Ohio 9834 and Ohio 9816: Processing Tomato Breeding Lines with Partial Resistance to Race T1 of Bacterial Spot

David M. Francis¹

Department of Horticulture and Crop Science, The Ohio State University, Ohio Agricultural Research and Development Center, 1680 Madison Ave, Wooster, OH 44691

Sally Miller

Department of Plant Pathology, The Ohio State University, Ohio Agricultural Research and Development Center, 1680 Madison Avenue, Wooster, OH 44691

Additional index words. CIELAB, chromaticity values, disease resistance, inbred backcross breeding, *Lycopersicon esculentum*

the midwestern and eastern U.S., in Ontario, Canada, and in Victoria, Australia (Ashcroft et al., 2004; Garrison and Sudal, 2002, 2003; Loewen, 2002, 2003).

Origin

Ohio 9816 and Ohio 9834 were trailed as 981670.22 and Ohio 987034.1, respectively. They resulted from an inbred backcross breeding program and marker assisted selection to introgress partial resistance from Hawaii 7998 into Ohio 88119 (Berry et al., 1995). Ohio 9816 and Ohio 9834 are sixth generation selections following the final backcross with Ohio 88119.

Description

The vines of Ohio 9816 are medium to large in size and the vines of Ohio 9834 are small to medium in size. Vines of both lines are prostrate and determinate (*sp*). Foliage cover is adequate for ensuring good fruit quality at maturity.

Ohio 9816, Ohio 9834, and hybrid varieties developed using these lines as parents were evaluated for performance and fruit quality in multilocation trials in Ohio between 2000 and 2002. Variation in performance associated

Received for publication 8 Dec. 2004. Accepted for publication 15 Jan. 2005. Salaries and research support provided by state and federal funds appropriated to The Ohio State University, Ohio Agricultural Research and Development Center, and grant funds from the Mid-America Food Processors Association. The mention of firm names or trade products does not imply that they are endorsed or recommended by The Ohio State University over other firms or similar products not mentioned.

¹Corresponding author; e-mail francis.77@osu.edu.

Fig. 1. Pedigree of Ohio 9816 and Ohio 9834

Ohio 9834 and Ohio 9816 are midseason processing tomato (*Lycopersicon esculentum* Mill.) inbreds adapted to high population transplant culture, machine harvest, and bulk handling under humid growing environments. They are suitable parental lines for the development of hybrids used in the production

of peeled, whole-canned, and diced tomato products. Both lines have been tested in plot trials in the midwestern U.S. Hybrids using these lines have performed well in plot trials and in commercial scale strip trials in

Table 1. Summary of multilocation trials for yield and quality traits.

Trial ^z	Yield ^y ripe (t·ha ⁻¹)	Fruit wt (g)	Color ^x			Color uniformity ^w			Firmness ^v (kg)	Soluble solids (°Brix)
			L	Chroma	Hue	Ldif	Cdif	Hdif		
Year										
2000	82.6	62.7	40.8	34.8	43.8	3.3	3.0	5.3	4.8	4.9
2001	83.8	55.6	42.9	38.0	43.6	4.2	2.5	6.8	5.2	5.1
2002	74.8	60.2	40.6	37.3	41.2	3.6	2.6	5.1	5.4	5.3
Mean	80.4	59.5	41.4	36.7	42.9	3.7	2.7	5.7	5.2	5.1
LSD (0.05)	NS	3.7	0.9	0.9	1.3	0.4	0.2	0.9	0.3	NS
LSD (0.30)	NS	2.0	0.5	0.5	0.7	0.2	0.1	0.5	0.2	0.1
Year–location										
2000FRE	82.6	70.6	40.5	35.9	42.6	3.6	3.2	4.7	4.8	4.6
2000HZL	ND	51.0	39.5	33.0	43.4	3.2	3.3	5.6	5.1	5.0
2000WOO	ND	67.2	42.4	35.7	45.2	3.2	2.6	5.6	4.6	5.1
2001FRE	83.8	60.1	43.6	37.6	44.8	4.9	3.0	8.0	4.5	4.4
2001HZL	ND	46.5	42.9	36.7	43.1	4.0	2.4	6.8	6.2	5.8
2001WOO	ND	60.1	42.3	39.8	43.0	3.6	2.1	5.6	5.0	5.0
2002FRE	74.8	58.1	41.8	36.4	42.7	4.3	2.9	6.0	5.0	4.7
2002HZL	ND	68.0	40.6	38.4	40.8	3.7	2.5	5.6	6.0	5.3
2002WOO	ND	54.4	39.3	37.0	39.9	2.9	2.4	3.8	5.2	6.0
Mean	80.4	59.6	41.4	36.7	42.8	3.7	2.7	5.7	5.2	5.1
LSD (0.05)	NS	4.1	2.0	1.0	NS	0.8	0.4	1.4	0.3	0.3
LSD (0.30)	NS	1.9	1.0	0.5	1.5	0.4	0.2	0.7	0.2	0.1

^zTrial locations for multi-location trials were Ohio State University research farms in Fremont, Ohio (FRE) and Wooster, Ohio (WOO), and Hirzel Farms, Wood County, Ohio (HZL).

^yYields in tons per hectare are based on a planting density of 30,900/ha for 36 varieties planted in two replicates at Fremont, Ohio, and once-over mechanical harvesting.

^xColor values are based on the L, a, b color space with L indicating lightness to darkness; chroma, intensity; and hue, color.

^wColor uniformity measures are based on the difference between two measurements per fruit. Low difference values indicate uniform color, or the absence of color disorders.

^vFirmness of fruit was measured as kilograms of force to puncture using a 1-cm-diameter head probe mounted on a force gauge (Ametek, inc., Largo, Fla.).

Table 2. Three-year field performance data based on once-over mechanical harvesting in Fremont, Ohio.

Genotype	Yield ^z (t·ha ⁻¹)	Ripe (%)	Green (%)	Cull (%)	Wt ^y (g)	Disease ^x index (0–3)
OH 7983	72.1	81.2	13.7	4.7	62.4	1.3
OH 8245	97.9	85.2	8.9	6.1	62.4	1.3
OH 9242	76.8	76.3	13.6	9.6	68.0	1.3
OH 9816	110.0	82.9	11.5	5.7	56.7	1.1
OH 9834	95.2	79.3	8.9	11.9	56.7	1.3
H9423	69.5	76.4	16.9	6.4	68.0	1.8
OX150	96.4	81.2	13.4	5.3	59.5	1.5
OX23	96.9	79.6	12.7	6.3	56.7	1.5
OX323	99.9	84.1	11.9	4	59.5	1.4
OX324	97.2	75.6	20.4	3.9	68.0	1.0
OX325	110.0	79.6	15.8	4.6	65.2	1.2
OX327	97.2	74.2	20.7	5.1	62.4	1.3
OX328	110.5	81.6	11.5	6.9	56.7	1.4
OX331	110.5	81.8	12.8	5.4	62.4	1.3
OX52	83.4	80	15.6	2.3	53.9	1.3
PS696	106.2	82.2	10.9	6.5	62.4	1.3
TR12	82.6	79.8	14.7	5	56.7	1.3
Mean	94.9	80.1	13.8	5.9	59.5	1.3
LSD (0.05)	20.8	NS	5.4	5.1	5.7	0.4
LSD (0.30)	10.5	3.6	2.8	2.7	2.8	0.2

^zYields for 17 varieties and controls in tons per hectare are based on a planting density of 30,900/ha.

^yFruit weight in grams.

^xDisease index is a subjective score of vine health with 0 = no apparent foliar disease and 3 = severe defoliation.

Table 3. Three-year quality data, multilocation trial (three locations per year)^a.

Genotype	Color ^b			Color uniformity ^c			pH	Solids °Brix	Firmness ^d	
	L	Chroma	Hue	Ldif	Cdif	Hdif			Crack (%)	Force
OH 7983	41.4	35.1	44.0	3.9	2.8	6.7	4.35	5.32	50	5.2
OH 8245	43.4	39.0	44.0	5.1	3.1	7.4	4.34	4.96	13	5.4
OH 9242	39.4	35.8	40.2	3.8	3.4	4.8	4.43	5.18	50	4.5
OH 9816	41.3	34.7	44.4	4.0	3.0	6.1	4.39	5.03	10	4.8
OH 9834	43.2	36.1	45.9	4.6	2.8	7.3	4.43	4.63	13	4.6
H 9423	43.0	40.8	40.3	3.1	2.4	4.0	4.28	4.89	23	6.0
OX150	41.3	35.0	44.2	4.4	3.1	6.8	4.36	4.58	20	4.7
OX23	41.4	37.0	42.5	3.3	2.5	4.6	4.34	5.01	23	5.2
OX323	42.6	37.4	43.8	3.9	2.7	6.5	4.40	4.85	3	5.4
OX324	41.5	36.9	42.1	4.2	3.3	5.9	4.41	4.97	5	4.9
OX325	40.8	37.0	41.0	4.0	2.6	5.5	4.38	4.78	8	4.9
OX327	40.7	38.4	40.4	4.0	2.6	6.1	4.42	4.89	0	5.4
OX328	41.5	35.6	43.3	4.2	2.8	7.2	4.42	4.54	23	4.6
OX331	41.1	38.1	40.8	4.4	2.7	6.0	4.40	4.71	10	5.1
OX52	41.6	35.4	44.1	3.8	2.6	6.8	4.34	4.72	23	4.8
PS696	42.8	37.6	45.0	4.3	2.8	6.8	4.25	4.83	18	5.3
TR12	40.9	36.0	43.2	3.3	2.5	5.0	4.28	5.11	33	5.2
Mean	41.6	36.8	42.9	4.0	2.8	6.1	4.4	4.9	19.1	5.0
LSD (0.05)	1.7	0.9	2.5	0.8	0.4	1.7	0.07	0.30	25	0.4
LSD (0.30)	0.9	0.5	1.3	0.4	0.2	0.9	0.04	0.16	13	0.2

^aTrial locations for multi-location trials were Ohio State University research farms in Fremont, Ohio, and Wooster, Ohio, and Hirzel Farms, Wood County, Ohio.

^bColor values are based on the L, a, b color space with L indicating lightness to darkness; chroma, intensity; and hue, color.

^cColor uniformity measures are based on the difference between two measurements per fruit. Low difference values indicate uniform color or the absence of color disorders.

^dFirmness of fruit is measured as percentage of fruit cracked following a 1.25-m drop onto concrete or as kilograms of force to puncture using a 1-cm-diameter head probe mounted on a force gauge (Ametek, inc., Largo, Fla.).

with these trials is summarized in Table 1. The average machine harvest yield of Ohio 9816 was 110.0 t·ha⁻¹ over 3 years of testing, outperforming the major early season inbred variety Ohio 7983 and the main-season inbred variety Ohio 8245 (Table 2). Yields of Ohio 9816 were comparable to hybrid varieties (Table 2). The average machine harvest yield of Ohio 9834 was 95.2 t·ha⁻¹ over 3 years of testing, comparable to other inbred varieties (Table 2). Fruit of Ohio 9816 and Ohio 9834 average 56.7 g with two to three locules. The ovate fruit have a small stem scar and core, are uniform ripening (*u*), and are attached by a jointless pedicel (*j2*).

The sampled raw and processed product is

characterized by soluble solids content that is comparable to industry standards in the mid-west and eastern U.S. (Table 3). The color and uniformity of color for fruit for both lines is comparable to midseason varieties currently in use in the midwestern and eastern U.S. making these lines appropriate for the development of hybrids for peeled, whole-canned, and diced tomato products (Table 3). Evaluation of Ohio 9816 and Ohio 9834 in test crosses indicate a potential for both lines as parents for hybrid varieties (Table 4).

Disease Resistance

Ohio 9816 and Ohio 9834 have partial resis-

tance to race T1 of bacterial spot [*Xanthomonas campestris* pv. *vesicatoria*], resistance to race 1 (*I*) of Fusarium wilt [*Fusarium oxysporum* Schlechtend. F. sp. *lycopersici* (Sacc.) Snyder and Hansen], and resistance to race 1 (*Ve*) of verticillium wilt [*Verticillium dahliae* Kleb]. The source of partial resistance to bacterial spot is Hawaii 7998. Both Ohio 9816 and Ohio 9834 carry an introgression on chromosome five that includes the molecular markers TOM49, Rx3-L1, and CosOH73 (Yang et al., 2005). This region had been implicated in the hypersensitive reaction (HR) in response to T1 strains and designated Rx3 (Wang et al, 1994a and Yu et al., 1995). Due to the poor correlation between greenhouse HR and resistance

Table 4. Test cross evaluation from 2000 observation harvest trial, Fremont, Ohio.

Genotype	Ripe (t·ha ⁻¹) ^z	Ripe (%)	Green (%)	Cull (%)	Fruit wt (g)	Disease index ^y (0–3)	Fruit rot index ^x (0–3)	pH	Solids °Brix	Female	Male
OX150	112.0	90.1	5.2	4.7	68.0	1.5	0.8	4.3	4.7	OH 88119	OH 9242
FG99-15	93.9	73.4	15.3	11.2	79.4	1.5	0.8	4.5	5.1	OH 97710	OH 9242
FG99-45	97.2	82.5	8.8	8.7	79.4	1.5	1.0	4.5	4.9	OH 97710	OH E3259
OX330	123.5	87.6	4.3	8.1	62.4	2.3	1.3	4.4	3.9	OH 981205	OH 9242
OX336	117.2	88.5	4.3	7.2	68.0	2.0	1.0	4.4	4.4	OH 981205	OH 9816
FG99-19	114.0	80.5	13.7	5.7	70.9	1.0	1.0	4.3	4.9	OH 9816	OH 9242
OX328	111.0	74.7	19.9	5.5	68.0	1.5	0.5	4.4	4.0	OH 9816	OH E3259
FG99-21	101.4	76.1	11.8	12.1	70.9	1.0	1.3	4.3	5.4	OH 9834	OH 9242
OX329	114.0	82.0	10.5	7.4	65.2	1.5	1.0	4.5	4.4	OH 9834	OH E3259
OH 8245	111.5	88.5	6.8	4.7	73.7	1.5	1.0	4.4	4.7		
OH 9242	71.1	73.8	17.6	8.6	82.2	1.8	1.3	4.5	5.3		
OH 88119	77.1	81.9	6.5	11.7	62.4	2.0	1.0	4.4	4.4		
OH 981205	91.1	86.8	4.5	8.7	62.4	1.3	1.5	4.5	3.7		
OH 9816	100.4	80.0	16.8	3.2	65.2	1.0	0.8	4.3	5.2		
OH 9834	104.2	80.9	9.5	9.6	65.2	1.0	1.3	4.4	4.2		
OH E3259	85.9	80.4	11.6	8.0	68.0	1.8	1.0	4.4	4.4		
Mean	101.7	81.7	10.5	7.8	68.0	1.5	1.0	4.4	4.6		
LSD (0.05)	22.8	9.0	8.9	6.6	8.5	0.7	0.8	0.1	0.8		
LSD (0.30)	12.1	4.7	4.7	3.5	5.7	0.4	0.4	0.1	0.4		

^zYields in tons per hectare are based on a planting density of 30,900/ha.

^yDisease index is a subjective score of vine health with 0 = no apparent foliar disease and 3 = severe defoliation.

^xFruit rot index is a subjective score of fruit integrity with 0 = no disease or cracking and 3 = severe fruit disease and/or cracking.

Table 5. Bacterial spot disease severity ratings.

Variety	Disease rating ^z	
	2 Year	3 Year
OH 981205	8.0	---
OH 88119	7.3	7.7
OH 9242	6.2	---
PetoSeed 696	6.0	---
OH E3259	5.7	5.1
OX 323	5.3	---
OH 8245	4.8	---
OX 329	4.5	---
OX 328	4.3	---
OH 9834	4.2	4.6
OH 9816	3.7	4.3
Mean	5.45	5.43
P	0.0062	0.0089
LSD 0.05	2.18	2.45

^zRatings are based on the 1–12 Horsfall-Barratt scale (Horsfall and Barratt, 1945) with lower values indicating less disease. Data are for 2000–01 (2 year) and 1999–2001 (3 year), Fremont, Ohio, from field trials inoculated *Xanthomonas campestris* pv. *vesicatoria* strains 110C, 118, and 89.

in the field (Somadi et al., 1994; Wang et al., 1994b), our evaluation emphasized evaluation under the relevant field environment and we found that the chromosome 5 introgression explained up to 41% of the genetic variation for T1 resistance (Yang et al., 2005). Disease evaluations were conducted in 1999, 2000, and 2001 at the Vegetable Crops Branch, Fremont Ohio. Six-meter plots were grown with 0.3 m within plot spacing and 1.5 m between row spacing on standard beds. Plots were replicated three times in a randomized complete block

design. Plants were inoculated with a mixture of T1 strains (110C, 118, and 89) about 3 weeks after transplant. Years and replications within years were considered random effects in the analysis of variance. Ohio 9816 and Ohio 9834 exhibited significantly ($p=0.0089$) more resistance than the parent line Ohio 88119 (Table 5). Ohio 9816 also exhibited significantly ($p=0.05$) more resistance than the bacterial spot tolerant hybrid, PetoSeed 696 (Table 4) in 2 years of trials.

Availability

Small samples of seed for research purposes are available from the corresponding author. Distributions require a signed material transfer agreement, which may be obtained from the Office for Technology Licensing, The Ohio State University, 1960 Kenny Road, Columbus, OH 43210-1063, (614)292-3911; Fax (614)292-8907.

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