Typical yield of Zinfandel grapes in ambient air, left, and carbon-filtered air, right.

Antioxidants Reduce Grape Yield Reductions from PHOTOCHEMICAL SMOG

C. R. THOMPSON · GERRIT KATS

INJURY TO GRAPES by Los Angeles type (photochemical) smog was recognized as early as 1957. The component of this mixture which causes the most damage is ozone. A "stipple" condition of leaves characterized by small brown areas of dead cells develops where smog is heavy, usually in May or early June. As the season progresses these leaves turn bronze and drop. Some conifers develop a yellow mottle on the needles which progresses, with continued exposure to ozone, to severe chlorosis and defoliation. Citrus may develop irregular-shaped brown to black spots on the upper leaf suface.

Previous studies of the effects of photochemical smog on citrus in the Los Angeles Basin showed that the combined pollutants caused reduced water use, reduced photosynthesis, increased leaf and fruit drop, and a severe reduction in yield. Because all of these effects occurred in citrus without overt leaf damage, it was thought that major economic damage must be occurring in grapes but a field study was required to assess the total effect.

Twelve plots, each consisting of four Zinfandel grapevines in a vineyard near Cucamonga, California, were covered with 12 × 12 ft plastic-covered greenhouses. The vines were 8 ft apart, thus allowing one vine in each corner of the greenhouses. The experiment was begun in May 1968 when about two leaves per cane were showing. Two treatments with six replications were used. One treatment received nonfiltered ambient air supplied at 80 m^3/min. This provided about two volumes of air per minute. The other treatment received activated charcoal-filtered air at a comparable rate. The filters removed most of the ozone, peroxyacyl nitrates and nitrogen dioxide present in the photochemical smog complex.

Dusting

The only chemical treatment of the vines during the growing seasons was a dusting with Sevin to control leafhoppers. No supplemental water was supplied to the plants during the experimental period.

Fourteen weeks after the experiment started, the vines receiving carbon-filtered air were obviously much greener than those receiving ambient air. The chlorophyll content of mature leaves picked from each vine was determined. Results (table 1) showed that leaves in filtered air had much more of this vital pigment. Differences were statistically significant at the 1 per cent level.

TABLE 1. CHLOROPHYLL CONTENT OF GRAPE LEAVES

	Ambient Air	Carbon Filtered Air
	micrograms/cm^2	micrograms/cm^2
1968	28.8	48.8
1969	15.0	39.1

TABLE 2. WEIGHT OF INDIVIDUAL GRAPE BERRIES

	Ambient Air	Carbon Filtered Air
	g/berry	g/berry
1968	1.65	2.09
1969	2.13	2.72

TABLE 3. SUGAR AND ACID CONTENT OF GRAPE JUICE*

	Ambient Air		Carbon Filtered Air	
	Sugar	Acid	Sugar	Acid
	%	%	%	%
1968	21.7	.51	26.0	.49
1969	18.9	.44	21.8	.49

*Sugars expressed as sucrose; acids as tartaric.

TABLE 4. TOTAL WEIGHT OF PRUNINGS, ZINFANDEL VINES

	Ambient Air	Carbon Filtered Air
	Dry wt. grams	
1968	508	699
1969	561	831

TABLE 5. TOTAL WEIGHT OF GRAPES PER VINE

	Ambient Air	Carbon Filtered Air
	gr	gr
1968	1669	1892
1969	3123	8079

TABLE 6. EFFECT OF DPPD ON GRAPE YIELD*

	DPPD†	Untreated
No. vines	50	53
Kg/vine	4.87	3.88
Lb/vine	10.7	8.53

*3 sprayings: 5/23; 6/12; 7/15
†N,N'-diphenyl-p-phenylenediamine

Harvest

The grapes were picked and weighed in early September and 100 individual berries were clipped from different clusters at random from each vine. The average weight per berry was about one-fourth greater from vines in filtered air (table 2). These differences were also significant at the 1 per cent level. Juice was pressed from the berries and analyzed for sugar and total acids. Sugar content, as measured by refractometer, was significantly higher (1 per cent level) in the grapes grown in carbon-filtered air (table 3). Acid content was roughly the same in both treatments. Canes removed during pruning were air-dried and weighed (table 4). Vines in carbon filtered air had produced about 25 per cent more growth during the season.

The most significant result was in the yield of grapes harvested after the second season (table 5). Yield of grapes in 1968 was 13 per cent greater in carbon-filtered air than in ambient air but individual variation rendered the differences statistically nonsignificant. Yield differences in 1969 increased to 258 per cent under the same conditions. This difference from the 1968 values was attributed to the fact that the 1968 flower buds had probably been injured during setting in the fall of 1967 (or in 1968 before the treatments began) while the 1969 buds had been protected in 1968. Typical yields of grapes from single vines are shown in the photos.

Zinfandel grapes dusted twice during the 1967 season with N,N'-diphenyl-p-phenylenediamine (DPPD) showed an average increase in yield of about 20 per cent but the variation was too great for statistical validity. A similar study in 1968 showed no differences. The dust may have been washed from the leaves by unseasonal rains in 1968.

Spraying

In 1969, 103 comparable grapevines were separated randomly into two groups of 50 and 53 vines each. Fifty of the vines received three spraying each (5/23, 6/12 and 7/15) with 1.5 g "active" DPPD/vine formulated in a citrus storage wax emulsion. Where the emulsion collected and dried in heavy deposits, the leaves remained greener than the surrounding leaf tissue. The grapes were picked from these vines September 16, 1969. Yield from untreated vines averaged 3.88 kg while the sprayed vines yielded 4.87 kg (table 6). These differences were statistically valid at the 1 per cent level.

As suspected from previous studies, and from obvious leaf injury symptoms in current studies, grape varieties which suffered extensive leaf injury from photochemical smog produced fewer grapes of lower quality (based on sugar content). Destruction of chlorophyll and possibly other biochemical effects of the air pollutants seemed to be impoverishing the plant. Prevention of at least part of this loss seems to be a distinct possibility—if the conditions for application of effective antioxidants can be determined.

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RICE STRAW UTILIZATION BY LIVESTOCK

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Population pressures, plus the increased awareness of the need for environmental improvement, are limiting the use of burning as a method for disposing of all agricultural wastes, and rice straw is no exception. Producers are actively seeking alternate methods for disposal, or use, of the four tons of straw produced per acre on an average rice field in California. The summary reported here is from a detailed study of literature on the utilization of rice straw by livestock (available from local Farm Advisors as Agricultural Extension Service Publication MA–1). Further studies are in progress.

UNSUPPLEMENTED RICE STRAW is too low in digestible energy, crude protein, calcium and phosphorus to be used as the only source of nutrients for beef cows or growing cattle (see table for comparison with alfalfa hay). Rice straw is apparently also low in cobalt, copper, magnesium and sulfur, with the possibility of borderline deficiencies for these minerals. Additional analyses are needed, particularly for iron and zinc, to give a more complete picture for the nutritionally essential minerals.

Mixture

From data in the table it can be calculated that a mixture of approximately 60 per cent rice straw, 10 per cent cottonseed meal and 30 per cent barley would have the digestible energy and protein necessary for a beef cow nursing a calf, and for a growing beef steer to gain 1 to 1.5 lbs/day. In addition, .25 to .50 lb of trace mineral salt and .5 lb of limestone or oyster shell flour (cottonseed meal and barley will supply adequate phosphorus) per 100 lb of the mixture should be added to eliminate the possibility of mineral deficiencies. For dry pregnant cows, a mixture of 80 per cent rice straw, 4 per cent cottonseed meal and 16 per cent barley—along with the .25 to .5 lb of trace mineral salt and .2 lb of dicalcium phosphate or bonemeal per 100 lb of the ration—would meet nutrient requirements.

Using current prices it is estimated that rice straw has a value of about 35

MAJOR NUTRIENT VALUE COMPARISON OF TYPICAL RICE STRAW WITH AVERAGE ALFALFA HAY FOR REQUIREMENTS OF PREGNANT MATURE BEEF COWS OR GROWING STEER CALVES

	TYPICAL COMPOSITION		REQUIREMENTS	
	Rice straw	Alfalfa	Cows with calves	Growing steers
Digestible energy, mcal/kg.	1.9	2.5	2.5	2.5
Crude protein, %	4.5	17.0	9.2	10.0
Ether extract, %	1.5	2.0	—	—
Crude fiber, %	35.0	27 0	—	—
Lignin, %	4.5	6.5	—	—
Cellulose, %	34.0	24.0	—	—
Nitrogen-free extract, %	42.0	40.0	—	—
TDN	43.0	57.0	57.0	57.0
Ash, %	16.5	10.0	—	—
Silica, %	14.0	1.5	—	—
Ca, %	0.19	1.3	.28	.25
Co, mg/kg.	.05	.09	.07	.07
Cu, mg/kg.	5.0	14.0	4.0	4.0
K, %	1.2	1.5	.7	.7
Mg, %	.11	.33	.1	.1
Mn, mg/kg.	400	30	20	10
P, %	.10	.23	.22	.20
S, %	.10	.3	.1	.1