from the root environment during the time of crop maturation and maximum requirement (Tables 2 and 3) leaves an insufficient concentration for mass flow and also indicates insufficient movement by gradient. This depletion is an indication of potential stress, even though the root can proliferate into a root environment closer to the soil bed surface, one that contains more favorable concentrations of N and K, but at the same time, perhaps osmotically less favorable (4). A more positive indication of stress is the deterioration of crop quality toward the end of a season which can often be correlated with deterioration of the root environment. This may also help to explain crop limitations and yield variations that fluctuate above and below the average. Wieser (5) has stated that the average production is 3 to 7 times short of the potential—90% of that environmental. The use of mulches to stabilize the root environment has been associated with a 100% increase in the average tomato yield in Florida (4). By recognizing the limitations and the potential functional efficiency of the gradient-mulch system, production potentials should be 2 to 3 times that of the current average.

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EVALUATION OF GENETIC TOLERANCE TO FUSARIUM WILT RACE 3 IN TOMATO[1]

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Abstract. **Two tomato (**Lycopersicon esculentum **Mill.) (Le) breeding lines (US 629 and US 638) and 2** Lycopersicon pimpinellifolium **(Lp) breeding lines (BTN 421 and BTN 472) from Australia, tolerant to Fusarium wilt,** Fusarium oxysporum **(Schlecht.) f. sp.** lycopersici **(Sacc.) Snyder & Hansen race 3, were crossed to tomato cultivars susceptible to Fusarium wilt race 3. In the spring of 1983 the parents and the F_1 and F_2 generations were grown in a field plot which had the pH adjusted to 6.0 to 6.5 and was inoculated with the race 3 pathogen. Plants were rated weekly for disease symptoms and given a mean disease index rating at the end of the season. The 2 Lp lines, BTN 421 and BTN 472, had the lowest disease incidence, followed by the F_1 and F_2 generations with BTN 421 parentage, and then by Le line US 629. The other Le line, US 638, had disease incidence similar to susceptible control lines. All hybrids had greater disease incidence than their tolerant parents. The Lp hybrids had significantly less disease than the susceptible parents, but the US 629 hybrid was not significantly different than its susceptible parent. Breeding and genetic aspects of working with this material are discussed.**

Fusarium wilt of tomato *Lycopersicon esculentum* Mill. incited by *Fusarium oxysporum* (Schlecht.) f. sp. *lycopersici* (Sacc.) Snyder & Hansen race 3 was first reported in Australia (1). In 1982 Fusarium wilt race 3 was found on the west coast of Florida (3). Fusarium wilt race 3 symptoms were found on Fusarium wilt race 2 resistant cultivars in 25 of 91 fields surveyed with disease incidence as high as 80% (2).

Four *Lycopersicon* sp. breeding lines tolerant to Fusarium wilt race 3 obtained from Mr. D. J. McRath, Horticultural Research Station, Box 538, Bowen, Queensland, Australia, are being utilized in Florida breeding programs. Although these lines have acceptable field tolerance in Australia (5), they have not been field tested in Florida. Some F_1 and F_2 generations of these lines crossed with race 3 susceptible lines have been developed. The objective of this study was to evaluate the tolerance of the Australian breeding lines and derived F_1 and F_2's under Florida field conditions.

Materials and Methods

Two tomato lines, US 629 and US 638, and 2 Lp lines, BTN 472 and BTN 421, with reported Fusarium wilt race 3 tolerance were obtained from Australia. Crosses were made between these 4 lines and race 3 susceptible breeding lines or cultivars. F_1 seed was self-pollinated to obtain F_2 seed. These genotypes plus control lines with different resistances to races 1 and 2 were used in this study (Table 1).

Seed was sown in wooden flats containing SAF-T-Blast® (Mineral Aggregates, Inc.) on January 26, 1983. Seedlings were planted into TODD® containers with 1.5 inch cell sizes (#150 TODD® Planter flats) on February 9, 1983 and transplanted to the field of Myakka fine sand on March 9. Before transplanting, the field was treated with sulfur to decrease the pH to 6 to 6.5. Raised 6 inch high beds, 30 inches wide, on 4.5 ft centers, were fertilized with 1856 lb./acre of 18-0-25-2 distributed in 2 bands 18 inches apart. Full bed dressing was 18-0-25-2 at 329 lb./acre and superphosphate (0-20-0 plus FN 503 oxide micronutrients at 80 lb./ton) at 599 lb./acre. Thus, elemental amounts per acre were: 394 lb. N, 120 lb. P_2O_5, 547 lb. K_2O, and 43.6 lb. MgO. The beds were then fumigated with 66% methyl bromide—33% chloropicrin (Dowfume® MC-33) at 344 lb./acre and covered with black polyethylene mulch.

Eleven days after fumigation, planting holes 24 inches apart were punched in the beds. One oz of race 3-infested

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Table 1. Genotypes tested in a field infested with Fusarium wilt race 3 in spring 1983 at Bradenton, Florida.

Genotype	Generation	Fusarium wilt disease status
Bonny Best	Control	Susceptible to all Fusarium races
Manapal	Control	Resistant to race 1 only
Hayslip	P_1	Resistant to races 1 and 2, susceptible to race 3
Flora-Dade (FD)	P_1	Resistant to races 1 and 2, susceptible to race 3
US 629	P_2	Tolerant to race 3, resistant to races 1 and 2
US 638	P_2	Tolerant to race 3, resistant to races 1 and 2
BTN 421	P_2	Tolerant to race 3, resistant to races 1 and 2
BTN 472	P_2	Tolerant to race 3, susceptible to races 1 and 2
US 629 X FD	F_1	
US 638 X FD	F_1	
FD X BTN 421	F_1	
FD X BTN 472	F_1	
Hayslip X US 629	F_2	
Cl 11d X US 638	F_2	
FD X BTN 421	F_2	
FD X BTN 472	F_2	

vermiculite, prepared as previously described (4), was placed in each hole and plants were set 2 days later.

A randomized block design was used with 4 blocks. There was one 10-plant plot per block for control, parental and F_1 generations and four 10-plant plots per block of the F_2 generation. Plants were rated for disease symptoms at weekly intervals from April 4 to June 6. Disease symptoms were indexed by adapting a formula reported by Sonoda et al. (6) for rating bacterial wilt survival:

$$S = \frac{n_1t_1 + n_2t_2 + \ldots n_it_i + NT}{n} \text{ where:}$$

S = Symptom index-mean number of days plants remained symptomless
n_1 = number of plants with disease symptoms up to t_1
t_1 = days after transplanting that weekly rating was made—3.5 days
n_2 = number of plants with disease symptoms between t_1 and t_2
N = number of plants without symptoms at the final rating time
T = days from transplanting to final rating + 3.5 days
n = number of plants per replicate

Time of weekly readings minus 3.5 was used to obtain the average time of symptom expression between readings. T was arbitrarily set at 3.5 days after the final reading which assumes plants were disease-free for 3.5 days more. The percentage of healthy plants at the end of the experiment was also calculated for each line.

Results

The 2 Lp lines BTN 421 and BTN 472 had the longest period without disease, followed by the F_2 and F_1 generations derived from BTN 421, and then by US 629 (Table 2). The other Australian source, US 638, did not have significantly less disease than any of the susceptible cultivars except 'Bonny Best' which was extremely susceptible. Disease tolerances of hybrids from BTN 421 and BTN 472 were significantly less than their tolerant parents and significantly greater than their susceptible parents. The hybrid from US 629 was significantly less tolerant than US 629 and not significantly different than its susceptible parent.

BTN 421 had the greatest percentage of healthy plants followed by BTN 472 and the F_2 and F_1 generations derived from BTN 421 (Table 2). Both US 629 and US 638 had statistically similar percentages of healthy plants, 13.1 and 12.5%, respectively, which was significantly greater than the susceptible lines except for 'Manapal.' The hybrid of BTN 421 was the only F_1 with any healthy plants (37.5%) at the end of the experiment. Healthy plants for the F_2's ranged from 54.6% for the BTN 421 F_2 to 1.4% for the US 638 F_2.

Table 2. Mean days without disease and percent healthy plants of tomato genotypes in a Fusarium wilt race 3 infested field at Bradenton, Florida, spring 1983.

Genotype	Generation	Days without disease	Healthy (%)[z]
BTN 421	P_2	89.7 a[y]	91.9 a[y]
BTN 472	P_2	84.2 a	69.5 b
Flora-Dade x BTN 421	F_2	75.0 b	54.6 bc
Flora-Dade x BTN 421	F_1	70.1 b	37.5 cd
US 629	P_2	58.3 c	13.1 ef
Hayslip x US 629	F_2	57.1 cd	16.1 de
Flora-Dade x BTN 472	F_2	51.9 cde	8.3 efgh
Flora-Dade x BTN 472	F_1	49.1 de	0.0 h
Flora-Dade x US 629	F_1	44.0 ef	0.0 h
US 638	P_2	43.7 ef	12.5 efg
Manapal	Control	40.0 f	3.5 fgh
US 638 x Flora-Dade	F_1	36.2 f	0.0 h
Flora-Dade	P_1	35.9 f	0.0 h
Cl 11d x US 638	F_2	35.7 f	1.4 gh
Hayslip	P_1	35.4 f	0.0 h
Bonny Best	Control	23.6 g	0.0 h

[z]At 89 days after transplanting, data were transformed to arcsin $\sqrt{\%/100}$ for analysis.
[y]Means separation in columns by Duncan's new multiple range test, 5% level.

Discussion

Breeding. The Lp lines have greater race 3 tolerance than the Le lines, but horticultural type is far better for the 2 tomato lines. Therefore, it appears the best short term approach to breeding a commercial cultivar would be to utilize US 629 since it had greater tolerance than US 638. Use of the Lp sources could result in greater tolerance levels but would require more backcrossing. Since BTN 421 had greater tolerance than BTN 472, it would be the better line to utilize. Whatever the source used, rigorous selection pressure for race 3 tolerance in a modified backcross program would need to be practiced since even BTN 421 had 8.1% diseased plants.

Even though US 638 did not have a high level of tolerance in this study, a tolerant line derived from that source has been adequate under Australian field conditions (5). Furthermore, some selections derived from US 638 in the University of Florida breeding program have had very good tolerance (J. W. Scott, unpublished data). Nonetheless, as these data indicate, larger populations will be needed to recover plants with adequate tolerance from US 638 crosses.

It is not known if tolerance from these sources will be adequate as lines with greater fruit loads are developed. Some F_2's of US 629 parentage have pretty good fruit set and fruit size with adequate tolerance. Thus, this tolerance should prove acceptable. Other sources of improved tolerance have been reported (8) and new sources are presently being investigated at Bradenton.

Race 3 tolerant hybrid cultivars utilizing the Australian sources will require tolerance on each side of the cross since hybrids with susceptible parents had high disease incidence.

Genetics. In this study a genetic analysis was not pursued due to constraints of the genotypes used, such as different susceptible parents in the F_1 and F_2 generations of the US 629 crosses, and a lack of backcross generations. Genetic interpretation is also difficult since there were susceptible plants segregating in all tolerant parental lines. Volin (8) reported US 629, US 638 and BTN 472 were all phenotypically homozygous and had been screened and selected for tolerance for 2 and 3 generations before their introduction to Florida. Attempts to improve the resistance of BTN 472 by selection of resistant plants at Bradenton were not successful (J. W. Scott, unpublished data). Therefore, incomplete penetrance, as suggested by Volin and Jones (8), appears to be a plausible explanation for segregation reactions in the tolerant parents. This adds complexity to genetic interpretations. McGrath and Toleman (5) indicated resistance from BTN 472 material was polygenic with significant non-additive gene effects. In our experiment, the F_1 and F_2 generations from BTN 472 had less mean days without disease than the midparent value (60.0) which would indicate non-additive gene effects, such as dominance, favor susceptibility. This is supported by the low percentage of healthy plants in these generations. Volin and Jones (7) suggested 2 genes control resistance of BTN 421 since a derived F_2 generation fit a 9:7 ratio. In this study the F_2 from BTN 421 also fits a 9:7 ratio of healthy to diseased plants (data not shown). However, such a model would require all the F_1's to be healthy which was not the case. The mean days without disease for the F_1 and F_2 generations with BTN 421 are greater than the midparent value (62.8), which would indicate some dominance for tolerant expression. This additive-dominance reaction is supported by the relatively high recovery of healthy plants in the F_1 and F_2 generations.

The tolerance level of US 629 is not as great as BTN 421 or 472. The F_1 of US 629 x 'Flora-Dade' was slightly less than the midparent value (47.1) but the F_2 with 'Hayslip' was greater. Gene action is probably largely additive but further study is needed to verify this assertion.

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NEMATICIDE OPTIONS FOR NORTHEAST FLORIDA POTATO GROWERS[1]

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Abstract. **Detectible residues of aldicarb [(2-methyl-2 (methylthio) propionaldehyde 0-(methylcarbamoyl)oxime] and EDB (ethylene dibromide), 2 nematicides which are widely used in northeast Florida (NEF) potato** (Solanum tuberosum **L.) production, have been found in well water in other sections of the state. Most uses of EDB have been suspended in Florida and those of aldicarb restricted. The relative efficacies of nematicides available to NEF potato growers are compared. Most consistent reductions in nematode population densities and increases in tuber yields have been associated with the soil fumigants 1,3D (100% dichloropropene and related C_3 hydrocarbons) at 5.5-6.2 gal dichloropropene/acre in-the-row, EDB at 1.5 gal/acre in-the-row, and aldicarb at 3.0 lb. a.i./acre in-the-row. All soil fumigants evaluated were ineffective in controlling corky ringspot disease (CRS) whereas aldicarb and oxamyl (methyl-N[1], N[1]-dimethyl N-[methyl carbamoyl)oxy]-1-thiooxamimidate) (when applications were adequately scheduled) were highly effective in reducing the incidence of CRS. The role of nematicides as part of a management system for nematodes and soil-borne diseases in NEF is discussed.**

Virtually all potato growers in Northeast Florida (NEF) use nematicides. Average potato production/acre has increased > 15% in NEF since the introduction and use of nematicides in the late 1960's (15, 19). The nematicides most widely applied in recent years have been aldicarb and EDB [see Table 1 for a summary of all nematicides discussed in this paper]. During 1982 aldicarb was used on essentially 100% of the 20-21,000 acres of potatoes grown in NEF. An estimated 6-7000 acres were treated with EDB, mostly in combination with aldicarb.

During 1983 nearly all agricultural uses of EDB were suspended by federal and state agencies; and uses of aldicarb restricted by Florida State Department of Agriculture and

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