

**Final Report
For
ARB Agreement A1-132-33**

**THE EFFECTS OF AMBIENT AIR POLLUTION
ON THOMPSON SEEDLESS GRAPES**



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Sept. 15, 1983

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THOMPSON SEEDLESS GRAPES

Final Report on ARB Contract Al-132-33

"The Effects of Present and Potential Air Pollution
on Important San Joaquin Valley Crops: Grapes"

September 15, 1983

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ACKNOWLEDGEMENTS

The advice and assistance of the following individuals and their staff is gratefully acknowledged:

1. Fred Jensen, Extension Viticulture Specialist, University of California, Kearney Agricultural Center, Parlier.
2. John Sanders, Contract Officer, California Air Resources Board, Research Division.

DISCLAIMER STATEMENT

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Robert F. Brewer and Rulon Ashcroft

Introduction and Background

Thompson Seedless grapes (Vitis vinifera L. Thompson Seedless) is the most important single grape variety grown in California. With slight modifications in cultural practices it is grown for the fresh fruit market (table grapes), raisin production and for crushing to be fermented for wine or brandy production. Over 250,000 acres of Thompson Seedless worth in excess of \$200,000,000 are grown in the seven county area encompassing Fresno, Madera, Tulare, Stanislaus, San Joaquin, Merced and Kern Counties. An additional 30,000 acres of Thompsons are grown near Indio in the Coachella Valley of eastern Riverside County; an area experiencing increasing air pollution due to intrusion over the San Gorgonia Pass from the Los Angeles air basin.

Oxidant injury on vinifera grapes, usually characterized as "oxidant stipple", has been recognized since the mid 1950's as an air pollution problem on certain wine grape varieties growing in the Los Angeles basin (1). Providing pollution free, carbon filtered air to vines enclosed in plastic chambers or spraying periodically with an antioxidant reduced the visible leaf injury and increased yields of Zinfandel vines growing near Cucamonga (2) about forty miles east of the city of Los Angeles. In New York, Lambrusca type grapes growing east of Lake Erie were also found to be suffering from oxidant stipple, sometimes combined with sulfur dioxide injury (3,4,5) Attempts to quantify the effects of ambient pollutants under New York conditions on grapevine growth and fruit production using open top

chambers were frustrated mainly due to large within-treatment variations which clouded the results (4). Results of these tests did show significantly reduced leaf stipple, increased soluble solids and a four year mean increase in pruning weights as a result of providing carbon-filtered, pollution-free air.

In 1978 an experiment was initiated at the Kearney Agricultural Center near Parlier to answer a simple, but important, question:

- Are present levels of oxidant air pollution in the central San Joaquin Valley having a detrimental impact on the Thompson Seedless grape industry?

To accomplish this objective it was decided to provide enough grapevines with pollution-free air to determine differences exceeding 10 percent with a confidence level of .05 percent (19 to 1 odds). Statistical analysis of cane prunings and fruit production during the 1977 and 1978 production years indicated that four replications with three vines per replication should achieve the desired confidence level.

Eight large blower ventilated plastic covered open-top chambers (Figure 1) were constructed during the winter of 1978-79 and installed over the north row of a block of ten year old own-rooted Thompson Seedless vines previously used in a nutrition and weed control experiment. There should have been no carry over effects of the previous experiments because the row in question, adjacent to an open field, had been used as a guard row in previous experiments with no special fertilizer treatments. The adjacent middles had been clean cultivated, the usual means of weed control in most vineyards. The open space to the north provided room for the blowers and sampling equipment where they would not interfere with incident light on the chambers. The blowers were initially adjusted

GRAPE CHAMBERS
10' W x 24' L x 10' H

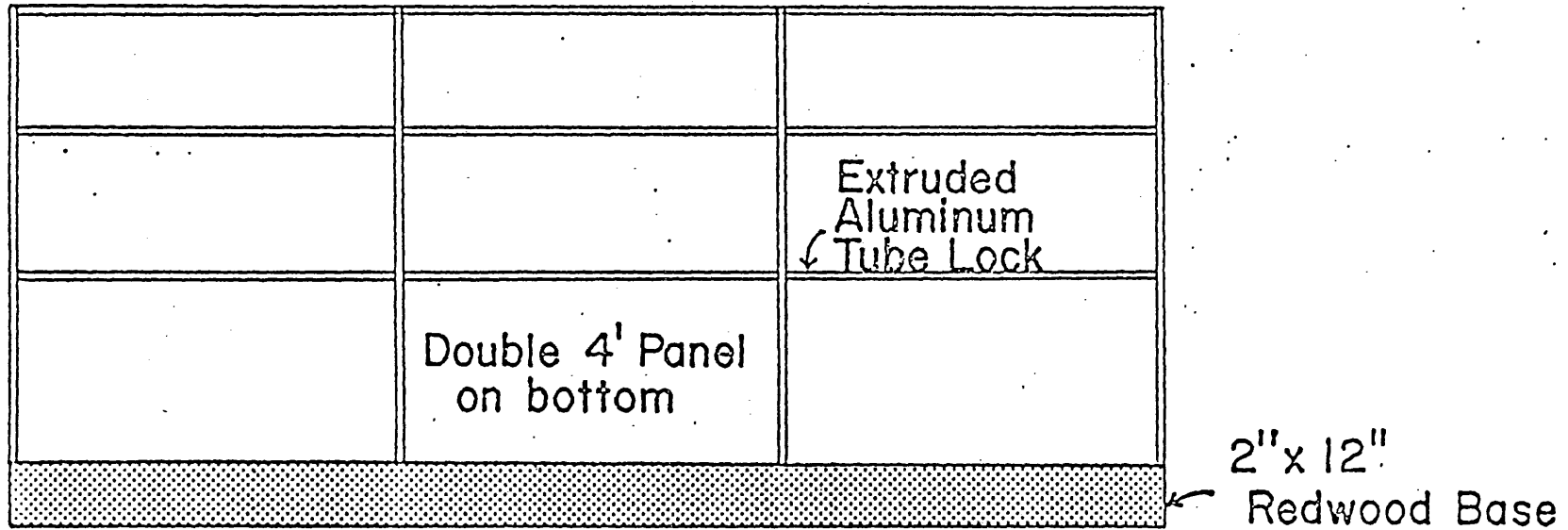
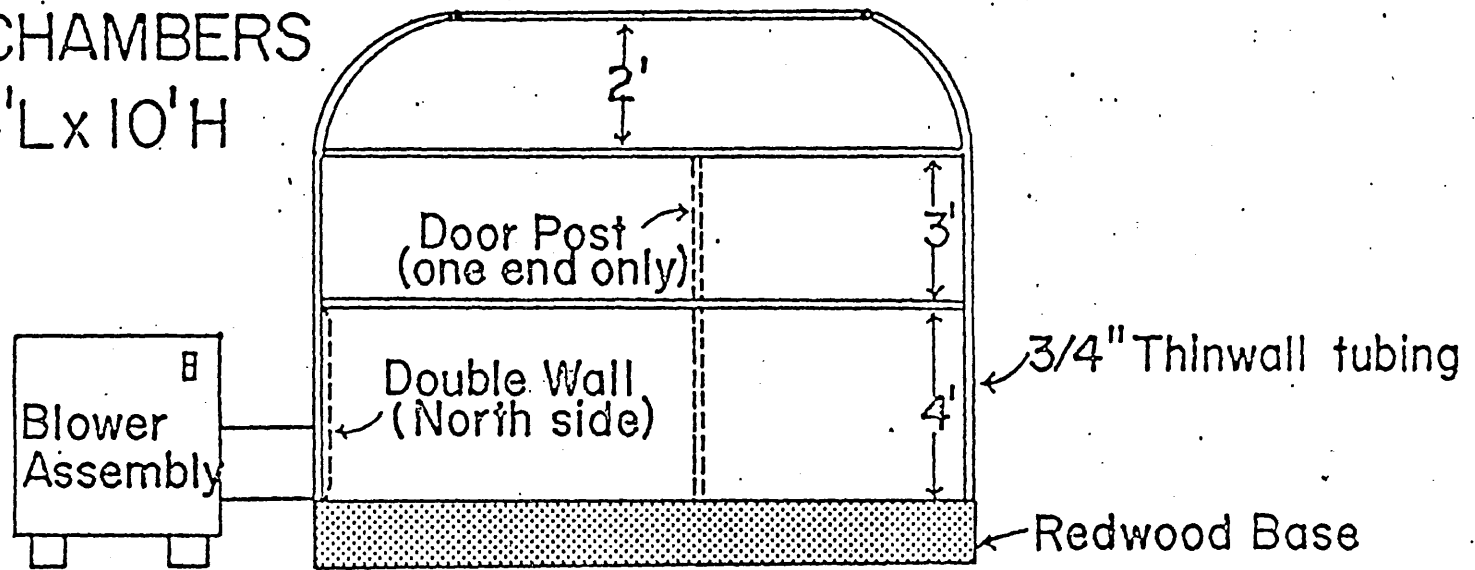


Figure 1. End and side views of open top plastic covered chambers built for pollution exclusion experiment with grapes.

to provide approximately 36,000 CFM of either carbon-filtered or ambient air, enough to change the air volume in the chambers 1.5 times per minute. In 1981, after the second season, larger motors were installed on the filtered units and the blower speeds increased to provide 4,500 CFM, or approximately two changes per minute. This was done to provide more ventilation and help prevent the reoccurrence of a severe mildew and bunch rot problem experienced during the cool and damp 1980 summer growing season. The air entered the chambers through a perforated double wall on the lower north side (see Figure 1).

Each of the chambers, which measured 10 feet wide by 24 feet long by 10 feet high, enclosed three vines trained on a three-wire trellis. Each vine was spring pruned to six canes, three in each direction, one cane per wire. (The row and therefore the trellis, ran in an east-west direction.) Since the vines were planted eight feet apart in the row there were four feet between the center of the end vines and the walls of the chambers.

Measurements of light, temperature and air movement in the chambers at various times during the growing season indicated only slight variations from outside or field conditions. Temperatures were slightly (1-2^oF) higher at mid-day and mid-night, light measurements were slightly lower in early morning and late afternoon and slightly higher, presumably due to reflection from the plastic walls, at mid-day (11 a.m. to 3 p.m.). Air movement was somewhat greater than outside during night and early morning hours, but less than outside from 11 a.m. to 6 or 7 p.m. Vine growth in the chambers was normal in all respects and, except for a slight (7 to 10 days) earlier bud break and bloom, paralleled the rest of the vineyard. The severe mildew and subsequent bunch rot problems encountered

in 1980 were the result of deliberate avoidance of what proved to be necessary twice weekly sulfur dustings. It was feared that so much sulfur might complicate the air pollution situation. We had not had problems with mildew in 1978 or 1979 when minimum applications of dusting sulfur were applied. In the 1981 and 1982 seasons three applications at monthly intervals of a new systemic mildewcide, Bayleton (TM) marketed by Mobay Corporation, effectively prevented any mildew infections. This material is new and widely used in commercial vineyards for mildew control, to a large extent replacing the dustings with sulfur which many growers previously applied at 7 to 10 day intervals starting in early May and continuing through late July or early August.

Weed control in and around the chambers was achieved by a combination of the use of a preemergence herbicide (Treflan (TM)) lightly rototilled into the soil in the spring followed by hand hoeing, when necessary, during the growing season. Irrigation water was applied using the original furrow system which passed under the ends of the redwood bases supporting the chamber walls. The experimental vines received irrigation water along with the rest of the neighboring vineyard. Insect control was accomplished by a post-bloom spraying with Kryocide (TM) or by applications of Dipel (TM) (*Bacillus Thuringiensis*) for leaf roller and leaf skeletonizer control. A single late winter spraying of dormant vines with sodium arsenite solution was made to control a fungus disease called "measles" which regularly occurred on several of the vines.

In all instances, cultural practices were kept as nearly the same as commercial operations within the limitations of the experiment.

The walls of the chambers were closed and the blowers started soon after bud break (around April 10). The units operated continuously until

October 20, approximately a month after picking, at which time the blowers were shut off and the chamber end panels removed to provide for natural ventilation.

A Dasibi ozone monitor working through a clock controlled solenoid valve system sequentially sampled O_3 in two of the filtered and two of the ambient chambers. Vines in the chambers equipped with carbon filters were exposed to approximately one-third as much air pollutants as those in the ambient air chambers. Most of the time ozone levels in the filtered chambers peaked at less than .05 ppm and at no time were levels measured in excess of .07 ppm. Blowers and air ducts on the ambient units removed about ten percent of the oxidants existing outside the chambers.

Temperatures of air entering the ambient and filtered units, as well as air temperatures within the vine canopy were measured periodically with copper-constantan thermocouples and recorded on the same strip chart used to record ozone concentrations. Actual temperatures were not as important as relative temperatures, since variations from one chamber to the other were caused by differences in chamber air exchange and therefore an indication of filter blockage, belt slippage (or breakage) or motor failure. Very few such problems occurred during the four seasons that the chambers were in operation over the grapevines.

Experimental Results

Response measurements made during this experiment with Thompson Seedless grapes included length and weight of prunings, weight of fruit produced per cane and vine, berry size, number of fruit bunches per cane and vine, soluble solids (sugar) and acid contents of representative

fruit samples at harvest. Soluble sugars were determined using a standard industry optical procedure (a temperature compensated refractometer). Total titratable acidity was determined on a sample of juice from 100 grapes using phenolphthalein indicator (6).

Vegetative Growth

Pruning weights of dormant canes removed from individual vines annually before and after the treatments were begun are listed in Appendix A. Statistical analysis of all these data indicated a significant response to the filtered air only in 1980 and 1983, due in large part to the highly variable outside vines. When the data for the chamber-enclosed vines are analyzed separately as in Table 1, statistical significant mean differences (.05) occur every year after the treatments were started, with highly significant differences (.01) every year except 1982. The vines receiving filtered air produced approximately 12 percent more cane wood than did those in chambers which received ambient air, and approximately 8.5 percent more than the outside vines. Cane production in a perennial crop such as grapes is especially important because it represents increased photosynthetic area, which, in turn, can provide increased carbohydrates for development of the crop and root system. Food reserves stored in the trunk and root system are particularly important in getting developing fruit and vegetative buds off to a good start in the spring and early summer when rapid growth is consuming more energy than is being accumulated by the new and developing foliage.

Fruit Production

Fruit production for individual vines for the years 1978 through

Table 1.

PRUNING WEIGHTS
1978-1983
Grape prunings - Kg/3 vines/chamber
Pruned and weighed in January-February each year
(weighing of year noted represents growth of previous season)

Treatment	1978 ^{1/}	1979 ^{1/}	1980	1981	1982	1983	Totals 1980-83	
							Per chamber	Per vine
Ambient #1	18.2	19.8	20.3	17.2	29.7	31.8	99.0	33.0
Ambient #3	14.3	15.2	18.2	16.4	28.3	27.8	90.7	30.2
Ambient #6	18.8	12.4	18.2	15.6	27.1	23.7	84.6	28.2
Ambient #8	16.0	14.2	19.7	17.2	27.0	24.7	88.6	29.5
Total 12 vines	67.3	61.6	76.4	66.4	112.1	108.0	362.9	120.9
Plot Mean	16.8	15.4	19.1	16.6	28.0	27.0	90.7	30.2
Filtered #2	17.8	16.2	20.4	19.8	28.9	36.6	105.7	35.2
Filtered #4	14.2	14.4	20.8	17.4	31.0	35.0	104.2	34.7
Filtered #5	15.0	14.8	21.0	17.2	29.4	32.2	99.9	33.3
Filtered #7	19.2	15.6	23.9	20.0	28.0	27.3	100.7	33.5
Total 12 vines	66.2	61.0	86.1	74.4	117.3	131.1	410.5	136.7
Plot Mean	16.6	15.3	21.5	18.6	29.3	32.8	102.7	34.2
Difference ($M_F - M_A$)	-0.2ns	-0.1ns	+2.4**	+2.0**	+1.3*	+5.8**	+11.9**	+4.0**
Standard Error of Means	.72	.74	.64	.55	.48	1.67	2.7	0.9
LSD ^{2/} .05	1.8	1.8	1.6	1.3	1.2	4.1	6.6	2.2
LSD .01	2.7	2.7	2.4	2.0	1.8	6.2	10.0	3.3

^{1/} Pretreatment data, filtration was started 4/79.

^{2/} Using T-test, 6 degrees of freedom where $t = \frac{D}{E_D} \geq 2.477$ for .05 and ≥ 3.707 for .01 level of probability.

Table 2.

Number of bunches and weight (kg) of fruit produced in filtered and ambient chambers 1978 to 1982. The 1980 crop was lost due to severe mildew attack. Each chamber enclosed three vines.

Chamber No.	Treatment	1978		1979		1981		1982		3 Year Total	
		Bunches	Weight	Bunches	Weight	Bunches	Weight	Bunches	Weight	Bunches	Weight
1	Ambient	102	63.50	165	103.00	109	41.74	115	69.43	399	214.17
3	Ambient	155	94.65	162	123.86	89	30.73 ^{1/}	136	76.14	381	230.73
6	Ambient	179	87.99	192	115.07	137	49.61	129	72.71	458	237.39
8	Ambient	180	85.47	172	91.54	116	44.77	103	48.06	391	184.37
Ambient Mean (M_A)		153	82.90	173	108.37	113	41.71	121	66.58	407	216.66
2	Filtered	127	79.27	161	104.54	132	45.49 ^{1/}	148	82.02	440	232.05
4	Filtered	167	84.76	184	118.87	138	65.91	157	89.57	479	274.24
5	Filtered	184	83.74	162	98.70	115	49.16	115	73.78	392	221.64
7	Filtered	162	87.85	195	113.18	160	73.65	123	75.94	478	262.72
Filtered Mean (M_F)		160	83.90	175	108.82	136	58.55	136	80.33	447	247.66
Difference ($M_F - M_A$)		+7.0	+1.00	+2.0	+0.45	+23*	+16.84*	+15	+13.75*	+40*	+31.00
% Difference		+3.75	+1.19	+1.14	+0.41	+16.91	+28.76	+11.03	+17.12	+8.94	+12.52
$S\bar{X}$ (Std. Error of mean)		10.2	3.2	5.0	3.9	7.7	4.8	6.4	4.2	14.5	9.8
LSD .05 ^{2/}		25.0	7.9	12.2	9.5	18.8	11.7	15.7	10.3	35.5	24.0
LSD .01 ^{3/}		37.8	12.0	18.5	14.4	28.5	17.8	23.7	15.6	53.7	36.3

^{1/} Represents total of 2 vines; one vine diseased (measles)

^{2/} Based on T-test value of 2.447 at 6 degrees of freedom

^{3/} Based on T-test value of 3.707 at 6 degrees of freedom

1982 with the exception of 1980 are tabulated in Appendix B. The 1980 crop was lost due to a severe mildew infection brought on by the cool, moist weather during summer months. Table 2 is a summary of the yields for individual chambers, each chamber enclosing 3 vines. The pretreatment data collected in 1978 is important because it indicates the variation to be expected within treatments and the fact that the means for those vines which were to later receive filtered air were very close to those for vines which continued to grow in ambient air. As was expected, based on similar studies by other workers (2,4), there was no measurable effect of the first year's (1979) air treatments on fruit set or production that year. This is not surprising because, barring a catastrophe such as a spring freeze or severe mildew or other pest attack, the current year's crop is primarily determined the previous season. Unfortunately, the second year's (1980) crop was lost due to a severe mildew infection which in turn led to cracking and subsequent fruit rot. In 1981, the third treatment year, bunch set was approximately 17% higher and fruit yields more than 28% higher in the filtered chambers. It should be noted that Thompson Seedless yields were generally low in 1981, averaging between 6 and 7 tons per acre, where the long term average is between 10 and 12 tons per acre. In 1982, the fourth treatment year, and a generally high yield year (14 to 17 tons per acre), bunch count was increased only 11% and yields approximately 17% by the removal of ambient pollutants. Since bunch count is the primary factor determining area-wide yields, it is significant that air pollution is more limiting in years of generally low yields than in years of high yield potential. One could speculate, on the basis of data presented here, that higher than usual air pollution during the growing season, particularly during July, August and September

when new canes and fruiting buds are being developed, probably is a significant factor in reducing potential yields the following season. A very significant finding is that fruit yields as indicated by total weight was reduced more than was the number of bunches, an indication of larger bunches associated with cleaner air. Ordinarily reducing the number of bunches per vine increases the size of individual bunches, and for this reason bunch thinning is a common viticultural practice among grape growers who produce Thompson Seedless grapes for the table grape market. A combination of less bunches and smaller bunches is a definite indication of reduced vigor and photosynthetic activity.

Fruit Quality

Grape production in terms of gross tons per acre (or kilograms per hectare) is important, but of almost equal importance is fruit quality as indicated by sugar and acid contents, and to a lesser degree berry size. Table 3 contains a summary of sugar (brix) and acid contents of fruit samples taken at harvest time in 1979, 1981 and 1982 and berry size measurements for 1981 and 1982. A three year mean is included. Although there was variation in both criteria from one year to another, mainly as a consequence of crop size, there were never any indication of a significant impact on either berry size or acid contents. In 1981, a light production year so far as Thompson Seedless were concerned, the grapes produced in filtered air contained approximately one percentage point more sugar than those grown in ambient air. A slightly smaller difference in 1979 was not statistically significant, but the difference between three year means was statistically significant at the .05 level. It is especially significant that the berry size and sugar contents were not reduced by

Table 3.

Fruit quality criteria (size, sugar and acid) for Thompson Seedless grapes grown in ambient (A) or filtered (F) atmospheres.

Chamber No.	Treatment	Mean Berry Weight (g)			Sugar %				Acid %			
		1981	1982	2 Yr. Mean	1979	1981	1982	3 Yr. Mean	1979	1981	1982	3 Yr. Mean
1	Ambient	1.98	2.00	1.99	22.2	20.8	18.9	20.6	.51	.41	.43	0.45
3	Ambient	1.82	1.91	1.86	21.4	21.8	21.1	21.6	.51	.42	.42	0.45
6	Ambient	1.85	1.70	1.77	20.1	20.9	20.4	20.5	.53	.40	.42	0.45
8	Ambient	1.66	1.69	1.67	21.9	20.8	20.5	21.1	.54	.42	.45	0.47
Ambient Mean (M_A)		1.83	1.82	1.82	21.4	21.1	20.2	20.9	.53	.41	.43	0.45
2	Filtered	2.03	1.96	1.99	22.7	22.3	19.5	21.5	.53	.40	.42	0.45
4	Filtered	1.91	2.01	1.96	22.7	21.4	20.4	21.8	.53	.40	.43	0.45
5	Filtered	1.83	1.90	1.86	22.1	21.7	20.6	21.5	.52	.43	.43	0.46
7	Filtered	1.82	1.86	1.84	21.2	21.6	21.8	21.5	.51	.40	.45	0.45
Filtered Mean (M_F)		1.90	1.93	1.91	22.2	22.0	20.6	21.6	.52	.41	.43	0.45
Difference ($M_F - M_A$)		0.07	0.11	.09	0.80	0.90*	0.40	0.70*	-.01	.00	.00	0.00
Standard Error Between Means		.06	.10	.08	0.65	0.33	0.66	0.27	.01	.01	.01	.01
LSD .05 (n=6)		0.15	.24	.19	1.59	0.81	1.61	0.66	.02	.02	.02	.02
LSD .01 (n=6)		0.22	.37	.30	2.41	1.22	4.37	1.00	.04	.03	.03	.04

the increased bunch count associated with air pollution removal. Bunch and berry size as well as sugar content are usually inversely proportional to the number of bunches, other factors being equal. Fruit quality in the outside vines was similar to fruit quality in the ambient chamber vines, except there was more variability and the sugars were somewhat lower, probably as a result of the later start by the outside vines.

Summary and Conclusions

The results of this four year study with Thompson Seedless grapes indicates that air pollution in the Central San Joaquin Valley is having a significant negative impact on yields and to a lesser degree on quality of this important grape variety. Yield responses after the first season resulting from pollution removal ranged from a low of approximately seventeen percent in a high yield year (1982) to over twenty-eight percent in a low yield year (1981). No differences were found the first year after treatment was begun which confirms previous findings that the grape crop potential for any given season is mostly determined the previous season. The primary responses were less prunings (wood weight), less bunches per cane or vine, smaller bunches (less weight per bunch) and reduced sugar content on vines grown in ambient air as compared with vines grown in filtered air.

In general the responses measured in this experiment correlate closely with previous results with another important valley crop Acala SJ-2 cotton. In both cases it is a reduction in fruit set which is responsible for approximately twenty percent reduction in yields. At the present time we have no basis on which as can correlate grape yield reduction with ambient pollution levels other than those which existed

at the experimental site some twenty miles southeast of Fresno. This information as well as the effects of other pollutants such as sulfur dioxide (SO₂) will have to be developed at a later date using expanded and more sophisticated facilities.

The potential for similar response by other grape varieties grown in the San Joaquin Valley to existing pollution can only be speculated upon at the present time. Thompson Seedless is a moderately vigorous variety, with many more vigorous and a substantial number of less vigorous varieties currently being grown. Comparable or even more significant impact can be expected on many important varieties including Petite Sirah, Barbera, and Carignane. There is no reason to believe that Thompson Seedless is more sensitive, or more tolerant than most of the thirteen other table grape varieties or the forty or more wine grape varieties commonly grown in the area. It would seem reasonable, therefore to expect a mean negative impact of approximately twenty percent on yields on the crop as a whole on the east side of the San Joaquin Valley where monitoring stations indicate air pollution levels are very similar.

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Appendix A. Pruning weights (kg/vine) of canes removed in January of 1978 through January 1983.

Vine No.	Chamber Number	Air Treatment	1978*	1979*	1980	1981	1982	1983	Total 1980-83
1			5.68	7.21	7.14	6.53	9.50	13.37	36.54
2	1	Ambient	7.08	6.24	6.13	6.52	10.03	10.83	33.51
3			5.44	6.40	7.00	4.15	10.13	7.64	28.92
5**	Outside	Ambient	5.14	3.18	6.40	5.02	5.94	8.11	25.47
6			6.57	4.54	6.70	6.66	10.97	12.00	36.33
7	2	Filtered	6.23	5.59	9.31	6.53	9.84	12.81	38.49
8			5.03	6.02	4.43	6.59	8.08	11.79	30.89
9	Outside	Ambient	5.77	5.90	8.79	5.29	7.19	8.99	30.26
10			4.69	4.77	5.91	4.85	8.62	8.65	28.03
11	3	Ambient	4.27	5.11	5.79	5.74	9.41	8.57	29.51
12			5.24	5.34	6.47	5.80	10.32	10.59	33.18
13	Outside	Ambient	7.32	7.15	6.10	6.00	9.74	9.41	31.25
14			4.35	3.41	6.36	5.25	8.99	9.80	30.40
15	4	Filtered	5.12	5.90	8.28	7.48	12.09	13.30	41.15
16			4.70	5.10	6.13	4.70	9.92	11.91	32.66
17			5.45	4.42	6.29	5.26	9.40	8.54	29.49
18			6.46	3.97	7.08	6.04	8.14	11.90	33.16
19	Outside	Ambient	4.97	4.65	7.65	4.62	10.81	10.21	33.29
20			5.24	4.54	7.76	5.84	10.36	8.67	32.63
21			4.20	4.66	7.26	5.13	9.15	9.67	31.21
22	5	Filtered	4.74	5.57	7.38	4.80	8.85	10.64	31.67
23			6.11	4.53	6.36	7.28	11.51	11.92	37.07
24	Outside	Ambient	5.60	4.76	6.58	5.16	11.49	7.94	31.17
25			5.49	3.52	5.70	4.70	9.95	7.35	27.70
26	6	Ambient	6.59	4.54	5.83	4.74	8.71	8.21	27.49
27			6.76	4.31	6.69	6.14	8.43	8.16	29.42
28	Outside	Ambient	5.45	4.08	5.22	4.12	11.38	6.40	27.12
29			6.69	6.01	4.99	4.48	10.89	10.02	30.38
30	7	Filtered	5.16	3.97	9.65	8.81	9.71	7.09	35.26
31			7.30	5.67	9.30	6.76	8.83	10.18	35.07
32	Outside	Ambient	4.90	4.42	6.94	6.81	10.02	8.14	31.91
33			5.82	5.79	6.38	5.08	8.81	9.66	29.93
34	8	Ambient	4.82	3.63	7.14	5.46	9.81	7.17	29.58
35			5.35	4.76	6.17	6.62	8.40	7.91	29.10
36	Outside	Ambient	7.29	6.36	8.28	8.42	11.55	12.74	40.99

Means

Filtered Chambers	5.52	5.08	7.17a	6.20	9.76	10.93a	34.22a
Ambient Chambers	5.61	5.13	6.38b	5.53	9.33	9.00b	30.24b
Outside Vines	5.78	4.85	7.01a	5.70	9.60	9.18b	31.52b

Statistical Analysis

S \bar{X} Standard Error of Mean	0.26	0.30	0.34	0.33	0.40	0.51	0.94
LSD at .05 level, 11 d.F.	0.57	0.66	0.75	0.73	0.88	1.12	2.07
LSD at .01 level, 11 d.F.	0.81	0.93	1.05	1.02	1.24	1.58	2.92

Means not sharing the same subscript are significantly different at .05 or less.

*. Pretreatment data. ** Vine 4 not included, not Thompson Seedless.

Appendix B. Weights (kg) of grapes produced in Thompson Seedless Grapes grown in ambient or filtered air - 1978-1982.

Vine No.	Air Treatment	1978		1979		1981		1982		3 Year Σ	
		Bu	Wt ^{1/}	Bu	Wt	Bu	Wt	Bu	Wt	Bunches	Weight (kg)
1		41	25.32	38	20.72	50	17.61	43	27.07	131	65.40
2	1A ^{2/}	32	21.60	68	41.06	33	13.07	35	17.18	136	71.31
3		29	16.58	59	41.22	26	11.06	37	25.18	132	77.46
5**	OSA ^{2/}	44	25.12	47	20.67	28	18.00	41	33.11	116	71.78
6		68	41.31	46	32.18	51	20.58	55	30.41	151	83.17
7	2F ^{2/}	30	15.65	61	39.61	61	24.91	43	20.49	165	85.01
8		29	22.31	54	32.75	20	4.16	50	31.12	124	63.87*
9	OSA	51	30.67	46	22.37	33	14.97	33	26.80	112	64.14
10		51	27.89	61	43.83	32	13.55	51	26.02	144	83.40
11	3A	61	36.09	57	43.70	38	17.18	41	21.94	130	82.82
12		43	30.67	44	36.33	19	5.60	44	28.18	107	64.51*
13	OSA	49	25.51	52	34.02	17	10.26	33	23.98	102	68.26
14		63	40.85	65	42.56	44	22.96	63	31.69	172	97.20
15	4F	52	23.95	60	42.36	35	16.08	53	29.99	148	88.43
16		52	19.96	59	33.95	59	26.87	41	27.89	159	88.61
17		49	26.87	46	29.65	27	11.34	36	24.38	109	65.37
18		62	26.65	69	45.28	45	19.60	53	29.51	167	94.39
19	OSA	73	35.04	66	42.66	36	15.50	43	19.94	145	78.10
20		54	26.96	59	30.14	29	13.26	41	20.38	129	63.78
21		67	24.69	57	39.35	43	17.24	39	28.72	139	85.31
22	5F	62	30.45	49	29.65	25	10.54	38	20.22	112	60.41
23		55	28.69	56	29.70	47	21.38	38	24.84	141	75.92
24	OSA	48	28.21	66	35.21	27	15.31	37	36.00	130	86.32
25		59	26.11	65	38.19	43	14.68	52	25.60	160	78.47
26	6A	62	34.64	66	35.04	56	23.19	54	34.61	176	92.84
27		58	27.24	61	41.84	38	11.74	23	12.50	122	66.08
28	OSA	64	32.15	47	22.35	23	9.30	43	35.70	113	67.35
29		59	34.16	67	39.07	46	21.77	49	30.50	162	91.34
30	7F	68	35.35	69	43.38	51	23.24	40	25.54	160	92.11
31		35	18.34	59	30.73	63	28.64	34	19.90	156	79.27
32	OSA	71	31.49	52	27.95	25	10.12	34	23.70	111	61.77
33		77	29.54	53	29.31	62	23.05	44	24.12	159	76.48
34	8A	62	36.51	62	30.65	32	14.62	33	10.66	127	55.93
35		41	19.42	57	31.58	22	7.10	26	13.28	105	51.96
36	OSA	67	28.38	66	33.76	28	10.99	46	29.54	140	74.59

Means

Filtered	53.3	29.79	58.5	36.27	45.4a	19.86a	45.2a	26.77a	149.1a	82.55a
Ambient	51.3	27.63	57.6	36.12	37.6b	14.37b	40.2b	22.19b	135.8b	72.22b
Outside	57.4	28.82	56.0	31.27	28.9b	13.51b	40.0b	27.54a	124.9b	72.32b

Means not sharing the same subscript are significantly different at .05 percent level.

^{1/} Bu = Bunches; Wt = Weight. ^{2/} A = Ambient Air; OSA = Outside Ambient Air;

F = Filtered Air Chamber. ^{3/} Diseased bunches. * Only two years average.

** Vine number 4 is not included because it was not Thompson Seedless.