Source of Inoculum, Yield, and Quality of Tomato as Affected by *Leveillula taurica*

W. B. JONES, Former Graduate Research Associate, and S. V. THOMSON, Associate Professor, Department of Biology, Utah State University, Logan 84322-5305

ABSTRACT

Jones, W. B., and Thomson, S. V. 1987. Source of inoculum, yield, and quality of tomato as affected by *Leveillula taurica*. Plant Disease 71: 266-268.

Tomato transplants from southern Nevada were the primary source of inoculum of *Leveillula taurica* and showed disease symptoms of powdery mildew about 3 wk before Utah-grown tomato transplants. Plants from Nevada and Utah were equally infected 7 wk after planting, and no differences in severity or yield were detected at the end of the season attributable to rapid spread of the fungus. Tomato yields were reduced about 40% in check plots compared with plots treated with triadimefon, propiconazol, or sulfur. The amount of sunburned fruit in check plots was three to four times greater than in plots where the disease was controlled. Yields from benomyl and dinocap treatments were no greater than those from check plots.

Additional key words: *Oidiopsis taurica*, *Oidium taurica*

The first reported occurrence of powdery mildew caused by *Leveillula taurica* (Lêv.) Arn. in the United States was made on *Mimulus glutinous* Wendl. in California in 1906 (9). It was subsequently observed on mesquite (*Prosopis chilensis* Stuntz., *glandulosa* Torr.) in Texas in 1945 (10), kenaf (*Hibiscus cannabinus* L.) in Florida in 1951 (1), and on *Diplacus aurantiacus* Jeps. in California in 1977 (12). The first observation of *L. taurica* on tomato in North America was made in California in 1978 (4) and was probably also in Arizona, Nevada, and Utah in 1978 (5,11). The same disease has also been found on guar (*Cyamopsis tetragonoloba* Taub.), desert bird of paradise (*Caesalpinia gilliesee* Wass.), and wild tobacco (*Nicotiana trigonophylla* Dunal.) in Arizona (5).

According to Hirata (2), the host range of *L. taurica* extends over 710 species in 290 genera and 59 families. Palti (7) reported that at least 750 species including 27 major vegetable and field crops are hosts of *L. taurica*.

Present address of first author: NPI, 417 Wakara Way, Salt Lake City, UT 84108.

Accepted for publication 7 August 1986.

The incidence of tomato powdery mildew is sporadic in the early part of the season in Utah. Disease symptoms were first observed on plants imported from Nevada and subsequently developed on Utah-grown plants (3). This suggested that the primary inoculum was introduced from Nevada.

Fungicide applications have been successful in controlling the disease in the Mediterranean area, where the disease causes serious losses (8). At the time of this study, there were no fungicides registered in the United States for this disease. This study was undertaken to determine which fungicides would be effective in controlling the disease under Utah conditions and to determine the importance of Nevada transplants as a source of inoculum.

MATERIALS AND METHODS

Effects of disease. Field-grown tomato transplants were obtained 13 May 1981 from a commercial producer in Logandale, NV. The bare-root plants were packed in moist peat moss until planting in Salt Lake City (SLC), Tremonton, and Farmington, UT. The SLC and Tremonton plots were planted with untreated Nevada transplants on 25 May and 1 June, respectively. The experimental design was a 6 × 6 Latin square at both locations with individual plots four rows wide and 1.4-m buffers between columns. The following fungicides, formulations, and rates were used: triadimefon (Bayleton 50WP) at 140.1 g/ha, benomyl (Benlate 50WP) at 1,120.8 g/ha, dinocap (Karathane 19.5 WP) at 840.6 g/ha, sulfur (THAT Big 8 64F) at 5.8 L/ha, and propiconazol (Tilt 3.6 EC) at 438 ml/ha. Sulfur and dinocap were applied weekly on 13, 20, and 27 July and 3, 10, 17, and 24 August for a total of seven applications. Triadimefon, benomyl, and propiconazol were applied biweekly on 13 and 27 July and 10 and 24 August for a total of four applications. Checks were not sprayed. Plots were sprayed with a backpack sprayer operated at 25 psi with compressed CO_2. The spray boom had four nozzles, with two nozzles per row of tomatoes. The boom was held about 50 cm above the plant canopy.

Disease incidence and yields were evaluated 21–28 August. All data were taken from 12 plants in the center two rows of each two-row plot. The number of sunburned, ripe, and total fruit was determined. A visual severity rating was made for each of the 12 plants in the plot, where 0 = healthy and 100% = dead. A rating of 50% indicated that half of the foliage was infected. All fruit over 2.5 cm was weighed regardless of ripeness.

Source of transplants. The plots at Farmington were planted with both benomyl-treated and untreated Nevada transplants and transplants grown in a greenhouse at Bountiful, UT. The same seed source of tomato cultivar Del Monte 71-24 was used in both locations. Treatments were as follows: Nevada transplants were treated once with benomyl (560.4 g/ha) 1 wk before shipping to Utah. They were dug on 13 May, packed in moist peat moss, and stored for 6 days in a greenhouse until planting. Nevada transplants were bare root and about 14 in. tall when planted. Many plants were flowering and some had small fruit. Utah plants were grown in 2-in. pots, and the entire root and soil ball were planted. All plants were hand-planted at Farmington on 19 May and irrigated within 24 hr. Rows were 91 cm apart and plants were 76 cm apart. The experimental design was a randomized block with five replicates of 10 plants per replicate. Trifluralin and fertilizer were applied preplant. Carbaryl was applied as needed for tomato hornworm control. Plants were furrow-irrigated semiweekly. Tomatoes had not been planted in the area for at least 10 yr, and there were no commercial tomato plantings within 8 km. Plants were examined every 3 days until symptoms were first observed.

Disease incidence (percentage of plants with lesions) was recorded on 17 June and 8 July, and disease severity (numbers of lesions per plant) was taken on 15 July and 14 August. Data on the total number of fruit greater than 2.5 cm and the number of sunburned fruit were taken. Fruit yields were taken at Farmington on 2 September.

RESULTS

Disease control. There were significant differences in disease severity among treatments at both SLC and Tremonton. Sulfur, triadimefon, and propiconazol provided the best control (Table 1). There were significantly higher fruit yields ($P = 0.01$) in plots treated with propiconazol, triadimefon, and sulfur at Tremonton than in the check plots (Table 2). In SLC, only propiconazol and triadimefon treatments increased the yields significantly over those of the controls ($P = 0.05$). When the foliage was protected by propiconazol, triadimefon, and sulfur, there were 25–50% fewer sunburned fruit ($P = 0.05$) than in the dinocap, benomyl, and check plots in Tremonton (Table 2).

Source of transplants. The transplants from Nevada were disease-free at the time of transplanting. Initial symptoms were observed on 20% of the untreated and 25% of the benomyl-treated Nevada-grown transplants on 17 June, whereas no lesions were detected on Utah-grown plants at that time. Lesions were usually present only on the older leaves on the Nevada transplants. Microscopic observations of leaves confirmed the presence of conidia of *L. taurica*. On 8 July, a few lesions were noted on 5% of the Utah-grown transplants, whereas the number and size of lesions in the Nevada transplants had increased greatly and were present on 60 and 65% of the untreated and benomyl-treated plants, respectively.

Counts of lesions on 72 plants in each treatment were made on 15 and 30 July and 13 August. Counts on 15 July showed a total of 139 lesions on Utah plants, 409 lesions on untreated Nevada plants, and 437 lesions on benomyl-treated Nevada plants. There was little difference among treatments on 13 July and 13 August, with lesion counts averaging 60 per plant. Yield differences were not significantly different on 2 September.

Transplants were also grown in separate areas (to prevent potential spread) in the same greenhouse in Logan, UT, starting on 17 May. Plants from Nevada showed symptoms of powdery mildew within 4 wk on 14 June, whereas Utah-grown plants were free of disease for 12 wk until 30 August, when they were discarded.

Observations made in Nevada on 16 September 1980 and in the springs of 1981 and 1982 failed to detect tomato plants with disease symptoms in the field; however, inspection of a hydroponic greenhouse in Logandale, NV, on 17 September 1980 growing the tomato cultivar Tropic revealed plants severely infected with mildew. In March 1981, cleistothecia of *L. taurica* were found on dried tomato leaves in the same greenhouse.

In 1981 and 1982, *L. taurica* was found growing on *Solanum nigrum* L. (black nightshade) and *Physalis subglabrata* Mack. & Bush. (ground cherry) plants located near diseased tomato plants in SLC and Tremonton. Symptoms were observed after sporulation had occurred on the infected tomato foliage.

DISCUSSION

Results of the fungicide trials demonstrated that losses can occur when powdery mildew is not controlled. Yields averaged 31% higher when powdery mildew incidence was significantly reduced with fungicides. Propiconazol and triadimefon, compared with the check, were the most effective fungicides in controlling foliar symptoms, whereas benomyl and dinocap were no better than the check. Propiconazol and triadimefon treatments also resulted in yields significantly higher ($P = 0.01$) than those of the check. Based on 1981 prices of \$60.00/ton (\$54.00/t) for processing tomatoes, this yield increase would have resulted in an increased income of \$120.00 per acre (\$297.00/ha) in SLC and \$390.00 per acre (\$965.00/ha) in Tremonton. In addition to the yield loss in weight, the pathogen also caused severe dieback of foliage, resulting in extensive sunburn of exposed fruit. The number of sunburned fruit was three to four times higher in the check plots than in the triadimefon or propiconazol plots. Sulfur was the only chemical registered (1982) for use on tomatoes (for tomato russet mite) that was effective against *L. taurica* in this study.

The benomyl treatment of Nevada-grown plants was intended to prevent infection of plants before shipping into Utah, but it is evident from the incidence of disease on treated plants that benomyl did not prevent infection or reduce transport of the disease into Utah. This evidence, in addition to the results of the fungicide trial (Tables 1 and 2), indicates that the strain of *L. taurica* in Utah may be resistant to benomyl.

The first powdery mildew infections at Farmington were observed on the Nevada-grown transplants. About 3 wk later, a few lesions were observed on the Utah-grown plants. This evidence supports the hypothesis that the pathogen is introduced into Utah on transplants from Nevada. The spread from infected Nevada plants to Utah-grown plants was rapid and occurred so early in the season that no significant differences were detected in disease severity, yield, or sunburn between the Utah and Nevada-grown plants at harvest.

Powdery mildew is usually very infrequent and occurs late in the season in commercial fields of tomatoes using only Utah transplants if they are not within 0.5 km of Nevada transplants.

Table 1. Effects of fungicide treatments on severity of powdery mildew of tomato caused by *Leveillula taurica*

	Disease severity[y]	
Treatment	**Salt Lake City (%)**	**Tremonton (%)**
Check	86 a[z]	80 a
Benomyl	73 ab	74 a
Dinocap	72 ab	75 a
Sulfur	62 bc	59 b
Triadimefon	48 cd	60 b
Propiconazol	33 d	41 c

[y]Severity rating expressed as percentage of total foliage infected (0 = healthy, 100% = dead). Each value is the mean of six replicates with 12 observations per replicate.

[z]Means in the same column followed by the same letter are not statistically different ($P = 0.01$) as calculated by the method of least significant differences.

Table 2. Incidence of sunburn on fruit and tomato yield from plants treated with six fungicides to prevent infection by *Leveillula taurica*

	Sunburn[x]		Yield[y]	
Treatment	**Salt Lake City (%)**	**Tremonton (%)**	**Salt Lake City (t/ha)**	**Tremonton (t/ha)**
Check	6.0 a[z]	11.2 a	16.4 a	35.9 a
Benomyl	4.8 a	7.0 b	17.9 ab	35.6 a
Dinocap	3.9 a	4.9 b	16.6 a	42.8 a
Sulfur	3.3 a	2.3 c	18.6 abc	50.4 b
Triadimefon	1.0 a	2.0 c	20.6 bc	50.0 b
Propiconazol	1.5 a	2.0 c	21.5 c	49.3 b

[x]Sunburn expressed as percent of harvested fruit showing sunburn symptoms.

[y]Yields based on harvest of 12 plants per treatment with six replicates.

[z]Means in the same column followed by the same letter are not statistically different ($P = 0.05$) as calculated by the method of least significant difference.

The fact that powdery mildew was evident on Nevada plants 4 wk after transplanting to a greenhouse while Utah transplants grown in isolation in the same greenhouse remained symptomless for 12 wk also shows that Nevada transplants serve as a source of the fungus.

The pathogen is present in the Moapa Valley of Nevada but is not commonly found on field-grown tomatoes. There is no commercial production of tomato fruit and only occasional tomato plants in home gardens. Tomato transplants are grown in the field and completely removed by 15 May. Temperatures in the summer in the Moapa Valley frequently reach 40–46 C, the relative humidity is low, and rain is negligible. Temperatures of 15–26 C are optimal for spore germination of *L. taurica* at optimal relative humidities of 75–100%, whereas at 36 C, there was less than 5% germination (7).

The presence of a severe epidemic of powdery mildew on greenhouse-grown tomatoes in the Moapa Valley demonstrates the presence of *L. taurica* in the transplant production area. The expression of symptoms in the greenhouse and lack of disease in the field seems irregular but is probably due to the major differences in environment between the greenhouse and field.

The lack of disease expression on newly imported Nevada transplants may also be due to environmental conditions that are not conducive for symptom expression at the time plants are shipped to Utah from Nevada. Young plants also do not express symptoms until fruit is set (6).

Early infection of direct-seeded tomato plants has been observed in southern Utah in an area where Nevada transplants were not grown. Southern Utah has a climate similar to that of the Moapa Valley of Nevada that could favor overwintering of the pathogen but does not get as hot in the summer as the Moapa Valley.

There are other potential sources of the fungus in addition to Nevada transplants that may prove important. Utah growers also obtain tomato transplants from several other southern states that may harbor the fungus, but plants show no field symptoms when grown in their respective states. Local greenhouses might also be an overwintering site and a source of inoculum if plant material is kept year-round. There is also the possibility of airborne spores coming from other areas or weed hosts during the growing season. It is clear, however, that Nevada tomato transplants are an important source of *L. taurica* for Utah fields and that the disease causes highly significant yield losses.

LITERATURE CITED

1. Diehl, W. W. 1952. Powdery mildew of kenaf in Florida. (Abstr.) Plant Dis. Rep. 36:52.
2. Hirata, K. 1966. Host Range and Geographical Distribution of the Powdery Mildews. Fac. Agric. Niigata Univ. 472 pp.
3. Jones, W. B., and Thomson, S. V. 1982. Occurrence of powdery mildew (*Leveillula taurica*) on tomato transplant stock. (Abstr.) Phytopathology 72:934.
4. Kontaxis, D. G., and Van Maren, A. F. 1978. Powdery mildew of tomato—a new disease in the United States. Plant Dis. Rep. 62:892-893.
5. Mihail, J. D., and Alcorn, S. M. 1984. Powdery mildew (*Leveillula taurica*) on native and cultivated plants in Arizona. Plant Dis. 68:625-626.
6. Palti, J. 1971. Biological characteristics, distribution and control of *Leveillula taurica* (Lév.) Arn. Phytopathol. Mediterr. 10:139-153.
7. Palti, J. 1974. Striking divergences in the distribution of *Leveillula taurica* (Lév.) Arn. on some major crop hosts. Phytopathol. Mediterr. 13:17-22.
8. Reichert, I., Palti, J., and Minz, G. 1944. Field trials for the control of tomato leaf diseases. Palest. J. Bot. Rehovot Ser. 4(2):117-141.
9. Salmon, E. S. 1906. On *Oidiopsis taurica* (Lév.) an endophytic member of Erysiphaceace. Ann. Bot. (Lond.) 20:187-200.
10. Stevenson, J. A. 1945. Powdery mildew of mesquite. Plant Dis. Rep. 29:214-215.
11. Thomson, S. V., and Jones, W. B. 1981. An epiphytotic of *Leveillula taurica* on tomatoes in Utah. Plant Dis. 65:518-519.
12. Yarwood, C. E. 1977. *Leveillula* in U.S.A. (Abstr.) Proc. Am. Phytopathol. Soc. 4:212.