Evaluation of Tomato Germplasm and Selection of Breeding Lines for Resistance to Begomoviruses in Guatemala

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Abstract

Tomato genotypes with resistance to begomoviruses derived from different wild species were evaluated in Guatemala. Selection of individual plants for several generations resulted in breeding lines with high levels of resistance. Resistance derived from *L. hirsutum* was dominant, while resistance from the other sources was more recessive in nature. Crosses among resistant lines resulted in higher levels of resistance for F1 populations than crosses between resistant and susceptible lines. Resistant lines were crossed to susceptible lines with other traits of interest, namely resistance to other pathogens and desirable fruit characters. Improved breeding lines with begomovirus resistance have been selected from these hybrids. These breeding lines are currently being used in the production of begomovirus-resistant hybrids with acceptable market quality and yields.

INTRODUCTION

Leaf-curling diseases of tomato, caused by whitefly-transmitted geminiviruses (begomoviruses), have significantly affected tomato production in Guatemala and other countries in Central America for over a decade (Polston and Anderson, 1997; Morales and Anderson, 2001; Mejía et al., 2002). Many tomato fields in the main growing regions of Guatemala have 100% incidence of infection with begomoviruses and are often abandoned. When the plants become infected early in development, the symptoms are severe and include yellowing and puckering of the leaves and severe stunting of the plant. Although cultural practices, such as the use of virus-free seedlings or the use of net-covered tunnels in the field for up to 30-days after transplanting, have reduced the severity of these diseases, growers can still sustain considerable losses. The excessive use of insecticides has a high economic cost and a detrimental effect on the environment and human health. The introduction of resistant cultivars would be a desirable addition to other integrated management strategies for the control of these diseases. No begomovirus-resistant cultivars are currently available in Guatemala and Central America. A project to select tomatoes for resistance to begomoviruses was started in eastern Guatemala in 1998. This project is located in an irrigated area of intensive horticultural production the year round. The climate in this area is hot and dry and whitefly populations are usually high. Tomato plantations normally show 100% incidence of infection by begomoviruses. This area is a “hot spot” for tomato-infecting begomoviruses; and seven of eight begomoviruses currently known to occur in Central America are present and mixed infections usually occur.

MATERIALS AND METHODS

Tomato genotypes, with resistance to *Tomato yellow leaf curl virus* (TYLCV), a monopartite begomovirus from the Eastern Hemisphere, and *Tomato mottle virus* (ToMoV), a bipartite begomovirus from Florida, were obtained from several breeding programs. These included different sources of resistance, from the wild the species *L. hirsutum* (Vidavsky and Czosnek, 1998), *L. chilense* (Scott et al., 1995), *L. peruvianum* (Friedmann et al., 1998) and *L. pimpinellifolium* (Laterrot, 1992). The seedlings were started near the trial site in the open field and naturally exposed to viruliferous whiteflies coming from infected fields. No specific control was used against the vector and fungicides were used for control of foliar pathogens. The seedlings were transplanted in a randomized block design with four replications of ten plants each, at a spacing of 1 x 0.4 m. Symptoms were scored on a Disease Severity Index (DSI) scale of 0-4, in which a score lower than 2 is considered indicative of resistance. DSI scores were recorded at 30 and 60 days after transplant. Average fruit weights and average yields per plant were recorded at harvest. Resistant plants were selected individually for several generations until phenotypically homogenous lines were obtained.

RESULTS

Lines with resistance from *L. hirsutum* (Vidavsky and Czosnek, 1998) were Gh1, Gh3, and Gh13 selected from hybrid Favi 9 and line Gh2 from hybrid Favi 12 (Table 1). Lines with resistance from *L. peruvianum* (Friedmann et al., 1998) were Gper11 selected from breeding line TY198 and Gper12 and Gper19 from breeding line TY197. Lines with resistance from *L. chilense* (Scott, 1995) were Gc9 and Gc16 selected from breeding lines Fla 595-2 and Fla 658-2BK, respectively. Line Gpimper10 was selected from segregating population Pimper J-13 with resistance derived from *L. pimpinellifolium* and *L. peruvianum* (Laterrot, 1992). The susceptible line GC6 was selected from the Cuban cultivar HC-7880, which is adapted to tropical conditions. Not all TYLCV-resistant genotypes tested in Guatemala had useful levels of resistance to local begomoviruses; lines TY 52 with resistance derived from *L. chilense* (Zamir et al., 1994) and H24 with resistance from *L. hirsutum* (Kaloo and Banerjee, 1990) were both susceptible, when grown in the field trial (data not shown).

At 30 days after transplanting, the DSI's for the susceptible line GC6 was generally above 3, whereas the DSI's of the lines with resistance derived from *hirsutum*, *chilense* or *peruvianum* were less than 2 (Table 1). Yield per plant ranged from 148 g for GC6 to 2,312 g for Gc16.

The DSI and yield was determined for various hybrids from crosses among resistant parental lines with different sources of resistance genes (Table 2). In all cases, the DSI's were lower and yields substantially greater than the susceptible commercial hybrid Elios. The DSI's of the hybrids were similar to those of the parents (Table 1 and 3).

Resistant lines with different sources of resistance were crossed with susceptible lines to determine dominance of resistance. The crosses from Gc9, Gc16, Gper11, or Gpimper10 by a susceptible line or hybrid all gave F1 populations that were highly susceptible (data not shown). Only crosses of resistant parents with the *hirsutum*-derived resistance genes by susceptible lines or hybrids gave F1 populations with DSI's less than 2 at 30 days after transplanting (Table 3).

In order to introduce other traits of interest into the begomovirus resistant lines, crosses were made to susceptible lines carrying some of these traits (Table 3). These traits included primarily resistance to other pathogens and fruit characters, such as the Saladette shape and increased firmness, since around 80% of the tomatoes planted in Guatemala are field grown firm, Saladette types. Breeding lines have been selected from these hybrids based on resistance to begomoviruses, fruit shape, firmness and yield. Several of these lines, which now have excellent levels of begomovirus-resistance combined with other desirable traits, have been crossed to produce hybrids that are currently being evaluated for commercial production (Table 4). Currently, over 30 breeding lines with high levels of resistance and various fruit sizes and shapes are available as parental lines for development of hybrids for the Guatemalan and Central American markets.

DISCUSSION

TYLCV-resistant germplasm selected in Israel with begomovirus-resistance genes from either *L. hirsutum* (Vidavsky and Czosnek, 1998) or *L. peruvianum* (Friedmann et al., 1998) showed high levels of resistance to the bipartite begomovirus-complex in Guatemala. Also, the germplasm with *L. chilense* introgressions selected for resistance in Florida, USA to both TYLCV and ToMoV (Scott et al., 1995) were resistant in Guatemala. This was not the case for line H24 selected for resistance to the monopartite begomovirus *Tomato leaf curl virus* (Kaloo and Banerjee, 1990), which was susceptible in Guatemala. Also, line TY52, which has the *Ty-1* gene from *L. chilense* (Zamir et al., 1994), was susceptible in Guatemala; however, recent field tests in Israel have indicated that this line is only moderately resistant to TYLCV (data not shown). These results indicate that it is possible to develop breeding lines that are resistant to both monopartite and bipartite begomoviruses.

Early crosses with resistant lines indicated that the level of resistance of the hybrid could be increased, when resistance genes were introduced from both parents. For example, when the parental line P2-1132 (the parental line from where Gpimper10 was selected) was crossed to a susceptible line, the hybrid showed a low level of resistance (DSI at 60 days after transplanting = 2.9, compared to 3.1 in the susceptible control). However, when this same line was crossed to resistant line F6-2211 (the parental line that produced Gh13), it produced a hybrid with a high level of resistance (DSI = 1.9). This could not be attributed to dominance alone, since the parental line F6-2211 crossed to the susceptible line had an intermediate level of resistance (DSI = 2.1) (data not shown). Subsequent field trails showed that the crosses between two resistant lines produced the highest levels of resistance (Table 2 and 3). These crosses also indicated that the resistance derived from *L. hirsutum* was at least partially dominant, while that derived from *L. pimpinellifolium* and *L. peruvianum* was more of a recessive nature. The hybrids with a parental line with resistance derived from *L. hirsutum* as one of the parents were always more resistant (Table 2 and 3). It is suggested that combining sources of resistance from different wild species may have the advantage of providing greater durability. Thus, future hybrids will combine begomovirus-resistance genes from *L. hirsutum* and *L. chilense*, e.g. Gh13 crossed with Gc9 (Table 3).

The hybrids between resistant lines and susceptible lines of high horticultural value have shown high levels of resistance and good yields (Table 2). Improved breeding lines with high levels of resistance and horticultural traits of interest have been selected from these hybrids. The crosses among these improved resistant lines are expected to result in hybrids with high resistance to begomoviruses and good qualities for the Guatemalan market. Sixty hybrids are currently being evaluated.

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<u>Tables</u>

Table 1. Symptom severity and yield of begomovirus-resistant lines evaluated in Guatemala from April to September 2002.

Line and source of resistance	**Average DSI 30**	**Average DSI 60**	**Average weight/fruit (g)**	**Average yield/plant (g)**
GC6	3.2	3.4	16	148
Favi 9 and Favi 12				
Gh1	1.1	1.5	81	1,756
Gh13	1.2	1.5	96	2,031
Gh2	1.1	1.6	58	1,060
TY 197 and TY 198				
Gper19	1.2	1.7	45	1,750
Gper11	1.7	2.5	38	1,241
Fla 595 and Fla 658				
Gc9	1.2	1.8	82	1,742
Gc16	0.9	1.2	68	2,312
Pimper J-13				
Gpimper10	2.4	3.2	43	3,75

Table 2. Performance of hybrids produced by crosses between resistant lines (R x R) evaluated from April to September 2002.

Hybrid and source of resistance	**Average DSI 30**	**Average DSI 60**	**Average weight/fruit (g)**	**Average yield/plant (g)**
Elios (Peto Seed Co.)	3.1	3.3	22	116
L. hirsutum				
Gh1 x Gh2	1.3	1.3	65	1,940
L. hirsutum x *L. peruvianum*				
Gh2 x Gper11	1.2	1.6	48	2,121
Gh2 x Gper12	1.3	1.6	52	1,877
L. peruvianum x *L. pimpinellifolium*				
Gper11p x Gpimper10	2.1	2.9	39	1,193
Gper12 x Gpimper10	1.3	1.8	39	1,781

Table 3. Performance of hybrids produced by crosses between resistant lines and susceptible lines (R x S) evaluated from April to September 2002.

Hybrid and source of resistance	**Average DSI 30**	**Average DSI 60**	**Average weight/fruit (g)**	**Average yield/plant (g)**
Marina (Sakata Seed Co.)	3.1	3.3	15	136
Favi 9 (*L. hirsutum*)				
Gh1 x M82	1.8	2.5	35	1,327
Gh1 x Very Firm	1.6	2.4	56	1,446
Gh1 x HC-7880	1.3	1.9	36	1,320
Gh3 x Sun Coast	1.9	1.8	65	1,719
Gh3 x Rodade	1.4	2.5	48	612
Favi 12 (*L. hirsutum*)				
Gh2 x M82	1,7	2.5	35	1,314
Gh2 x Sun Coast	1.8	2.5	48	612
Gh2 x HC-7880	1.8	2.4	49	1,340

Table 4. Symptom severity and partial yield of begomovirus-resistant hybrids evaluated from December 2003 to April 2004.

Hybrid	**Average DSI 30**	**Average DSI 60**	**Average weight/fruit (g)**	**Average yield/plant (g)**
Gh3 x susceptible	1.2	1.7	59	1,997
Gc9 x Th47-1[1]	1.1	1.6	71	1,277
Gh13 x Th47-1	1.0	1.5	95	1,262
Gh13 x Gc9	1.0	1.5	87	1,973
Elios (Peto Seed Co.)	2.4	3.0	31	802
Marina (Sakata Seed Co.)	2.4	2.9	27	596
Silverado (Ferry-Morse Seed Co.)	2.3	2.9	39	955
Sheriff (Ferry-Morse Seed Co.)	2.3	3.1	20	446

[1]Resistant line selected from a hybrid between a line selected from Favi 9 and a susceptible line.