Creation of *Liriomyza trifolii*-resistant tomato lines

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ABSTRACT
Cultivated tomato is often attacked by *Liriomyza* sp leafborers. A breeding programme was set up to tap the resistance of *Lycopersicon cheesmanii* LA 1401 to *L trifolii*. The programme involves alternating "improvement" backcrosses with selfing since this resistance is polygenic. Three agronomically interesting lines have been created, which are also resistant to *Fusarium* and *Stemphylium*.

Création de lignées de tomate résistantes à *Liriomyza trifolii.*

RÉSUMÉ
La tomate cultivée est souvent affectée par les mineuses du genre *Liriomyza*. Un programme de sélection tend à exploiter la résistance de *Lycopersicon cheesmanii* LA 1401 vis-à-vis de *L trifolii*. Cette résistance étant polygénique, le programme a été conduit en faisant alterner recroisements améliorateurs et autofécondations. Trois lignées intéressantes d'un point de vue agronomique ont été sélectionnées ; elles sont également résistantes au *Fusarium* et au *Stemphylium*.

Creación de castas de tomate resistentes a *Liriomyza trifolii.*

RESUMEN
El tomate cultivado es frecuentemente afectado por las minadoras del género *Liriomyza*. Un programa de selección tiende a explotar la resistencia de *Lycopersicon cheesmanii* LA 1401, frente a *L trifolii*. Esta resistencia siendo poligénica, el programa se llevó a cabo alternando recruzamientos mejorantes y autofecundaciones. Se seleccionaron tres lineas interesantes de un punto de vista agronómico ; también son resistentes al *Fusarium* y al *Stemphylium*.

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KEYWORDS
Tomato, *Lycopersicon*, *Liriomyza trifolii*, breeding methods, pest resistance, selection.

MOTS CLÉS
Tomate, *Lycopersicon*, *Liriomyza trifolii*, méthode d'amélioration, résistance aux organismes nuisibles, sélection.

PALABRAS CLAVES
Tomate, *Lycopersicon*, *Liriomyza trifolii*, métodos de mejoramiento, resistencia a las plagas, selección.

introduction

In many regions of the world, *Liriomyza* (Diptera, Agromyzidae) serpentine leafminers have a marked effect on tomato plants. *Lycopersicon cheesmanii* LA 1401, a wild species endemic to the Galapagos Islands and closely related to cultivated tomatoes, was found to be *Liriomyza*-resistant during serious outbreaks on protected crops in France in 1985 (GINOUX, personal communication, 1985). This high resistance was then confirmed under artificial infestation with *L trifolii* (BORDAT *et al*, 1987; LATERROT *et al*, 1987).

A breeding program was thus set up to tap this resistance source, which was also found to be efficient against the leafminer *L sativae* Blanchard.

materials and methods

controlled infestation

The *L trifolii* strain used in this study originated from Réunion. It was maintained on green bean (*Phaseolus vulgaris*) plants placed in altuglass cages covered with fine netting to allow air circulation. The mass-breeding yields were 500–700 adults/day (DALLE and BORDAT, 1993).

Ready-to-oviposit females used in the selection tests were collected randomly in the rearing enclosure with a mouth aspirator, then introduced in six cages (about 50 leafminers/cage) containing plants to be bred on the basis of their resistance. The control cage contained a susceptible tomato variety (cv Flora Dade), while the five other cages contained batches of plants to be bred. For each test, 300 *L trifolii* females were used; such tests were performed on a weekly basis.

The tomato plants (20 plants/cage) exposed to the female leafminers were at the three to four leaf stage. The day after ovipositioning, which lasted 24 h, adult leafminers were removed from the cages and the dead insects counted.

Plants exposed to these fly pests were monitored 4 days after oviposition to count the number of bore channels on each plant (1 bore-channel = 1 larva). Plants with no bore-channels, or only one or two, were set aside for the breeding programme.

breeding material and techniques

Lycopersicon cheesmanii LA 1401 is a wild very self-fertile species that produces small orangy fruit. It is very easy to hybridize with cultivated tomato female parents. F1 hybrids derived from this tomato x *L cheesmanii* cross are fertile and no sublethal traits appear in later generations.

The first tests revealed incomplete dominance concerning resistance in the F1 hybrids of the tomato x LA 1401 cross. Segregation observed in the F2 progeny of the same cross indicated that this resistance is under the control of several genes. These results were taken into account in the genetic improvement programme set up to insert the resistance character into the cultivated tomato species by alternating "improvement" backcrossing and selfing (appendix 1).

The resistance tests were carried out on plants obtained by selfing. Three series of intercrosses were performed to ensure genetic mixing: a first time with plants derived from the first backcross, a second time with resistant plants obtained after selfing the third backcross, and a third time with plants obtained by selfing the fourth backcross.

The improvement backcrosses were carried out by hybridizing resistant plants with a series of tomato varieties, chosen on the basis of various quality criteria (size, fruit firmness and colour, and resistance to various diseases).

A series of tomato varieties bred in tropical and subtropical zones was used in the fourth backcross.

breeding results

The "tropicale" population (appendix 1), derived from the intercross corresponding to the fourth backcross, was monitored by EV Coly in Senegal in CDH-ISRA (Centre pour le développement de l'horticulture, dépendant de l'Institut sénégalais de recherches agronomiques, Camberene, Dakar) experimental plots during the 1990–1991 winter season. They were under natural infestation conditions, with a supplement of pupae at the prehatching stage. The extent of the attacks varied markedly between plants, the number of bore-channels/plant ranged from nine to 113. Hence, no lines derived from plants bred at this stage of the programme had a fixed high level of resistance. This was also the case for material that was laboratory-observed under controlled infestation conditions in cages, thus confirming that the targeted resistance was polygenic.

Genotypes which seemed to be fixed for this resistance trait were obtained after the third selfing performed after the "tropicale" population was obtained. Nine lines were chosen for field experiments in France (summer 1992). These nine lines showed determinant growth.

The observations (1992 test) revealed that only three of the nine lines were of agronomic interest: they produced firm round, or slightly flattened, medium-sized fruit. They were also resistant to vascular *Fusarium* race 0 (ex 1) and to *Stemphylium* spp. After controlled infestation, an average of six bore-channels were counted on plants from these selected lines, whereas 16 were noted on the control plants (cv Flora Dade). These lines were distributed to several correspondents in various Mediterranean and subtropical zones for evaluation.

In addition to these field tests, the breeding scheme was continued: eight plants derived from the fourth selfing, crossed with the susceptible control variety (cv Flora Dade), were used to obtain F1 hybrids for assessment of their behaviour in the presence of *Liriomyza*. The results of tests carried out with these F1 hybrids, and with lines obtained by selfing plants that had been used to create them, are given in table I. The behaviour of the F1 hybrids was midway between those of the susceptible control and the resistant lines, but closer to the latter. The selected resistance was therefore polygenic and incompletely dominant in F1 hybrids.

Different combinations of F1 hybrids were created with the selected material and varieties of agronomic interest or possessing resistance to other pathogenic agents. The agronomic interest and behaviour of these F1 hybrids in the presence of *Liriomyza* spp will now be studied.

A phytochemical study, carried out at the same time as this breeding programme with *L cheesmanii*, led to the discovery, in this species, of an active substance against *L trifolii*, identified as a sucrose ester (JOUY, 1990; JOUY *et al*, 1992). It would be interesting to determine the levels of this substance in the tomato lines obtained in the breeding programme.

Table I
Resistance of F1 hybrids derived from a cross between cv Flora Dade (susceptible control) and eight tomato lines resistant to *Liriomyza*.

Test no	*Susceptible control*	*Resistant lines*	*F1 hybrids between cv Flora Dade and the resistant lines*
197	Flora Dade 14.2	B18-19-2-10 2.2	F1 G 2.3
197	Flora Dade 14.2	B18-19-2-11 2.0	F1 H 5.6
195	Flora Dade 15.6	G9-18-1-5 5.9	F1 D 9.5
194	Flora Dade 20.0	G9-18-4-17 2.5	F1 A 10.2
194	Flora Dade 20.0	G9-18-11-14 4.4	F1 B 8.9
200	Flora Dade 19.4	G9-18-13-4 2.9	F1 C 11.1
196	Flora Dade 12.4	Q18-7-19-2 3.1	F1 E 6.2
196	Flora Dade 12.4	Q18-7-19-9 2.2	F1 F 7.1
Overall means for eight tests	Flora Dade 16.0	Lines 3.2	F1 hybrid 7.6

The results represent the mean number of bore-channels (1 bore-channel = 1 larva) observed per plant; this mean was calculated on the basis of observations of 20 plants per line or per hybrid.

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Appendix 1
Scheme set up for the breeding programme designed to insert the *Liriomyza*-resistance character into cultivated tomatoes from *Lycopersicon cheesmanii* LA 1401.

5/84	Tomato x *L cheesmanii* LA 1401	→ F1
12/84	Selfing Screening Lirio	→ F2
7/85*	Tomato x resistant F2	→ 1 BC
11/85	Intercross Screening Lirio	→ 1 BCI
7/86	Tomato x 1 resistant BCI	→ 2 BC
12/86	Intercross Screening Lirio	→ 2 BCI
6/87	Tomato x 2 resistant BCI	→ 3 BC
12/87	Selfing Screening Lirio	→ 3 BC ⊕
12/88	Intercrossing the 3 resistant BC ⊕ Screening Lirio	→ 3 BC ⊕ I
8/89	Tomato x 3 resistant BC ⊕	→ 4 BC
1/90	Intercross Screening Lirio	→ 4 BCI = Tropicale
7/90	Selfing 4 resistant BCI Screening Lirio	→ 4 BCI ⊕
1/91	Selfing 4 BCI ⊕ Screening Lirio	→ 4 BCI 2 ⊕
4/91	Selfing 4 BCI 2 ⊕ Screening Lirio	→ 4 BCI 3 ⊕→1992 test
11/91	Selfing 4 BCI 3 ⊕ Screening Lirio	→ 4 BCI 4 ⊕→F1 obtaining
7/92	Selfing 4 BCI 4 ⊕	→ 4 BCI 5 ⊕

*Various tomato varieties were used to obtain the F1 and successive backcrosses (= BC). They provided agronomic qualities and resistance to various pathogenic agents to separate this part on a third line; ⊕: selfing; I: intercrossing with pollen blends.