

# Evaluation of Tomato Varieties for Resistance to Ozone



Carl D. Clayberg

The **CONNECTICUT**  
Agricultural  
Experiment Station  
NEW HAVEN

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Some crop plants are severely damaged by exposure to ozone, a major air pollutant. The problem is so acute in certain parts of the country that susceptible varieties can no longer be grown. Either resistant varieties are developed or the crop is discontinued. One instance of this is shade-grown cigar wrapper tobacco in the Connecticut Valley. Even the resistant varieties that have been bred show some weather fleck, the name given symptoms of ozone damage in this crop. Onions too can be severely damaged by ozone, the major symptom being a browning, or burning, of the leaves starting at the tips. Studies of tipburn in onion indicate that varietal differences exist which are simply inherited (Engle and Gabelman, 1966), so that resistant varieties can be identified by testing or can be bred for use in regions where this disease is a problem.

Tomatoes are among those crops most sensitive to ozone (Ledbetter *et al.*, 1959), and reports of serious damage to them in the field are increasing (Springer, 1972). In the hope of finding resistant varieties or sources of resistance for the breeder to use, researchers have screened tomatoes for their response to ozone. Reinert *et al.* (1969, 1972) tested 12 tomato varieties for resistance and found that 'Heinz 1439', 'VF 13L', and 'VF 145B' were more tolerant than the others evaluated. Gentile *et al.* (1971) tested 63 different tomato accessions, most of which were wild species and species hybrids. The ozone-tolerant strains they identified, all in the cultivated tomato *Lycopersicon esculentum* Mill., in decreasing order of resistance were: 'KY 1' (PI 247089), 'VFN 8', PI 304234, PI 309915, and 'Manzana' (PI 203229). In a more extensive screening of 1200 tomato lines, mostly of *L. esculentum*, from a world-wide collection, I found (Clayberg, 1971) five varieties that were ozone resistant: 'Pierette' (PI 109835 and PI 237136), 'Tatiner' (PI 303792), 'Heinz 1439', 'New Yorker', and 'Charkowskij' (PI 285443).

These tests clearly indicated that there was variation among tomato varieties for resistance to ozone and that some commercial varieties were as resistant as any lines tested. It was thus worthwhile to evaluate as many American varieties as possible to identify the resistant ones and see how they compared with those already found. For this purpose seed samples were requested of major seedsmen in the United States and Canada, particularly those specializing in tomatoes. A total of 295 different varieties and hybrids was received and tested for response to ozone during the summer of 1971.

### Cover Photo

Four degrees of ozone damage to tomato leaves. Using a scale from 5 (severe) to 1 (no damage), the leaves shown, left to right, are in groups 5, 4, 3, and 2.

Plants were exposed to ozone when the first true leaves were 2½ to 4 inches long. Exposures were made in a closed greenhouse only under sunny conditions to ensure open stomata for a reliable response to the ozone. The ozone was generated by an Orec Ozonator model 03V2 and concentrations were measured by a Mast Ozoné Meter model 724-2. Exposure time was 75-85 minutes at  $25 \pm 1$  pphm ozone, and this concentration in the test chamber was precisely controlled by wiring the meter in series with a Simpson contactless meter relay model 3326 XTA (Tomlinson and Rich, 1971). In the first experiments the relay activated a small pump to regulate the flow of ozonated air into the test chamber. Because of difficulties in drying greenhouse air sufficiently before ozonating it, in subsequent tests bottled compressed air was used and the relay controlled its flow by a solenoid.

Tomato leaves show typical injury symptoms following exposure to ozone (Ledbetter *et al.*, 1959). Mild symptoms are a chlorotic yellowing or whitening of tissue between the leaf veins or, less often, small brownish, necrotic flecks marginally or all over the leaf. More severe damage results in large water-soaked areas over the entire leaf surface right after exposure to ozone. These areas turn brown about 48 hours later at which time scoring for damage is most easily done. All scoring was based on a graduated scale of 1 to 5 with 1 representing no damage and 5 severe damage.

For the initial screening, varieties were grown in flats, six plants per variety and ten varieties per flat. Because the size of the test chamber did not permit all of the varieties to be tested simultaneously, they were divided into two approximately equal lots and tested separately (Tests 1 and 2). In the two subsequent tests (Tests 3 and 4) varieties were grown in 2-inch pots and set out in randomized complete blocks one plant per plot in four replicates.

The results for Tests 1, 2, and 3 are given Table 1. Although entries in Tests 1 and 2 have been separately identified in the table, the overall results for the two tests were not appreciably different from each other, considering that most entries in both were susceptible. Fifty-seven varieties in Tests 1 and 2 had damage rating values less than 3 and were reevaluated in Test 3.

Test 4 (Table 2) compares the most resistant varieties from Tests 1 to 3 with those identified by other researchers. This test contained all varieties from Test 3 with values of 2.3 or less plus three from Test 1 with values less than 2, varieties I previously identified as resistant (Clayberg, 1971), and all resistant lines reported by Reinert *et al.* (1969, 1972) and Gentile *et al.* (1971).

It is apparent from the results of Table 2 that some varieties, such as 'Charkowskij', which were previously found to be resistant, did not differ significantly from the susceptible controls. The most resistant varieties, like 'Pierette' and 'Heinz 1439', are consistently resistant in successive tests, while susceptible ones like 'Roma VF' and 'Fruhernte' are consistently susceptible. But I and others (Feder, personal communication) have observed that varieties of an intermediate level of resistance, such as 'Charkowskij' and 'New Yorker', will vary in their relative positions from test to test due to the difficulties in reproducing test conditions precisely each time. Although not too much faith should be put in the use of Duncan's Multiple Range test to distinguish nearby varieties in Table 2, the varieties in the top two-thirds of the table

are considered to possess some ozone resistance. The rest of the varieties reported in Tests 1 to 4, including all of the ozone-resistant varieties of Gentile *et al.* (1971), are probably about equally susceptible under the conditions of testing used. Unfortunately, the range between the most resistant and the most susceptible tomato varieties is not as great as in crops like tobacco. Experiments are in progress to see whether crosses between the resistant varieties of Table 2 can lead to higher levels of resistance.

I thank Dr. Saul Rich of the Plant Pathology and Botany Department for the use of and assistance in operating the ozonating equipment.

Table 1. Response of tomato varieties to ozone

Variety	Source*	Damage rating† in tests		Variety	Source*	Damage rating† in tests:	
		1	3			1	3
Ace	2	4		Earliana, Burpee's			
Ace Royal	9	4		Sunnybrook	4	3	
Ace 55 VF	2	4					
African Beefsteak	9	2	3.0	Earliana 498	9	4	
F <sub>1</sub> Ar-King	7	3		Earliest of All,			
Atkinson	9	3		Peart Strain	10	3	
F <sub>1</sub> Avalanche	9	4		Early Bird	10	3	
Basket Pak	4	4		F <sub>1</sub> Early Boy Hybrid	5	3	
Beefsteak	2	2	2.3	Early Chatham	9	4	
F <sub>1</sub> Beefsteak Hybrid	3	3		Early Cherry	1	4	
Bellarina	9	2	2.7	F <sub>1</sub> Early Delicious	9	3	
F <sub>1</sub> Big Boy Giant Hybrid	4	3		Early Detroit	10	3	
F <sub>1</sub> Big Early Hybrid	4	1.5	2.7	Early Fireball	10	3	
Bison	3	3		F <sub>1</sub> Early Giant	9	3	
Bonny Best	4	3		Early Red Cherry	9	3	
F <sub>1</sub> Bonus VFN	9	3		Early Red Chief	10	1	3.3
Bounty	8	3		F <sub>1</sub> Early Salad Hybrid	3	3	
Bush Beefsteak	10	2	3.3	Early Stokesdale No. 4	10	4	
California Pole Early	5	3		Early Summer Sunrise	10	3	
California Pole Late	5	3		Early Wonder	3	3	
Campbell 17	9	4		Earlypak PS9	9	3	
Campbell 19	10	4		Earlypak 7	2	1	2.3
Campbell 24	10	4		Earlypak 707	6	1	2.0
Campbell 1327	9	2	2.3				
F <sub>1</sub> Caravelle	7	3		Eastern States	1	3	
F <sub>1</sub> Cardinal Hybrid	7	3		ES 24	1	2	3.7
Caro Red	3	3		ES 58	9	3	
F <sub>1</sub> Challenger	1	3		Everbearing	3	3	
Chico	5	4		F <sub>1</sub> Fantastic	9	4	
Chico III	9	3		Fireball	7	3	
Climbing Trip-L-Crop	3	3		Fireball VF	6	2	2.0
Goldset	9	3		Firesteel	8	3	
Colossal Crimson	3	3		Floradel	2	3	
Colossal Golden	3	3		Floralou	9	3	
Colossal Red	3	3		F <sub>1</sub> Florida-Hawaii	9	3	
Colossal Yellow	3	4		Galaxie	9	2	2.3
F <sub>1</sub> Coronet	7	4		Gardener	10	3	
CPC 2	2	3		Gardener 67	1	4	
CR 1324	9	2	3.3	Giant Italian Potato Leaf	9	3	
Crack-Proof	3	3					
Crack-Proof Pink	10	2	2.3	F <sub>1</sub> Giant King	9	2	3.0
Crimson Cushion	8	3		Glamour	2	3	
Culiacan I	2	3		Globe, Burpee's	4	3	
de la Plata	2	2	2.7	Gloriana	4	4	
Delicious	4	2	1.0	F <sub>1</sub> Golden Boy	9	3	
Doublerich	3	3		Golden Queen	10	3	
Dwarf Champion	10	3		Grand Chico	6	4	
Earliana	8	3		Grand Pak	9	2	3.3
				Grand Prix VF	6	3	

Variety	Source*	Damage rating† in tests:		Variety	Source*	Damage rating† in tests:	
		1	3			2	3
Greater Baltimore	9	4		Marglobe	2	2	3.0
Greenhouse Forcing Rapids	10	5		Marion	2	2.5	2.0
Gulf State Market	9	3		Maritimer	10	2.5	2.0
Harbon	10	4		McMullen	10	4	
Harvester	9	4		Mech 9	9	2	3.3
F <sub>1</sub> Hawaii N-55	9	5		Mecheast	9	3	
Heinz 1350	2	3		Mecheast 55	9	4	
Heinz 1370	2	1.5	3.3	Michiana Hybrid No. 138	10	2.5	2.3
Heinz 1409	2	3		F <sub>1</sub> Michigan-Ohio Hybrid	7	3	
Heinz 1439	2	3		Michigan State Forcing	4	3	
Heinz 1548	2	4		F <sub>1</sub> Mocross Supreme	9	3	
Heinz 6201	9	4		F <sub>1</sub> Mocross Surprise	9	3.5	
High Crimson Improved	10	3		Moneymaker Select	9	4	
Homestead Elite	6	3		Monte Grande	9	3	
Homestead FM 61	6	3		F <sub>1</sub> Moreton Hybrid	7	3	
Homestead 24	6	3		Napoli VF	6	4	
Homestead No. 61	5	3		Nematex	9	3.5	
Homestead 240	9	3		F <sub>1</sub> New Jersey "300"	9	3	
Homestead 500	2	3		New Yorker	7	3	
Hotset	9	3		F <sub>1</sub> Ohio-Indiana 0	9	3	
F <sub>1</sub> Hybrid No. 1	3	3		Ohio W.R. 7	9	3	
F <sub>1</sub> Hybrid No. 2	3	3		Ohio W.R. 25	9	3	
F <sub>1</sub> Hybrid No. 3	3	3		Orange Queen	10	3	
F <sub>1</sub> Hybrid 980	1	3		Oxheart	2	3	
F <sub>1</sub> Hybrid Pink No. 1	10	3		F <sub>1</sub> Pa 103	9	3	
F <sub>1</sub> Hybrid Pink No. 6	10	2	2.0	Parker	9	4	
F <sub>1</sub> Hybrid Pink No. 12	10	3		F <sub>1</sub> Patio	9	3	
F <sub>1</sub> Hybrid Red No. 22	10	3		Pearson A-1 Improved	2	3	
F <sub>1</sub> Hybrid Red No. 23	10	3		F <sub>1</sub> Pearson Hybrid No. 9	10	3	
Hybrid Super Gold	3	3		Pearson S	2	3	
F <sub>1</sub> H-11	9	3		Pearson VF6	2	3	
Immokalee	5	3		F <sub>1</sub> Perfection Hybrid	3	3	
F <sub>1</sub> Imperial	5	3		Pickmaster	6	2.5	4.0
Indian River	2	3		Pink Shipper	9	3	
Italian Canner	3	2	2.7	F <sub>1</sub> Pink Supreme	5	3	
Jefferson	2	3		Pink Vogue	10	4	
F <sub>1</sub> Jet Star	7	3		F <sub>1</sub> Pixie	4	4.5	
J. Moran	9	3		Platense	5	2.5	2.7
John Baer	10	3		Polepak VF 78	9	2.5	3.3
Jubilee	4	1.5	2.0	Ponderosa	7	3	
F <sub>1</sub> Jumbo Hybrid	3	3		Ponderosa Pink	9	3	
June Pink	2	3		Ponderosa Red	9	3	
F <sub>1</sub> Kabob Hybrid	3	4		Porter	9	3	
La Plata	6	1	2.7	Porter Improved	9	3	
Little Dandy	1	3		Pritchard	2	3	
Livingston Globe	10	2	3.3	Quebec #13	10	3.5	
Longred	10	2	2.3	Quebec #314	10	4	
Mammoth Wonder	3	3		F <sub>1</sub> Queens Knight	9	3.5	
Manalucie	2	3		F <sub>1</sub> Ramapo	7	3	
Manapal	2	3		Red Cherry, Large	8	3.5	
F <sub>1</sub> Manhattan	7	3		Red Peach	10	4	
Manitoba	10	3		Red Pear	8	3	

Variety	Damage rating† in tests:		Variety	Damage rating† in tests:	
	Source*	2 3		Source*	2 3
Red Plum	8	3.5	Veecrop	10	3
Red Sugar	3	3.5	F <sub>1</sub> Veegan	7	3.5
Red Top	2	3	Veecet	10	4
Red Top Improved	5	3.5	Vendor	10	3.5
Red Top V9	2	3.5	VF Earlypak	2	2 3.3
Rideau	10	3.5	F <sub>1</sub> VF Hybrid, Burpee's	4	2 3.3
Rocket	10	3.5	VFN Bush	9	2.5 3.0
Roma	2	4	VFN 8	2	2 3.3
Roma VF	2	4	VF 13L	6	3.5
F <sub>1</sub> Rushmore	9	3.5	VF 13L-34	2	3
Rutgers	2	3	VF 14	2	2.5 2.3
F <sub>1</sub> Rutgers Hybrid	9	3	VF 36	2	2.5 3.3
San Marzano	2	4	VF 99	2	3
San Marzano Large Fruited	6	3.5	VF 100	2	3
Santa Cruz	2	3.5	VF 130	9	3
Scotia	10	3	VF 145B	6	2 3.3
Selandia	10	3.5	VF 145 B-7	2	2.5 3.0
Sheyenne	8	3	VF 145 B-8	2	2.5 3.7
Sioux	8	3	VF 145 B-7879	2	3
F <sub>1</sub> Small Fry	9	3.5	VF 145-F5	6	3
Spartan Red-8	3	3	VF 145 Gus	2	2.5 4.0
F <sub>1</sub> Spring Giant Hybrid	10	3	VF 145-21-4	2	2.5 3.0
F <sub>1</sub> Springset	7	4	VF 145-21-4P	6	2.5 3.7
Starfire	10	3	VF 145-21-4 Select	2	1.5 3.7
F <sub>1</sub> State Fair	8	3	VF 145-513	9	1.5 4.0
F <sub>1</sub> Stokes Early Hybrid	10	3	VF 198-69	9	3
Stokesalaska	10	3.5	VF 365	2	2.5 2.3
Stokesdale	10	3.5	VF 428-F2	6	2.5 3.3
Stone Improved	9	3.5	Viceroy	10	3
Sunray	7	3	Vinequeen	10	2.5 3.0
Sunset	1	3	F <sub>1</sub> Vineripe	9	2.5 3.3
F <sub>1</sub> Sun-Up	9	3.5	Viscount	10	2.5 2.7
F <sub>1</sub> Super Colossal Red Hybrid	3	3	Vision	10	2 2.3
Super Red	1	3	Vivid	10	4
Super Sioux	9	4	Vogue	10	3.5
Supermarket	2	3	VR Moscow	2	3
F <sub>1</sub> Supersonic	7	4	Walter	2	3
Swift	10	4	White Beauty	3	3
F <sub>1</sub> Terrific	9	3	F <sub>1</sub> Wonder Boy	9	2.5 3.0
Tiny Tim	4	5	XP 628	2	2 2.7
Tiny Tim Yellow	3	4	Yellow Cherry	8	2.5 3.0
Tomboy	9	2.5 3.0	Yellow Pear	8	4
Trellis 22	10	4	Yellow Plum	4	4.5
Tropic	9	3.5	Yellow Sugar	3	3
Tropic-Gro	2	3	No. 1402 (VFR)	2	3.5
Tropi-Red	2	3	F 6339 VF	9	3
F <sub>1</sub> Tuckcross 0	9	3	F 6343 VF	9	3
F <sub>1</sub> Tuckcross W	9	4			
F <sub>1</sub> Tuckcross 520	9	3			
Urbana	9	3			
Valiant	4	3.5			
Vantage	10	4			

	Damage rating
Test 1	
overall mean	2.99
controls (mean of 3 entries)	
resistant: Pierette (PI 237136)	1.3
susceptible: Fruhernte (PI 289211)	2.5
Test 2	
overall mean	3.12
controls (mean of 3 entries)	
resistant: Pierette	2.5
susceptible: Fruhernte	3.5
Test 3	
overall mean	2.85
controls	
resistant: Pierette	1.0
susceptible: Fruhernte	3.0

\*Source:

- 1 Agway Inc., Seed Division, P. O. Box 166, East Butler, Pa., 16029
- 2 Asgrow Seed Co., c/o Upjohn Co., Kalamazoo, Michigan 49001
- 3 Burgess Seed and Plant Co., P. O. Box 218, Galesburg, Michigan 49053
- 4 W. Atlee Burpee Co., Hunting Park Ave. at 18th St., Philadelphia, Pa. 19132
- 5 Dessert Seed Co., Inc., P.O. Box 181, El Centro, Cal. 92243
- 6 Ferry-Morse Seed Co., Inc., P.O. Box 100, Mountain View, Cal. 94040
- 7 Joseph Harris Co., Inc., Moreton Farm, Rochester, New York 14624
- 8 Northrup, King & Co., Minneapolis, Minn. 55413
- 9 Peto Seed Co., Inc., P.O. Box 4206, Saticoy, Cal. 93003
- 10 Stokes Seeds, Inc., Box 548, Buffalo, New York 14240

†Mean ozone damage based on a scale of 1 (none) to 5 (severe).

Table 2. Comparison of ozone-resistant varieties

Variety	Prior testing*	Mean damage rating†	
Pierette (PI 237136)	C1	2.12	a
Firebird VF	C2	2.50	ab
F <sub>1</sub> Hybrid Pink No.6	C2	2.50	ab
Earlypak 7	C2	2.74	bc
Heinz 1439	R	2.74	bc
Tatiner (PI 303792)	C1	3.00	cd
Vision	C2	3.12	cd
Earlypak 707	C2	3.25	d
VF 13L	R	3.25	d
VF 145B	R	3.25	d
Campbell 1327	C2	3.75	e
Crack-Proof Pink	C2	3.75	e
VF 365	C2	3.75	e
Maritimer	C2	4.00	ef
Heinz 1370	C2	4.12	efg
Beefsteak	C2	4.25	fg
Delicious	C2	4.25	fg
La Plata	C2	4.25	fg
Marion	C2	4.25	fg
New Yorker	C1	4.25	fg
VF 14	C2	4.25	fg
KY 1 (PI 247089)	G	4.50	gh
VFN 8	G	4.50	gh
PI 309915	G	4.50	gh
F <sub>1</sub> Big Early	C2	4.75	hi
Charkowskij (PI 285663)	C1	4.75	hi
Fruhernte (PI 289211)	C1‡	4.75	hi
Jubilee	C2	4.75	hi
Manzana (PI 203229)	G	4.75	hi
Roma VF	R‡	4.75	hi
PI 304234	G	4.75	hi
Galaxie	C2	5.00	i
Longred	C2	5.00	i
F <sub>1</sub> Michiana Hybrid No. 138	C2	5.00	i

\*These varieties previously tested by:

C1 Clayberg, 1971

C2 Clayberg, Table 1

G Gentile *et al.*, 1971

R Reinert *et al.*, 1969, 1972

†Means followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

‡Susceptible controls.

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THE CONNECTICUT  
AGRICULTURAL EXPERIMENT STATION  
NEW HAVEN, CONNECTICUT 06504

*Paul E. Waggoner*  
Director

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