Response of cultivars and breeding lines of *Lycopersicon* spp. to *Alternaria solani*

V. Poysa and J.C. Tu[1]

From 1990 to 1995 more than 650 tomato cultivars, breeding lines, and accessions of related species, were evaluated for resistance to early blight, caused by *Alternaria solani*. The levels of resistance for selected test lines are reported here. Promising material for use in early blight resistance breeding programs include the moderately resistant tomato breeding lines HRC90.145, HRC90.158, and HRC90.159 and the interspecific breeding lines HRC90.303, HRC91.279, and HRC91.341. Only limited success has been attained in incorporating resistance from the *Lycopersicon hirsutum* and *L. peruvianum* lines showing very high levels of resistance. The *L. hirsutum* lines LA2100, LA2124, and LA2204 have shown promise in producing interspecific lines in which the association between disease resistance and detrimental horticultural traits has been weakened.

Can. Plant Disease Surv. 76:1, 5-8, 1996.

Entre 1990 et 1995, plus de 650 cultivars de tomate, lignées généalogiques et obtentions d'espèces apparentées ont été évalués pour leur résistance à la brûlure alternarienne, causée par *Alternaria solani*. Le degré de résistance pour les lignées qui ont fait l'objet de tests est présenté ici. Parmi le matériel prometteur pour ce qui est des programmes d'amélioration visant à combattre la brûlure hâtive, on compte les lignées généalogiques modérément résistantes telles HRC90.145, HRC90.158 et HRC90.159, et les lignées généalogiques interspécifiques HRC90.303, HRC91.279 et HRC91.341. Un certain succès seulement a été atteint en ayant recours à la résistance conférée par *Lycopersicon hirsutum* et *L. peruvianum*, lignées démontrant des niveaux de résistance très élevés. Les lignées *L. hirsutum* LA2100, LA2124 et LA2204 se sont révélées prometteuses dans la production de lignées interspécifiques dans lesquelles l'association entre la résistance à la maladie et les caractéristiques horticoles nuisibles a été affaiblie.

Introduction

Alternaria solani Sorauer causes two distinct disease symptom complexes on tomato *(Lycopersicon esculentum* Mill.) plants: early blight and collar rot. Early blight, which defoliates mature plants, has been an important disease in eastern Canada and the United States (Horsfall and Heuberger, 1942; Basu, 1974; Poysa, *et al.*, 1993). While fungicides have been routinely used to control this and other foliar fungal diseases of tomato (Poysa *et al.*, 1993), there is an increasing interest in reducing the dependence on fungicides because of environmental concerns. Development of cultivars resistant to early blight should be the most effective means of controlling this disease.

Sources of resistance in *Lycopersicon* germ-plasm have been reported (Barksdale, 1969; Gardner, 1984; Martin and Hepperly, 1987). Several breeding lines moderately resistant to early blight have been developed, including USDA line 71B2, C1943 (Barksdale and Stoner, 1977), NC EBR-1, and NC EBR-2 (Gardner, 1988). Those lines, however, are relatively low-yielding and late-maturing (Barksdale, 1971; Gardner, 1988). Resistance to early blight in 71B2 and C1943 is conferred by recessive genes (Barksdale and Stoner, 1977), while in NC EBR-1 and NC EBR-2 resistance is primarily determined by additive genetic factors (Nash and Gardner, 1988; Maiero, *et al.*, 1990). The identification of additional sources of resistance could provide a broader genetic base to facilitate the development of resistant cultivars. This paper reports the results of a series of screening tests in which more than 500 tomato breeding lines, accessions, and cultivars, and more than 150 wild species accessions or interspecific breeding lines were evaluated for resistance to early blight.

Materials and methods

From 1990 to 1995, 40 to 200 selected tomato lines were screened annually for early blight resistance in a mist chamber similar to that described by Gardner (1990). For each screening 100 seeds were sown in a checkerboard design, in a 200 cell tray (Plastomer, Co., Barrie, Ontario) to facilitate inoculation and disease rating. A susceptible control, 'Heinz 2653', was sown at both ends of each tray. Twenty plants per line were evaluated in each of two to four replications. When the plants were 4-5 weeks old, the last fully expanded leaf was rubbed between thumb and

1 Agriculture and Agri-Food Canada, Harrow Research Centre, Harrow, Ontario, Canada N0R 1G0.
Accepted for publication, December 4, 1995.

forefingers to injure the leaf surface. Inoculum (10^5 spores/mL water) was sprayed on each plant to run-off, and the injured leaves were rubbed again. The trays of plants were placed in a plastic-covered chamber maintained near 100% relative humidity by intermittent mists from a cool-mist humidifier on a timer. The misting chamber was placed either in a growth room or in a greenhouse, with a 12 hour light period. From the second to the fifth day after inoculation, the plastic sides of the chamber were raised and the humidifier turned off to allow the plants to dry during the light period. The high humidity regime was re-established each night. Disease reaction was determined 7-10 days after inoculation, based on the size and number of lesions on the inoculated and adjacent leaves. Disease severity was rated on a 1 to 9 scale: 1 = asymptomatic; 2 = few small lesions; 3 = several small lesions; 4 = <10% of leaf area with infection; 5 = 10-20%; 6 = 21-50%; 7 = 51-80%; 8 = 81-99% of leaf area with infection; 9 = plant dead.

A score of 1 to 3.9 represents a very high level of resistance: field evaluation of these lines showed that plants with this level of resistance would not develop the disease in the field. A score of 4.0 to 4.9 represents a high level of resistance: plants with this level of resistance would normally not experience defoliation due to early blight in the field. A score of 5.0 to 5.9 represents a moderate level of resistance: field trials showed that plants with this level of resistance would normally not suffer yield losses due to early blight in the field. Scores from 6.0 to 9.0 represent moderate to high levels of susceptibility. Any material rated resistant (disease rating <6) was reevaluated to verify the level of resistance. Data reported in the tables are averages over all tests in which each line occurred.

Results and discussion

The levels of resistance to early blight for the 14 commercial cultivars evaluated exceeded 6.0, indicating that these plants were susceptible to the pathogen under the test conditions (Table 1). Among the named *L. esculentum* lines evaluated, NC EBR-1 (6.1), NC EBR-2 (6.3), and Ohio 8245 (6.3) had the lowest disease ratings. There were eleven breeding lines and plant introductions that had moderate levels of resistance, between 5.0 and 5.9, that might provide a gene pool for tomato breeders in developing resistant cultivars. During the tests, 417 of the 426 Harrow (HRC) *L. esculentum* breeding lines evaluated were rated >6.0 (data not reported herein).

The disease severity rating for seventeen accessions of related species, especially *L. hirsutum* and *L. peruvianum,* were between 2.0 and 3.9, indicating that they were extremely resistant (Table 2). In addition, low rating values for *L. pennellii, L. pimpinellifolium, L. chilense,* and *L. esculentum* var. *cerasiforme* indicate that there are useful levels of resistance within these species. Although the most resistant lines were accessions of *L. hirsutum* and *L. peruvianum,* some lines of these species were moderately to highly susceptible.

Very high levels of resistance were obtained in four interspecific breeding lines derived from *L. peruvianum, L. pimpinellifolium, L. chilense,* and *L. hirsutum* accessions (Table 3). These lines, however, are indeterminate, late-maturing, and relatively low-yielding. Seven breeding lines, primarily derived from *L. hirsutum,* had high levels of resistance, but were also indeterminate, late-maturing, and relatively low-yielding. Twenty-seven interspecific breeding lines derived from several wild species exhibited moderate levels of resistance, with ratings between 5.0 and 5.9, indicating that they might be potential sources of resistance for breeding programs. These lines, many of which had greatly improved maturity and yield relative to their resistant sources, were more resistant to early blight, under our test conditions, than NC EBR-1 or NC EBR-2. The more than 100 interspecific breeding lines from the Harrow program (HRC lines) with disease ratings over 6.0 are not reported.

These results suggest that the testing procedures can provide an estimate of resistance to early blight in a range of plant material currently available for commercial development. The results also provide information on sources of resistance that could be useful to breeders and seed companies in their development of tomato cultivars resistant to early blight.

Acknowledgement

The authors wish to thank cooperators for supplying the seed used in testing. The technical assistance of Bill Sturkenboom and Jing-Ming Zheng is also appreciated.

Literature Cited

Barksdale, T.H. 1971. Field evaluation for tomato early blight resistance. Plant Dis. Rept. 55:807-809.

Barksdale, T.H. and Stoner, A.K. 1977. A Study of the inheritance of tomato early blight resistance. Plant Dis. Rept. 61:63-65.

Basu, P.K. 1974. Measuring early blight, its progress and influence on fruit losses in nine tomato cultivars. Can. Plant Dis. Surv. 54:45-51.

Gardner, R.G. 1988. NC EBR-1 and NC EBR-2 early blight resistant tomato breeding lines. HortScience 23:779-781.

Gardner, R.G. 1990. Greenhouse disease screen facilitates breeding resistance to tomato early blight. HortScience 25:222-223.

Horsfall, J.G. and Heuberger, J.W. 1942. Measuring magnitude of a defoliation disease of tomatoes. Phytopathology 32:226-232.

Martin, F.W. and Hepperly, P. 1987. Sources of resistance to early blight, *Alternaria solani* and transfer to tomato, *Lycopersicon esculentum.* J. Agric. Univ. Puerto Rico 71:85-95.

Nash, A.F. and Gardner, R.G. 1988. Tomato early blight resistance in a breeding line derived from *Lycopersicon hirsutum* P.I. 126445. Plant Dis. 72:206-209.

Poysa, V, Brammall, R. and Pitblado, R.E. 1993. Effects of foliar fungicide sprays on disease and yield of processing tomatoes in Ontario. Can. J. Plant Sci. 73:1209-1215.

Table 1. Response of *L. esculentum* breeding lines, accessions, and cultivars to *Alternaria solani* infection.

Ave. Disease Severity Rating* (1-9 scale)	Line**
5.0 - 5.9	PI311115, PI414164, HRC86.320, HRC86.321, HRC86.327, HRC86.329, HRC86.331, HRC90.145, HRC90.157, HRC90.158, HRC90.159
6.0 - 6.9	NC-EBR-1, NC-EBR-2, Ohio 8245, FM6203, Heinz 9478, 23-E1, CC329, PE57, PE58, PI201266, PI201476, PI270407, PI270429, PI311279
7.0 - 7.9	Ace, Ohio 7814, Ohio 8556, Heinz 2653, Heinz 9230, Heinz 9035, CC164, CC218, CC7122, PE59, PE60, PI142968, PI262892, PI268407, PI270149, PI270403, PI270418, PI312188, PI427149, PI452027
8.0 - 8.9	TH318, EL19, AN-L-10

* Values are the average for all the tests using a line and the scale is based on a 1-9 scale, where 1 = asymptomatic; 2 = few small lesions; 3 = several small lesions; 4 = <10% of leaf area with infection; 5 = 10-20%; 6 = 21-50%; 7 = 51-80%; 8 = 81-99% of leaf area with infection; 9 = plant dead. None of the lines tested had ratings below 5.0 or above 8.9.

** PI lines obtained from the Plant Introduction Station, USDA, Geneva, New York;
HRC lines from V. Poysa, Agriculture and Agri-Food Canada, Harrow Research Centre, Harrow, Ontario;
PE, EL, and AN lines obtained from Dr. J. Cuartero, CSIC, Malaga, Spain.

Table 2. Response of related species of *Lycopersicon* to *Alternaria solani* infection.

Ave. Disease Severity Rating* (1-9 scale)	Line@**
2.0 - 2.9	LA2100[a], LA2650[a], PE33[b], PE36[a], PE44[c], PI390671[b]
3.0 - 3.9	LA1292[b], LA1365[b], LA1910[b], LA1983[b], LA2124[a], LA2552[a], PE34[a], PE35[a], PI270435[b], PI365951[b], PI390665[b]
4.0 - 4.9	LA1360[b], LA1366[a], LA1675[b], LA1929[b], LA2204[a], LA2573[b], LA2581[b], PE31[b], PI251305[a], PI251312[b], PI306811[b], PI365934[a], PI379014[a], PI390667[b]
5.0 - 5.9	LA751[c], LA1304[b], LA2404[e], PE63[f], PI128654[b], PI129144[b], PI251307[b], PI308183[b], PI375937[d], PI379017[b], PI415127[b], PI438880[f], PI438888[f]
6.0 - 6.9	LA1303[c], LA1723[b], LA2326[b], PE3[d], PE12[d], PE14[d], PE22[b], PE32[b], PE64[f], PE69[f], PE78[f], PI390513[a], PI422397[d]
7.0 - 7.9	LA1299[c], LA1960[e], PE2[d], PE8[d], PE73[f]
8.0 - 8.9	LA1920[c], PE49[b]

* Values are the average for all the tests using a line and the scale is based on a 1-9 scale, where 1 = asymptomatic; 2 = few small lesions; 3 = several small lesions; 4 = <10% of leaf area with infection; 5 = 10-20%; 6 = 21-50%; 7 = 51-80%; 8 = 81-99% of leaf area with infection; 9 = plant dead. None of the lines tested had ratings below 2.0 or above 8.9.

@ LA lines obtained from Dr. C. Rick, Tomato Genetics Resource Center, Davis, California;
PI lines obtained from the Plant Introduction Station, USDA, Geneva, New York;
PE lines obtained from Dr. J. Cuartero, CSIC, Malaga, Spain.

** Superscripts following each line indicate the species: [a] *L. hirsutum;* [b] *L. peruvianum;* [c] *L. pennellii;* [d] *L. pimpinellifolium;* [e] *L. chilense;* [f] *L. esculentum* var. *cerasiforme.*

Table 3. Response of interspecific hybrids of *Lycopersicon* to *Alternaria solani* infection.

Ave. Disease Severity Rating* (1-9 scale)	Line@**
3.0 - 3.9	HRC89.302[g], HRC90.189[e], HRC90.303[a], HRC90.305[a]
4.0 - 4.9	HRC90.190[a], HRC90.302[a], HRC91.140[a], HRC91.275[a], HRC91.276[a], HRC91.311[b], HRC91.341[a]
5.0 - 5.9	HRC84.267[c], HRC84.269[c], HRC84.286[c], HRC86.334[c], HRC90.108[a], HRC90.149[c], HRC90.162[c], HRC9.182[a], HRC91.035[b], HRC91.090[g], HRC91.277[a], HRC91.279[a], HRC91.281[a], HRC91.306[e], HRC92.101[b], HRC92.105[a], HRC92.111[a], HRC92.122[a], HRC92.124[c], HRC92.129[c], HRC92.153[f], HRC92.255[f], HRC92.256[f], HRC92.263[a], HRC92.266[a], HRC93.168[e], HRC93.179[e]
6.0 - 6.9	PI298934[b]

* Values are the average for all the tests using a line and the scale is based on a 1-9 scale, where 1 = asymptomatic; 2 = few small lesions; 3 = several small lesions; 4 = <10% of leaf area with infection; 5 = 10-20%; 6 = 21-50%; 7 = 51-80%; 8 = 81-99% of leaf area with infection; 9 = plant dead. None of the lines tested had ratings below 3.0 or above 6.9.

@ PI lines obtained from the Plant Introduction Station, USDA, Geneva, New York;
HRC lines from V. Poysa, Agriculture and Agri-Food Canada, Harrow Research Centre, Harrow, Ontario.

** Superscripts following each line indicate the related species involved in the cross: [a] *L. hirsutum;* [b] *L. peruvianum;* [c] *L. pimpinellifolium;* [d] *pimpinellifolium/hirsutum;* [e] *L. chilense;* [f] *peruvianum/hirsutum;* [g] *peruvianum/pimpinellifolium.*