Indian J. Genet., **52** (2): 118–125 (1992)

STUDIES ON THE REACTION OF CERTAIN TOMATO GENOTYPES AND THEIR F_1 TO COMBINED INFECTION BY *MELOIDOGYNE INCOGNITA* AND *PSEUDOMONAS SOLANACEARUM*

S. NIRMALADEVI* AND S. K. TIKOO

Indian Institute of Horticulture Research, Hessarghatta Lake P.O., Bangalore 560089

(Received: July 22, 1989; accepted: August 19, 1991)

ABSTRACT

In a study to find out the reaction of certain tomato genotypes and their F_1 hybrids to root-knot disease and bacterial wilt, it was found that the hybrids whose parents had dominant sources of resistance to bacterial wilt and root-knot diseases remained resistant to these diseases in the field. When the parents had partially dominant/recessive source of resistance to either of the diseases, the hybrids became susceptible to wilt. Still, it is possible to get F_1 hybrids with desirable economic characters and combined resistance to bacterial wilt and root-knot disease.

Key words: Tomato, F_1 hybrids, resistance, bacterial wilt, root- knot disease.

Tomato (*Lycopersicon esculentum*), one of the most important vegetable crops grown in many parts of the world is infected by fungi, bacteria, viruses, nematodes and insects. The bacterial pathogen *Pseudomonas solanacearum* causes wilt of tomato which is one of the most limiting factors in tomato production. Since the chemical control measures failed to achieve the desired success, attempts are on to find out genetic sources of resistance to the disease. The yield loss in tomato due to root-knot disease has been estimated to be upto 61%. Genetically resistant plants will enable the grower to control root-knot disease without increasing the cost of production. Since these diseases are the major problems in tomato cultivation and the resistance to bacterial wilt has been known to breakdown under conditions of infestation by nematodes, a study was undertaken to find out F_1 hybrids resistant to both the diseases.

MATERIALS AND METHODS

Six tomato lines resistant to bacterial wilt and 12 lines resistant to root-knot disease

*Present address: Division of Pomology and Floriculture, College of Horticulture, Vellanikkara, Kerala 680654.

(Table 1) formed the basic material for the present study. Each of the bacterial wilt resistant (BWR) line was crossed with all the nematode resistant (NR) lines and the F_1 along with the parents were studied for their reaction to bacterial wilt and root-knot disease. The field was sick of both *Pseudomonas solanacearum* (10^8 colony forming units/g soil) and *Meloidogyne incognita*. To ensure sufficient inoculum, 100 g nematode infested soil containing 1000 *M. incognita* larvae was put in the planting holes at the time of planting and *P. solanacearum* culture (O. D. 0.5) was inoculated in the axil of third leaf at flowering initiation.

Table 1. The BWR and NR lines used in the hybridization programme of tomato

BWR lines	NR lines
BWR 1	Rossol
CRA 66 Sel A	Ronita
83 BWR 12-2	IHR 998
BWR 5	IHR 999
83 BWR 90	Patriot
MITA 668	VFN 8
	Pelican
	LA 655
	LA 656
	83 BWR 120
	84 BWR 30
	84 BWR 32

The reaction to bacterial wilt was recorded in terms of percent survival in the field at intervals of 20 days and bacterial ooze index. The rate of flow of ooze from the cut end of the stem at collar region was scored as:

1—No ooze

2—Thin strand of ooze, not continuous, flow stops after two minutes

3—Continuous thin white strands, flow not restricted

4—Heavy ooze, within 2 minutes the water turns turbid

The plants were uprooted to monitor the roots for galls produced by *M. incognita*. The galling was scored in 1 to 5 scale:

Score	*Parameter*	*Plant response*
1	No gall formation	Highly resistant
2	1–10 galls/plant	Resistant
3	11–30 galls/plant	Moderately resistant
4	31–100 galls/plant	Susceptible
5	> 100 galls/plant	Highly susceptible

The data were analysed as suggested by Panse and Sukhatme [1].

RESULTS AND DISCUSSION

PER CENT SURVIVAL AGAINST BACTERIAL WILT

The parental lines and the F_1 differed significantly among themselves for per cent survival of plants on 20th, 40th, 60th, 80th and 100th day after transplanting in the sick field (Table 2). The BWR lines had higher survival rates than the NR lines but there was no significant difference among the BWR lines for survival. Results obtained in the present study shows that the survival rate of plants was less than reported earlier in case of BWR1 and CRA 66 Sel A [2] against bacterial wilt. This may be because the authors had used Furadan to keep the field free of nematodes in their study. But the experiment described here was in a field infested with both pathogens. This indicates that the nematodes are predisposing the plants to bacterial wilt thereby reducing survival of wilt resistant lines. Such predisposition phenomenon has also been reported earlier [3] in bacterial wilt and root-knot nematode complex in tomato. However, both BWR 1 and CRA 66 Sel A lines showed wilting symptoms at later stages as compared to the susceptible lines.

Survival rates declined progressively in wilt susceptible nematode resistant lines (Table 2). There was 100 per cent plant mortality in Patriot and VFN 8 by 100th day. MITA 668 and its derivatives, viz., 84 BWR 30 and 84 BWR 32 showed significantly higher survival rates than other NR lines because it was originally introduced as a BWR line from Peru.

The crosses of 83 BWR 12-2, BWR 1, 83 BWR 90, 83 BWR 120, BWR 5 and MITA 668 showed higher survival rates on 100th day when compared to the NR lines (Table 2). The F_1 hybrids of 83 BWR 12-2 were highly resistant to wilt and survival rates did not differ significantly from that of 83 BWR 12-2. It indicated that resistance to wilt is dominantly inherited in this line. BWR 1 was highly resistant (> 90% survival) and so were its hybrids, except the crosses with IHR 998 and IHR 999 where survival rates were 71%. However, none of these hybrids differed significantly from BWR 1 for survival, thereby confirming the dominant source of resistance to wilt in this line, as already reported [2]. Among the BWR 1 hybrids, the highest mortality was in the hybrid with 84 BWR 30, a derivative of MITA 668 which had recessive source of resistance to nematodes [4] and susceptibility of F_1 to nematodes might have predisposed the hybrid to wilt.

The line 83 BWR 90 was highly resistant to wilt but its F_1 hybrids with the nematode resistant lines differed significantly in per cent survival. The lowest per cent survival was observed in the hybrid with LA 655. The significant difference among the F_1 in survival is because 83 BWR 90 is a derivative of CRA 66 Sel A which has recessive source of resistance to wilt [2]. Though 83 BWR 120 was highly resistant to wilt, the F_1 hybrids were either susceptible or moderately resistant. The F_1 hybrids of CRA 66 Sel A were susceptible to wilt thereby confirming the recessive source of resistance reported [2] in this line. The susceptibility of the F_1 at a significantly later stage than the susceptible parents accounts for

Table 2. Mean performance of parental and F_1 lines of tomato in the field

Line/hybrid	Per cent survival against bacterial wilt on different days				Ooze index	Gall index
	20th	40th	60th	80th		
83 BWR 12-2	94.2	94.2	94.2	94.2	2.3	2.8
BWR 1	98.9	96.3	91.3	91.3	1.3	3.7
83 BWR 90	100.0	100.0	98.9	97.6	1.5	2.0
83 BWR 120	95.2	90.9	85.4	85.4	2.0	3.5
CRA 66 Sel A	97.6	88.4	88.4	88.4	1.7	2.8
BWR 5	98.8	98.8	85.8	85.8	1.2	4.0
Rossol	80.6	72.2	48.7	30.5	2.9	1.0
Ronita	95.9	81.9	47.4	47.4	2.4	1.0
IHR 998	98.6	62.0	37.5	24.9	2.9	1.0
IHR 999	94.9	75.0	24.2	2.6	3.0	1.0
Patriot	90.5	48.1	20.4	0.0	4.0	1.0
VFN 8	76.2	56.5	8.5	3.7	4.0	1.0
Pelican	51.9	44.3	1.7	1.7	3.7	1.0
LA 656	91.6	73.0	28.7	9.8	3.0	1.0
LA 655	25.0	0.0	0.0	0.0	3.4	1.0
84 BWR 30	98.7	91.7	82.5	82.5	2.0	1.0
84 BWR 32	100.0	88.7	79.3	79.3	1.3	1.0
MITA 668	98.7	75.7	39.4	39.4	2.7	1.1
83 BWR 12-2 x Rossol	100.0	98.8	98.8	98.8	2.0	1.0
83 BWR 12-2 x Ronita	93.3	93.3	93.3	93.3	1.9	1.2
83 BWR 12-2 x IHR 998	98.0	98.0	98.0	98.0	2.7	1.1
83 BWR 12-2 x IHR 999	84.7	75.8	65.5	65.5	2.6	1.3
83 BWR 12-2 x Patriot	95.5	93.3	93.3	93.3	2.5	1.3
83 BWR 12-2 x VFN 8	100.0	92.6	92.6	92.6	2.7	1.0
83 BWR 12-2 x Pelican	100.0	98.3	98.3	98.3	3.2	2.2
83 BWR 12-2 x LA 656	98.8	98.8	98.8	98.8	1.7	1.1
83 BWR 12-2 x 84 BWR 32	100.0	98.8	93.0	93.0	1.7	1.7
BWR 1 x Rossol	98.7	94.9	85.1	85.1	2.2	1.0
BWR 1 x Ronita	100.0	98.5	94.9	94.9	1.7	1.1
BWR 1 x IHR 998	90.0	83.7	71.5	71.5	2.1	1.0
BWR 1 x IHR 999	90.2	72.5	72.5	72.5	2.4	1.2
BWR 1 x Patriot	97.0	97.0	92.3	92.3	2.6	1.9
BWR 1 x VFN 8	100.0	92.9	87.6	87.6	1.5	1.2
BWR 1 xPelican	95.0	92.5	92.5	92.5	2.3	2.1
BWR 1 x 84 BWR 30	94.9	82.2	67.9	67.9	2.6	2.5

(Contd.)

Table 2. (Contd.)

Line/hybrid	Per cent survival against bacterial wilt on different days				Ooze index	Gall index
	20th	40th	60th	80th		
BWR 1 x 84 BWR 32	98.7	89.3	86.2	86.2	1.5	1.5
BWR 1 x LA 656	100.0	98.7	98.7	98.7	2.4	1.5
BWR 1 x LA 655	97.6	93.3	77.9	77.9	1.9	1.0
83 BWR 90 x Rossol	98.9	85.2	74.2	74.2	2.1	1.7
83 BWR 90 x Ronita	98.7	81.7	61.1	61.1	1.9	1.3
83 BWR 90 x IHR 988	89.0	76.6	61.2	56.8	3.0	1.3
83 BWR 90 x IHR 999	100.0	98.5	93.4	93.4	2.8	1.2
83 BWR 90 x Patriot	96.5	91.5	91.5	91.5	2.9	1.7
83 BWR 90 x Pelican	100.0	98.1	98.1	98.0	1.6	1.4
83 BWR 90 x 84 BWR 30	98.5	98.5	98.5	93.6	1.7	1.6
83 BWR 90 x 84 BWR 32	98.7	93.7	81.3	81.3	2.5	1.6
83 BWR 90 x LA 656	89.2	85.3	85.3	85.3	2.3	1.6
83 BWR 90 x LA 655	96.3	44.6	27.9	27.9	2.8	1.3
83 BWR 120 x Ronita	93.3	61.5	56.0	39.4	2.9	1.3
83 BWR 120 x IHR 998	92.2	66.4	50.1	34.0	3.2	1.9
83 BWR 120 x Patriot	94.9	76.3	64.2	64.2	2.0	1.0
83 BWR 120 x VFN 8	97.1	80.7	69.2	69.2	2.0	1.4
83 BWR 120 x Pelican	93.7	76.6	42.1	42.1	2.4	1.5
83 BWR 120 x LA 655	100.0	92.5	92.5	48.5	1.3	1.0
CRA 66 Sel A x Rossol	90.9	70.3	27.3	12.9	1.1	1.2
CRA 66 Sel A x Ronita	98.9	94.5	81.1	52.4	2.1	1.2
CRA 66 Sel A x IHR 998	97.6	71.6	30.1	30.1	2.2	1.0
CRA 66 Sel A x IHR 999	98.9	80.7	26.1	18.9	2.7	1.1
CRA 66 Sel A x Patriot	95.9	73.0	60.8	57.5	1.8	1.0
CRA 66 Sel A x VFN 8	83.6	59.2	55.5	41.8	2.5	1.2
CRA 66 Sel A x 84 BWR 30	95.2	86.4	51.5	51.5	1.7	2.6
CRA 66 Sel A x LA 656	97.4	84.4	33.5	33.6	2.5	1.3
CRA 66 Sel A x LA 655	88.4	64.5	57.3	50.7	1.7	2.3
BWR 5 x Ronita	100.0	97.6	97.6	97.6	2.1	1.2
BWR 5 x IHR 998	100.0	97.4	97.4	97.4	2.2	1.2
BWR 5 x Pelican	98.5	92.8	90.6	90.6	3.0	1.4
BWR 5 x 84 BWR 30	95.2	92.8	90.6	90.6	1.7	2.4
BWR 5 x 84 BWR 32	97.5	90.6	83.0	83.0	1.9	2.7
BWR 5 x LA 656	100.0	95.5	80.0	80.0	1.6	3.9
MITA 668 x 83 BWR 120	100.0	95.5	87.9	62.9	1.6	3.9
C. D. at 5%	22.17	22.68	23.40	24.63	0.91	0.77

the yield obtained in these lines. BWR 5 and its hybrids were highly resistant to wilt indicating the presence of dominant source of resistance in BWR 5. The hybrid of MITA 668 with 84 BWR 120 had only 62 per cent survival in the sick field. Since 83 BWR 120 has dominant source of resistance (Tikoo, unpublished) 100% survival is expected in the F_1. But the reduced survival percentage is possibly due to the recessive source of resistance to nematodes in MITA 668 whereby F_1 became susceptible to nematodes and they predispose the plants to bacterial wilt.

OOZE INDEX

Ooze index of the bacterial wilt resistant lines was more than 1 (Table 2) indicating that certain amount of bacteria are able to multiply in these resistant lines without killing the plants. All the nematode resistant lines except 84 BWR 30 and 84 BWR 32 had significantly higher ooze index than the BWR lines indicating that bacterial multiplication is very high. This is directly proportional to their susceptibility to wilt.

The ooze index of 83 BWR 12-2 hybrids varied from 1.7 to 3.2, indicating susceptibility or moderate resistance to wilt. But the high resistance to wilt observed in the field shows that these lines could withstand bacterial multiplication and survive in the field. There was significant difference in the ooze index of BWR 1 and its hybrids with Rossol, IHR 999, Patriot, Pelican, 84 BWR 30 and LA 656. The ooze index of 83 BWR 90 hybrids indicated resistance or moderate resistance to wilt. But in the field, the hybrids had higher survival percentage showing high resistance to wilt except in the hybrid with LA 655. As indicated by the ooze index, the 83 BWR 120 hybrids were either susceptible or moderately resistant to wilt. Though the ooze index of CRA 66 Sel A hybrids indicated moderate resistance to wilt, they became susceptible to wilt by 100th day. They were moderately resistant till 80th day and became susceptible later. This is because of delayed expression of disease. The amount of bacterial cells present in the vascular bundles when the lines were moderately resistant itself made them susceptible at the later stages. The BWR 5 hybrids, in spite of the moderate resistance or resistance indicated by the ooze index were highly resistant in the field as shown by higher survival per cent. The ooze index of hybrid MITA 668 x 83 BWR 120 (1.6) was significantly lower than that of MITA 668. It was resistant to wilt in the field.

GALL INDEX

In the field infested with both pathogens, NR lines remained resistant to nematodes as shown by their gall index. Some of these lines have been already reported resistant to *Meloidogyne incognita* [5–8]. The gall index of BWR lines varied from 2.8 to 4.0, indicating that they were highly susceptible to nematodes. This might have resulted in the susceptibility of these lines to wilt in the field infested with *M. incognita* and *P. solanacearum*.

The gall index of 83 BWR 12-2 hybrids varied from 1.0 to 2.2, indicating that they were either highly resistant or resistant to nematodes. The hybrid with Pelican had significantly

higher gall index and this might have resulted in its susceptibility to wilt as indicated by the ooze index. In general, the F_1 hybrids of BWR 1 were resistant to nematodes as indicated by the gall index. However, the high susceptibility of the hybrid with 84 BWR 30 to nematodes may be responsible for the high ooze index in it. The resistance to nematodes in other F_1 can be attributed to the inheritance of resistance being dominant in the NR lines. The resistance of 83 BWR 90 and 83 BWR 120 F_1 hybrids to nematodes also indicate that inheritance of resistance to nematodes is dominant. The hybrids of CRA 66 Sel A with 84 BWR 30 and LA 655 were only moderately resistant to nematodes. This again shows that resistance in 84 BWR 30 is not completely dominant as also observed in case of F_1 hybrids of BWR 5 with 84 BWR 30 and 84 BWR 32. This may be because they were derivatives of MITA 668 which had recessive source of resistance to nematodes.

The possibility of producing an F_1 hybrid with resistance to bacterial wilt, root-knot disease and with desirable economic characters has been investigated by the authors in the present study. We could observe that when the parents had dominant source of resistance to bacterial wilt and root-knot disease, the F_1 remained resistant to both the diseases. On the other hand when the parents had either partially dominant or recessive source of resistance the F_1 became susceptible to wilt. In addition, it was found that many hybrids remained resistant to wilt in the sick field even though the ooze index indicated susceptibility. This proves that certain lines can survive better in the field in spite of the high amount of bacterial inoculum in it (as indicated by the ooze index). Such lines can also be used in future breeding programme to produce F_1 tomato hybrids having resistance to bacterial wilt and root-knot disease. From among the different hybrids obtained selections will have to be made for desirable characters before any final recommendation is made.

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