somatic hybrids of the dihaploid *S. tuberosum* ‘C-13’ (+) *S. pinnatisectum* namely P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P12 and P13; parents dihaploid *S. tuberosum* C-13 and wild *S. pinnatisectum*

KEYWORDS: Evaluation, potato, late blight resistance, somatic hybrids.
Potato somatic hybrids for late blight resistance

(Sarkar et al., 2011); control varieties Kufri Jyoti (susceptible), Kufri Girdhari and Kufri Himalini (resistant) were used in the study. Somatic hybrids’ tuber multiplied from CPRIC, Modipuram were used for assessment of late blight resistance. Plants were evaluated in the field conditions planted in three replications in main crop season (May to August) at CPRS, Kufri for two years during 2011 and 2012. Pot-grown somatic hybrids plants (fully grown two pots of each hybrid) were assessed for late blight resistance after challenge inoculation of \( P. \text{infestans} \) by in vitro assays for two years 2012 and 2013 in the environment controlled chamber at CPRI, Shimla. Categorization of resistance/susceptibility was based on the area under disease progress curve (AUDPC) values as described by Kaushik et al. (2007) [HR (<50), R (50-100), MR (100-150) and S (>150);

where, HR=Highly resistant, R=Resistant, MR=Moderate resistant, S=Susceptible].

Details of the late blight reactions are presented in Table 1. Pictorial representation of late blight reactions on the somatic hybrids and the control cultivar is shown in Fig. 1. In both the field and in vitro challenge inoculations tests for the two years for late blight resistance, wild parent \( S. \text{pinnatisectum} \) showed it to be highly resistant while cultivated dihaploid parent C-13 was moderately resistant compared to the control variteis Kufri Jyoti (S), K. Girdhari (HR) and K. Himalini (MR). In the field test during the year 2011, somatic hybrids namely P1, P2, P3, P12 and P13 were observed to be highly resistant (HR) with AUDPC values ranging between 0.23 to 48.50; P4, P6, P7 and P10 were resistant (R) with AUDPC values between 65.67 to 104.83.

Table 1. Evaluation of somatic hybrids to foliage late blight resistance tests in the field test and in the in vitro assay.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Field test</th>
<th>In-vitro assay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>AUDPC</td>
<td>Reaction</td>
</tr>
<tr>
<td>P1</td>
<td>1.17</td>
<td>HR</td>
</tr>
<tr>
<td>P2</td>
<td>48.50</td>
<td>HR</td>
</tr>
<tr>
<td>P3</td>
<td>0.23</td>
<td>HR</td>
</tr>
<tr>
<td>P4</td>
<td>79.83</td>
<td>R</td>
</tr>
<tr>
<td>P5</td>
<td>120.00</td>
<td>MR</td>
</tr>
<tr>
<td>P6</td>
<td>94.00</td>
<td>R</td>
</tr>
<tr>
<td>P7</td>
<td>71.33</td>
<td>R</td>
</tr>
<tr>
<td>P8</td>
<td>104.83</td>
<td>MR</td>
</tr>
<tr>
<td>P9</td>
<td>144.67</td>
<td>MR</td>
</tr>
<tr>
<td>P10</td>
<td>65.67</td>
<td>R</td>
</tr>
<tr>
<td>P12</td>
<td>1.17</td>
<td>HR</td>
</tr>
<tr>
<td>P13</td>
<td>1.17</td>
<td>HR</td>
</tr>
<tr>
<td>C-13</td>
<td>145.64</td>
<td>MR</td>
</tr>
<tr>
<td>S. pinnatisectum</td>
<td>0</td>
<td>HR</td>
</tr>
<tr>
<td>Kufri Jyoti</td>
<td>331.50</td>
<td>S</td>
</tr>
<tr>
<td>Kufri Himalini</td>
<td>139.83</td>
<td>MR</td>
</tr>
<tr>
<td>Kufri Girdhari</td>
<td>1.17</td>
<td>HR</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>2.95</td>
<td>2.82</td>
</tr>
</tbody>
</table>

Note: AUDPC=area under disease progress curve; HR=highly resistant; R=Resistant; MR=moderately resistant and S=Susceptible.
Fig. 1 Evaluation of the somatic hybrids of C-13 (+) S. pinnatisectum for late blight resistance showed resistance (R) to high resistance (HR) levels by i) In vitro assay: a) & b) somatic hybrids, and c) control cv. Kufri Jyoti; and ii) Field test: d) somatic hybrids, and e) control cv. Kufri Jyoti.

to 94.0; and P5, P8 and P9 were moderately resistant (MR) with AUDPC values between 104.83 to 144.67 compared to susceptible control variety Kufri Jyoti (331.50/S) and highly resistant cv. Kufri Girdhari (1.17/HR). In wild parent S. pinnatisectum was observed to have high level of resistance (AUDPC = 0), where as C-13 had a moderate level of resistance (145.64). In the year 2012, all the somatic hybrids (P1, P2, P3, P6, P7, P8, P9, P10, P11, P12 and P13) were highly resistant (HR) with AUDPC value ranging from 11.67 to 44.17, except the hybrids P4 (58.33) and P5 (61.67) which were resistant (R). Moreover, in the in vitro assay during the year 2012, only the somatic hybrids P7 (45.83), P9 (5.83) and P13 (5.83) were highly resistant (HR). Other somatic hybrids were in the category of resistant (R) to moderately resistant (MR) with AUDPC values ranging between 65.83 to 131.67. In the in vitro assay during the year 2013, all the somatic hybrids were highly resistant (HR) except P9 which was resistant (R).
Over the years, potato somatic hybrids showed high level of resistance to late blight, which can be exploited in potato breeding through conventional breeding to introgress resistance to widen the genetic base of cultivated potato. Nevertheless, variable degree of resistance levels (MR to HR) were observed in the somatic hybrids across the years in the field and challenge inoculation testing methods. This may be due to inoculum doses and environmental conditions particularly temperature and relative humidity favourable for growth of the pathogen *P. infestans* causing late blight (Singh and Singh, 2007). Numerous experiments have been conducted on late blight resistance tests to evaluate potato genotypes (Kaushik et al., 2007; Bhardwaj et al., 2007; Srivastava et al., 2012). Recently, Srivastava et al. (2012) demonstrated that potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme. Kaushik et al. (2007) evaluated 19 potato germplasm accessions CP1673, CP2011, CP2068, CP2132 and CP2333 showed durable resistance against late blight at three locations viz., Kufri, Shillong and Ooty along with desirable tuber characters and can be utilized as parents in the potato breeding programme.

To conclude, somatic hybrids of C-13 (+) *S. pinnatisectum* were found for the variable degree of resistant (R) to highly resistant (HR) levels based on field tests and in vitro assays. Somatic hybrids showed a potential source of late blight resistance for the Indian potato breeding. Somatic hybrids may be exploited for future genomics based studies employing various molecular markers as described in the literature (Tiwari et al., 2012; 2013). To our knowledge, this is the first ever report in India on in vitro and in vivo evaluations of potato somatic hybrids for late blight resistance.

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