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Sensitivity of Grape Cultivars to Ambient Ozone

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Abstract. **Fifty-nine American, 40 Frency hybrid, and 6 *Vitis vinifera* L. grape cultivars growing in vineyards at Geneva, N.Y., were rated 4 consecutive years at mid-September for oxidant stipple injury from ambient ozone. There were significant differences in injury among the American and French hybrid cultivars. Cluster analysis separated the American cultivars into 3 sensitivity groups and the french hybrids into 2 sensitivity groups. American cultivars had the highest variability among cultivars in sensitivity, with Ives and Couderc 3309 having the highest sensitivity. High sensitivity to ozone as evidenced by oxidant stipple injury appears to originate within the American *Vitis* species. None of the cultivars examined was resistant to ambient ozone.**

Oxidant stipple injury to grapevine foliage caused by ambient air pollutants (primarily ozone) has been a persistent problem in northeastern United States vineyards. Research has documented large variability in oxidant stipple injury among *V. vinifera* (6), American, and French hybrid (1) grape cultivars. Kender and Carpenter (1) provided initial estimates of susceptibility to oxidant stipple injury on 25 American and French hybrid cultivars in mid-September, 1972, in vineyards in New York. They evaluated susceptibility of 53 American, 41 French hybrids, and several unnamed New York numbered selections in vineyards in New York and Ontario in 1973. American cultivars varied widely in tolerance. The cultivar 'Delaware' showed no injury and was considered resistant to ambient ozone, whereas 'Ives' was the most sensitive of the 94 cultivars examined. 'Concord', the most widely planted cultivar in the northeastern United States, was rated as having "considerable" (51–75%) injury. French hybrids were reported to be less affected by ozone than were American cultivars (1).

The data presented herein add to the initial estimates of Kender and Carpenter by providing a summary of an additional 4 years of data on oxidant stipple injury from ambient ozone to American and French hybrid grape cultivars and present new data on sensitivity of *V. vinifera* cultivars in New York.

From 1977–1980, 59 American, 40 French hybrid, and 6 *V. vinifera* grape cultivars were examined at mid-September for ozone injury. Injury was estimated as percentage of leaf area with oxidant stipple injury on leaves at the basal 6 nodes of each cultivar. Injury was estimated to the nearest 1% or 2% from 0–10% injury and to the nearest 5% for 10–100% injury. From 2 to 18 individual vines were examined for each cultivar, depending upon the number of healthy vines available from each cultivar. Grapevines rated were growing in the cultivar collection at the New York State Agricultural Experiment Station, Geneva, N.Y. Vineyards were managed to maintain healthy vines, including adding sufficient nitrogen fertilization to provide optimum N levels in grapevine foliage, and frequent spraying with the fungicide benomyl to control powdery mildew. N fertilizer and benomyl sprays were applied uniformly to cultivar vineyards. A high N level in grapevine leaves has been demonstrated to be related to reduced oxidant stipple injury (2, 4). Benomyl has been shown to be an effective antioxidant which reduces oxidant stipple on grapevine foliage (3, 4).

Grapes were separated into 3 groups for analysis: the American, French hybrid, and *V. vinifera* cultivars. Significance of cultivar and yearly differences within each group was assessed by analyses of variance. Cultivars within groups showing significant differences were separated by cluster analysis (7). The American and French hybrid groupings, used by Kender and Carpenter (1) and followed in this study, are based on cultivar origin rather than genetic classification. The American group includes those cultivars originating from crosses made primarily by American breeders, while French hybrids were developed by French breeders (5). American cultivars include those derived from native American *Vitis* species parentage or from crosses between American cultivars and *V. vinifera*. French hybrids are derived from crosses between *V. vinifera* and one or more American *Vitis* species.

Separate analyses of variance showed highly significant differences in oxidant stipple injury among American cultivars and among French hybrid cultivars within each

Table 1. Average percentage of oxidant stipple injury at mid-September on leaves at basal 6 nodes of *Vitis vinifera* grape cultivars growing at Geneva, N.Y., 1977–1980. Injury ratings were not significantly different.

Cultivar	Oxidant stipple injury (%)
Pinot Chardonnay	7.4
Cabernet Sauvignon	9.0
White Riesling	9.6
Gewurztraminer	11.7
Gamay	18.2
Pinot Noir	21.2

Table 2. Average percentage of oxidant stipple injury at mid-September on leaves at basal 6 nodes of American, French hybrid, and *Vitis vinifera* grape cultivars growing at Geneva, N.Y., 1977–1980, compared with rainfall at Geneva and ozone at Rochester, N.Y. (60 km distance upwind) and Syracuse, N.Y. (75 km downwind).

	Oxidant stipple (%)				
Variable	1977	1978	1979	1980	1977–1980 avg
Cultivar group					
American (59)[z]	43.8	11.9	15.4	17.4	22.1
French hybrid (40)	24.2	7.0	7.5	11.1	12.4
Vitis vinifera (6)	38.7	8.5	4.1	0.4	12.9
Avg (3 groups)	35.6	9.1	9.1	9.6	
Environmental data					
Rainfall (cm), 1 July–30 Sept.	38.3	16.5	28.2	19.3	
Ozone, ppm, Rochester[y]					
Max. 1-yr avg	0.129	0.148	0.107	0.122	
Arith. mean, annual	0.024	0.025	0.019	0.021	
Arith. mean, 1 June–30 Sept.	0.028	0.034	0.028	0.031	
Ozone, ppm, Syracuse[y]					
Max. 1-hr avg	0.126	0.140	0.135	0.114	
Arith. mean, annual	0.019	0.021	0.021	0.021	
Arith. mean, 1 June–30 Sept.	0.027	0.028	0.031	0.031	

[z]Number of cultivars in parentheses.
[y]Ozone data from N.Y. State Dept. of Environmental Conservation, Albany, N.Y.

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Table 3. Cluster analysis of oxidant stipple injury at mid-September on leaves at the basal 6 nodes of American grape cultivars growing at Geneva, N.Y., 1977–1980. Cluster analysis splits are significant at the 0.1% level.

American cultivar	Mean percentage of oxident stipple injury, 1977–1980	American cultivar	Mean percentage of oxident stipple injury, 1977–1980
Isabella	3.1	Kendaia	20.9
Delaware	3.9	Alwood	21.0
Wayne	4.4	Naples	22.3
Dutchess	4.5	Agawam	22.7
Himrod	5.0	Elvira	23.4
Iona	5.0	Ontario	24.2
Athens	5.6	Fredonia	24.3
Ventura	6.0	Eclipse	25.0
Alden	6.0	Buffalo	25.2
Schuyler	8.6	Sheridan	25.5
Lakemont	9.0	Veeport	26.4
Steuben	9.3	Cayuga White	27.4
Romulus	11.1	New York Muscat	28.1
Interlaken Seedless	11.4	*1st cluster analysis split*	
Urbana	11.4	Canadice	30.6
Keuka	13.0	Seneca	31.8
Salem	13.5	Vincent	31.9
Suffolk Red	13.5	Catawba	32.1
Canada Muscat	13.6	Brighton	33 1
Glenora	13.9	Clinton	34.6
Yates	14.0	Portland	34.6
Norwood	14.0	Moored	35.7
Niagara	15.1	Caco	38.1
Concord Seedless	15.4	Kensington	40.0
Hanover	16.9	Bath	45.0
Vinered	16.9	McCampbell	46.3
Golden Muscat	17.1	Ripley	52.5
Van Buren	17.3	*2nd cluster analysis split*	
Concord	19.4	Couderc 3309	66.6
Erie	19.6	Ives	78.6
Mills	20.2		

group. No significant differences in oxidant stipple were found among the 6 *V. vinifera* cultivars. *V. vinifera* cultivars tested in New York were not highly sensitive to ozone (Table 1).

There were highly significant year-to-year differences in oxidant stipple injury. Kender and Carpenter (1) had reported consistent injury to 25 grapevine cultivars rated in both 1972 and 1973. Most cultivars had considerably more injury in 1977 (Table 2). This injury may be related to high 1977 rainfall (Table 2), which has been shown to be associated with high oxidant stipple injury to grapevines (4, 8). Injury was not related directly to ambient ozone (Table 2).

Cluster analysis split the American cultivars into 3 statistically different groups (Table 3). The 1st split separated those with injury up to that of 'New York Muscat' (28.1%) into one group and those from 'Canadice' (30.6%) or above into another group. Although 'New York Muscat' and 'Canadice' are not significantly different from each other, the groups in which they occur by the cluster analysis are significantly different (7). A 2nd split separated the cultivars 'Couderc 3309' (a nonfruiting rootstock of *Vitis riparia* Michx. x *V. rupestris* Scheale parentage) and 'Ives' (primarily *V. labrusca* L. parentage) into a 3rd group having higher sensitivity. 'Concord' (primarily *V. labrusca*), the most widely grown cultivar in New York, fell well within the low-injury grouping. 'Concord' averaged 19.4% injury over the 4 years, confirming observations by Shaulis (8) that in well-managed vineyards oxidant stipple injury can be minimized on this cultivar. Frequent use of benomyl and optimum N levels likely contributed to the low-injury rating. 'Concord' had been rated as having 51-75% oxidant stipple in 1972–1973 (1). Other American cultivars showing low injury were 'Fredonia' (24.3%), 'Elvira' (23.4%), and 'Keuka' (13%), all estimated to have 76–100% injury in 1973 (1). In contrast, 'Seneca' (31.8%) was rated as having 0–5% injury in 1973 (1).

Cluster analysis separated the French hybrids into 2 significantly different groups (Table 4): those with injury of 13.1% or less and those with injury of 15.3% or above. Only the French hybrid cultivars 'Rosette' (30.6%) and 'Leon Millot' (35.4%) had more than 30% injury. Injury was particularly high for these cultivars in 1977. Our ratings agree

Table 4. Cluster analysis of oxidant stipple injury at mid-September on leaves at basal 6 nodes of French hybrid grape cultivars growing at Geneva, N.Y., 1977–1980. The cluster analysis split is significant at the 0.1% level.

French hybrid cultivar	Mean percentage of oxidant stipple injury, 1977–1980	French hybrid cultivar	Mean percentage of oxidant stipple injury, 1977–1980
Villard Blanc (SV 12-375)	1.2	Chancellor (S 7053)	11.4
Joannes Seyve 12-428	2.8	Bertille Seyve 2846	12.0
Seyve-Villard 18-307	2.9	Baco noir (Baco #1)	13.1
Rayon d'Or (S 4986)	3.5	Seyve-Villard 5-247	13.1
Verdelet (S 9110)	4.3	*1st cluster analysis split*	15.3
Joannes Seyve 23-416	4.4	Cascade (S 13053)	15.9
Seibel 14117	4.7	De Chaunac (S 9549)	16.5
Villard Noir (SV 18-315)	5.7	Seyve-Villard 1-72	17.1
Chelois (S 10878)	5.8	Seibel 8229	17.9
Seyval (SV 5-276)	6.2	Rougeon (S 5898)	18.1
Seibel 7136	6.9	Seibel 13047	18.8
Landot 4511	7.1	Tehere Dore (Ravat 578)	20.0
Seibel 10868	7.1	Marechal Foch (Kuhlmann 188-2)	20.0
Humbert 3	7.2	Totmur (Baco 2-16)	20.6
Seyve-Villard 23-512	7.3	Chambourcin (JS 26-205)	22.1
Aurore (S 5279)	7.5	Valerien (SV 23-410)	25.2
Joannes Seyve 26-627	7.8	Landal (Landot 244)	25.7
Le Commandant (BS 2862)	8.1	Vignoles (Ravat 51)	30.6
Ravat Blanc (Ravat 6)	8.7	Rosette (S 1000)	35.4
Colobel (S 8357)	8.8	Leon Millot (Kuhlmann 194-2)	
Le General (BS 5563)	9.6		

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with the placement of these 2 cultivars in 1972–1973 as having 26–50% injury (1). Cultivars differing from earlier classification include 'Baco Noir' (13.1%), 'Ravat Blanc' (8.7%), 'Aurore' (7.5%), and 'Joannes Seyve 26-627' (7.8%), all estimated as having 26–50% injury in the earlier rating (1).

American grape cultivars exhibited a wider range in sensitivity to ambient ozone than *V. vinifera* or French hybrid cultivars, with many American cultivars highly sensitive. The data indicate tolerance to exist within all 3 cultivar groups. Many of the French hybrids and American cultivars are of complex parentage involving several American grape species and *V. vinifera,* and their classification as American or French is not related to their genetic background. However, the French hybrid and *V. vinifera* cultivar groups have considerably less variability in sensitivity to ozone than the American cultivar group. The French hybrids tend to be more like the *V. vinifera* group. Sensitivity to ozone in *Vitis* may originate in one or more of the American *Vitis* species. The high sensitivity of some of the American cultivars was not transmitted to progeny in crosses made by developers of the French hybrids.

No grape cultivar was free of oxidant stipple injury. Even though 'Isabella', 'Delaware', 'Villard Blanc', 'Joannes Seyve 12-428', and others had little injury and can be considered tolerant, small amounts of injury occurred on those cultivars in most years. 'Ives' and 'Couderc 3309' were the most sensitive grape cultivars as reported earlier (1). 'Ives' has been used in New York as a bioindicator of ambient ozone since the early 1970s. In some years, oxidant stipple injury has been observed on 'Ives' foliage as early as several weeks before bloom of that cultivar.

Injury ratings of most of the cultivars we examined generally are consistent with earlier initial estimates (1). Major exceptions to the earlier estimates have been described. Differences may be related to vineyard location or management during the 2 study periods. Results reported here are specific for the site where these grapevines were growing in Geneva, N.Y. It is expected that the relative ranking of each cultivar may vary with microclimatic and soil changes due to vineyard location and with vineyard cultural practices (2, 4). In addition, we have found that injury rankings of grapevine cultivars vary from year to year. The tables can be used to indicate relative ranking in terms of general tolerance or sensitivity. Cultivar position ranking in the tables may vary somewhat from year to year and with specific vineyard conditions.

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Self-compatibility in 'Truoito' Almond and the Effect of Temperature on Selfed and Crossed Pollen Tube Growth

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Abstract **The level of fruit set of 'Truoito' almond from hand self-pollination was high (47.7% and 56.8% in 1982 and 1983, respectively) and similar to the fruit set from hand cross-pollination. Fruit set in bagged branches excluding pollinators (honey bees and wind) was high and similar to that from open pollination (38.0% and 40.0%, respectively). Effective self-pollination occurred without pollinators because the stigmatic surface was adjacent to the anthers, in contrast to other cultivars examined in which the stigma was above the anthers. Pollen tube growth in self-pollinated styles was faster than in those cross-pollinated at 10° and 15°C, but similar at 20° and 25° and slower at 30°. Inhibition of pollen tube growth occurred at 30° in 45% of the self-pollinated styles. Optimum temperatures for 'Truoito' pollen tube growth in either selfed or crossed styles were between 20° to 25°, and 54 hr elapsed before tubes reached the base of the style after pollination. Pollen tube growth under field conditions was similar in both selfed and crossed styles.**

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Commercial almond cultivars are self-incompatible (2, 3), and for an economical fruit set of 30% or higher, pollinizers are required (3). Almonds bloom early, and when the weather is not favorable for good bee activity, yields may be poor. Therefore, self-compatible cultivars are desirable. Self-compatible cultivars usually do not set fruit as linated. This difference is related to genotype (6, 7).

Temperature affects not only bee activity but also pollen tube growth and fruit set of almonds (1, 6). Pollen tube growth of various genotypes responds to different optimum temperatures (6).

Muhturi-Stylianidu (5) in Greece reported that the 'Truoito' almond is self-compatible, and fruit set with self-pollination is as high as that obtained from cross-pollination. In addition, she found that it can set fruit with out the aid of insects.

The objectives of this study were to confirm the self-compatibility of 'Truoito' by using fluorescent microscopy, to determine the extension and growth rate of selfed and crossed pollen tubes at various temperature regimes, and to determine relative levels of fruit set from self and cross-pollination without the aid of pollen transfer by insects.

Self- and cross-pollination with pollen of 'Texas' was performed by hand to emasculated flowers on 10 bagged branches for each treatment on 10 mature trees in 1982.

Fruit set of self-pollinated 'Truoito' flowers without the aid of insects was studied under lab and field conditions in 1983. First, bouquets from mature trees with only a few open flowers were brought to the lab, and flowers of all stages were removed except those at the balloon stage, which were left to open. Stigmas were examined for pollen after dehiscence. Secondly, 40 branches on mature trees in the field were chosen for examining self-pollinated stigmas and for fruit set determination. Ten of these were unbagged for open pollination. Twenty were bagged with cheesecloth to exclude bees, half to be hand self-pollinated, and the other half

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