Izquierdo (2) reported that when bolting was a problem ethephon increased yields. If bolting did not occur, damage from ethephon resulted in lower yields. They applied ethephon in late fall. In the present work ethephon reduced bolting when it was applied in early spring. Thus, it might be best used to offset bolting if weather conditions are favorable for it to occur.

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THE ASSOCIATION OF BROWN ROOT ROT RESISTANCE WITH YIELD COMPONENTS AND ROOT WEIGHT AMONG TOMATO SELECTIONS GROWN IN INFESTED AND NON-INFESTED SOIL IN DADE COUNTY, FLORIDA[1]

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Abstract. **Brown Root Rot (BRR) in tomato, caused by** Pyrenochaeta lycopersici **(Schneider and Gerlach), infests soil in Dade County, Florida. This organism is a significant contributor to the Old Land Decline syndrome in tomato. Yield components and root weight were compared in tomato selections and cultivars with and without BRR resistance genes grown in fumigated and nonfumigated naturally infested land. Marketable yield of fruit, fruit size, root weight and BRR disease rating were evaluated. In plants grown on non-fumigated soil the mean fruit yield and root weights were significantly reduced 56% and 28% respectively over those plants grown in fumigated soil primarily by the BRR fungus. While some of the selectcross resistant lines have comparable yields to Flora-Dade when grown in fumigated land the BRR resistant selectcrosses favored increased productivity, root size and reduced root lesion development when grown in non-fumigated plots. Although no selectcross completely free of BRR lesions has been obtained to date these results suggest that genetic factors which condition an intermediate level of resistance will significantly improve fruit yield. In addition to genetic factors conditioning resistance to BRR these crosses may also possess other genes conditioning larger roots which may be a factor in improved plant growth and development.**

Brown Root Rot (BRR), a fungal pathogen of tomato roots caused by *Pyrenochaeta lycopersici* Schneider and Gerlach has been prevalent in South Florida since the early 1970's (R. T. McMillan, Jr., unpublished). Damage from this disease is most apparent in fields in which tomatoes have been grown over a successive number of seasons and where soil fumigation is not practiced as a means of control.

This disease is known as a pathogen of tomatoes in the Netherlands (1), the United Kingdom (2, 3), the U.S. (4, 6) and Canada (5). Symptoms are evident in the form of brown, corky lesions which develop on the main roots and secondary roots of the plant. Many of the feeder and lateral roots appear shortened or stubby from the slow but progressive development of the fungus. The growth of the plant is restricted and productivity is reduced.

None of the tomato cultivars recently developed and released by the University of Florida, IFAS have demonstrated resistance to BRR. However, several tomato plant accessions from the germ plasm collection center in Ames, Iowa have been repeatedly screened as part of the Florida tomato breeding program and have been found to possess multiple factors which condition an acceptable level of resistance (6). These accessions are being used in a breeding-selection effort to combine BRR resistance and desirable horticultural characteristics into useful breeding lines.

The objectives of this study were (1) to determine the effect of BRR on fruit productivity and root development and (2) to evaluate the performance of improved crosses selected for multiple disease resistance.

Materials and Methods

Culture

Tomato selections were evaluated in the field during the 1978-79 season (season 1) and during the 1979-80 season (season 2). In the first season, 2 test fields were chosen for comparative evaluations in fumigated and non-fumigated soil beds. The non-fumigated land area had been cropped continuously to tomatoes for approximately 11 years and the soil had never been fumigated or otherwise treated for disease control. In a nearby field soil beds were fumigated to control soil-borne pathogens, including *P. lycopersici.* The fumigant Dowfume® (67% methyl bromide plus 33% chloropicrin) was injected at the rate of 220 lbs/acre (246 kgs/ha) into soil beds which were immediately covered with 0.0015 gauge (inch) plastic film. In the non-fumigated area, tomatoes were grown on soil beds without the plastic mulch cover.

During season 2, replicated tomato selections were grown only in the non-fumigated field but plants were grown on plastic-mulched beds.

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In all the mulch-covered beds, fertilizer was incorporated in one application of 1500 lbs/acre (1680 kgs/ha) of 7-14-14. In the uncovered beds used during the first season, 500 lbs/acre (560 kgs/ha) of 7-14-14 was applied as a side-dress 3 times during the growing season.

Overhead irrigation and pest control sprays were applied on demand and as routine sprays, respectively.

Tomato seedlings were reared in greenhouse flats and transplanted to replicated field plots during November of each season. In each of 4 reps, 8 plants were spaced 12 inches (30.5 cm) in beds centered 6 ft (1.83 m) apart. Fruit from all plots were graded and sized according to USDA standards for fresh-market fruit. Harvest was initiated when 10 to 15% of the fruit reached a pink stage. In season 1 each plot was picked 4 times at weekly intervals.

In season 2 plants were spaced 20 inches (50.8 cm) apart in beds centered 6 ft (1.83 m) apart. The plots, consisting of 10 plants and replicated 4 times, were only picked twice. The selections were evaluated for marketable yield and fruit size as in the first season.

Selection for resistance

Over several seasons of greenhouse and field screening, a group of tomato selections was chosen with good resistance to BRR. Each season the genotypes with the most desirable horticultural traits and multiple disease resistance were selectcrossed to superior, advanced lines in the Florida tomato breeding program. Select-crossing, as it is used here, differs from backcrossing in that a different recurrent parent is chosen each generation or each time a cross is made. This procedure allows the use of those improved, homozygous breeding lines progressively developed in the state-wide tomato breeding program. From 1 to 4 single plant selections were made in the selectcross families. Tests for resistance to grey leafspot (*Stemphylium solani* Weber), *Verticillium* wilt (*Verticillium albo-atrum* Reinke and Berthold.) and Fusarium wilt (*Fusarium oxysporum* Schlecht. f. sp. *lycopersici* (Sacc.) Snyder and Hans.) races 1 and 2 were done independently from the BRR resistance screening.

A listing of the BRR resistant accessions used as parents in the selectcrosses reported in this study is shown in Table 1.

After the selections were evaluated for yield and fruit size each plant was lifted carefully from moistened soil beds. The root mass was cleaned, weighed and each was assigned a BRR score based on the total estimated root area covered by BRR lesions. A score of 1 = no lesions apparent, 2 = 5% covered by lesions, 3 = 15%, 4 = 25%, 5 = 35%, 6 = 45%, 7 = 55%, 8 = 65%, 9 = 75%, 10 = 85%, 11 = 95% and 12 = 100% of the roots covered by BRR lesions. A plot mean was computed based on the arithemetic products of the numerical score and the frequency of scores within a given category.

Table 1. Tomato plant introductions used as parents in selections resistant to BRR.

Plant introduction	*Selections*
P.I. 91458	D74318, D76005 D76007, D76013
P.I. 127825	D76057
P.I. 142880	D73015, D76123 D76125, D76127
P.I. 262906	D76076
P.I. 270278	D76080
P.I. 280591	D76073
OND-KVFN[z]	D76130

[z]Obtained from Bruinsma Seed Co., Naaldwijk, Holland.

Results and Discussion

Because different tomato selections were evaluated in each season comparisons were restricted to within a given season.

In season 1 on non-fumigated land only one selectcross selection, D76057-D1, was statistically superior in fruit yield to Flora-Dade while two selections, D76007—D1 and D76005—D1, were superior to Flora-Dade in fruit size (Table 2). On fumigated soil whree the BRR pathogen was not a factor no selections were superior to Flora-Dade in yield whereas three were superior in fruit size (Table 2). Fumigation in season 1 seemed to have little effect on the mean fruit size.

When root weight was compared in season 1 we found that many of the selections were superior to Flora-Dade grown in either fumigated or non-fumigated soil. The mean fresh root weight of BRR resistant selections (excluding Flora-Dade) grown on non-fumigated soil was 27.7 g/plant.

Table 2. Tomato fruit yield and root quality from BRR resistant and susceptible selections grown in replicate on fumigated and non-fumigated soil. AREC, Homestead 1978-79.

	Non-fumigated				Fumigated		
Tomato selection	Mkt. yld. kg/plot[z]	Frt. size g/fruit	Root wt. g/plant	BRR rating[x]	Mkt. yld. kg/plot	Frt. size g/fruit	Root wt. g/plant
D76013—D1	11.2 cd[y]	136 bc	18.6 d	4.8 bc	37.4 ab	152 c	36.3 bcd
D76015—D2	18.4 ab	117 bcde	18.9 d	4.8 bc	31.8 bcd	122 d	29.2 d
D73015—D3	16.1 abcd	128 bcd	23.0 cd	5.6 cd	35.8 abc	123 d	29.2 d
D76080—D1	14.3 bc	104 ef	22.1 cd	5.6 cd	33.2 abcd	100 efg	35.7 bcd
D76007—D1	12.0 bcd	159 a	25.4 cd	6.5 de	29.4 bcd	122 a	26.8 d
D76057—D1	20.7 a	114 cde	27.0 bcd	3.9 ab	41.8 a	103 ef	44.7 abc
D76005—D1	16.7 abc	168 a	24.8 cd	5.6 cd	38.6 ab	178 b	27.7 d
D74318—D2—1	14.9 abcd	111 def	31.0 bc	3.5 a	24.4 de	100 efg	51.4 a
D74318—D1—D1	11.7 cd	98 ef	39.9 a	3.6 a	18.6 e	113 de	38.9 abcd
D76076—D1	13.3 bcd	90 f	20.8 d	5.4 c	37.1 ab	85 fg	30.6 cd
D76073—D1	11.8 cd	116 bcd	22.6 cd	8.4 f	26.4 de	82 g	33.2 bcd
Flora-Dade	12.0 bcd	118 bcde	18.2 d	6.9 e	37.6 ab	121 d	24.8 d
P.I. 270278	10.0 d	137 b	34.5 b	4.3 ab	27.8 cd	135 d	46.5 ab
Mean	14.1	123	25.2		32.3	126	35.0

[z]Based on means of 8 plants in each of 4 replicated plots picked 4 times.
[y]Mean separation, within columns, by Duncan's multiple range test, 5% probability level.
[x]Plant root rating based on numerical value from 1 to (resistant with no BRR lesions) 12 (susceptible with 100% of the roots with BRR lesions).

This exceeded the root weight of Flora-Dade, a susceptible cultivar by 52%. It was apparent that during the 1978-79 season BRR was a key factor in limiting the yield and root weight of susceptible selections and cultivars.

While in season 1, on non-fumigated soil, BRR lesions were apparent on the roots of all the selectcross selections, all except D76073–D1 and D76007–D1 were more resistant than Flora-Dade. Especially noteworthy were 2 selections, D74318–D2–D1 and D74318–D1–D1 which had lesions on less than 25% of the roots. These plants produced high quality, medium sized fruit with jointless pedicels. Reduction in BRR damage for these 2 selections were found to be highly significant.

In season 2 evaluation was conducted only on non-fumigated soil beds. Only one selection, D76057-DBk produced fruit which exceeded the yield of Flora-Dade while in 9 others there was no statistically significant yield difference (Table 3). Three selections produced fruit which exceeded the size produced by Flora-Dade. Selections D76123–DBk, D76057–DBk and Plant Introduction 270278 produced heavier roots but in the 2 latter designates fruit was of inferior quality. The root weight of D76123-DBk exceeded the root weight of Flora-Dade by 43% while the mean root weight of the 9 selectcrosses (excluding Flora-Dade and PI270278) exceeded the root weight of Flora-Dade by 25%. As in season 1 there were no selectcross selections which were free of BRR root lesions. The two entries which were most disease free were D76125–D1 and D76125–D4 with less than 5% of the root area with BRR symptoms.

Table 3. Tomato fruit yield and root quality from BRR resistant and susceptible selections grown in replicate on non-fumigated soil. AREC, Homestead 1979-80.

Tomato selection	Non-fumigated			
	Mkt. yld. kgs/plot[z]	Frt. size g/fruit	Root wt. g/plant	BRR rating[x]
Flora-Dade	15.7 bc[y]	97 de	23.5 de	7.7 e
D76013–DBk	11.2 c	107 bcde	33.5 cd	3.1 b
D76125–D1	18.7 ab	117 abc	21.2 e	1.6 a
D76125–D4	16.7 abc	113 bcd	27.5 de	1.9 a
D76127–D1–DA	17.3 abc	133 a	28.6 de	4.3 c
D76127–D2–DA	18.0 abc	99 cde	37.7 bcd	5.7 d
D76123–DBk	19.8 ab	98 cde	41.0 bc	5.2 d
D76130–D1	14.1 bc	88 e	26.5 de	5.9 d
D76057–DBk	23.0 a	100 cde	47.5 b	2.8 b
P.I. 270278	14.0 bc	115 abcd	66.4 a	1.9 a
648 x 71057	15.1 bc	124 ab	20.1 e	8.1 e
Mean	16.7	108	33.9	

[z]Based on means of 10 plants in each of 4 replicated plots picked 2 times.
[y]Mean separation, within columns by Duncan's multiple range test, 5% probability level.
[x]Plant root rating based on a numerical value from 1 (resistant with no BRR lesions) to 12 (susceptible with 100% of the roots with BRR lesions).

The rate of progress toward developing superior tomato breeding stocks with combined resistance to BRR has been slow. Several factors contribute to the arduous nature of this selection program: (1) the primitive nature of resistant stocks, necessitating numerous backcrosses or selectcrosses to recover horticulturally desirable traits; (2) the need to maintain multiple disease resistance in Florida tomato releases; (3) the laborious task of rating resistance and (4) the quantitatively heritable nature of BRR resistance.

Replicated testing of these one and two-generation selectcrosses have demonstrated that considerable progress is being made in resistance selection and combined horticultural desirability. For example, in season 2, two selections had a BRR rating equal in resistance to P.I. 270278, a resistant parent used early in the program. These same 2 selections also had yields, fruit size and root weights equivalent to or better than Flora-Dade.

From these superior tomato lines it will be possible during the coming season to select improved candidates for release as breeding lines. This added resistance component is expected to decrease the cultural dependency on soil fumigation as a means of BRR control. While growers still may choose to fumigate the soil for broad-spectrum pest and disease control the availability and economics of these materials may change in the future.

It appears that these breeding lines will also possess a greatly improved root structure and volume in addition to their superiority in BRR resistance. The heritability and horticultural potential of our promising selections is being investigated.

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