Final Report For:

ARB Agreement A7-119-30

THE EFFECTS OF PRESENT AND POTENTIAL AIR POLLUTION ON SAN JOAQUIN VALLEY COTTON

Dr. Robert F. Brewer
Associate Horticulturist
San Joaquin Valley Agricultural
Research and Extension Center
University of California
Parlier, CA 93648

June 15, 1979

ABSTRACT

A study designed to assess the affects of existing and potential levels of oxidant air pollution on cotton growing in the Central San Joaquin Valley was conducted near Parlier, California in 1978. Acala SJ-2 and Acala SJ-5 varieties of cotton were grown in open top plastic covered chambers supplied with varying concentrations of ozone achieved by either filtering existing ozone from the ambient air or adding electrically generated ozone to ambient air. Four air treatments were used in the chambers: ambient or non-filtered air, filtered air passed through activated carbon filters, a mixture of two-thirds ambient and one-third filtered air, and ozone-enriched ambient air with the ozone level raised to approximately twice the ambient level whenever the ambient level exceeded .05 ppm.

Approximately ten days after the enhanced ozone treatment was begun, ozone toxicity symptoms were observed on both SJ-2 and SJ-5 cotton foliage. Similar but less severe symptoms were observed on SJ-2 plants in the ambient treatment three weeks later. Similar symptoms did not appear on SJ-5 until the last week in October, nearly two months later, than on SJ-2.

The primary response by cotton to increased ozone levels was a reduction in the number of bolls set per plant. Boll set by SJ-2 plants was 12% less in ambient than in filtered air. Where ambient ozone levels were doubled, boll set reduction approached 17% for both SJ-2 and SJ-5. There was no significant difference in SJ-5 boll set between the filtered and ambient treatments.

Production of raw cotton fiber and seed by SJ-2 varied inversely with ozone dose, ranging from a 34% reduction resulting from doubling ambient ozone levels, to 8% from exposure to two-thirds ambient ozone levels. Ambient ozone reduced SJ-2 yields 14%. Raw cotton production by SJ-5 at ambient and two-thirds ambient ozone levels were essentially the same as in filtered air; however, doubling the ambient ozone concentration reduced SJ-5 raw cotton production 25%. Lint quality was also reduced by exposure to ozone.

These experiments indicate that Acala SJ-2, which accounts for approximately 70% of the San Joaquin Valley's cotton crop, is now being seriously damaged by ozone levels prevailing on the east side of the valley, and should present ozone levels increase significantly, SJ-5, apparently not damaged by present levels, would also be damaged.

Table of Contents

List of Figures

List of Tables

Acknowledgements

The advice and assistance of the following people and organizations is gratefully acknowledged:

1. Dr. H. B. Cooper, U.S.D.A. Cotton Research Station, Shafter, California.
2. Dr. Beth Teviotdale, Extension Plant Pathologist, San Joaquin Valley Research and Extension Center, Parlier, California.
3. Fred Jensen, Extension Viticulturist, San Joaquin Valley Research and Extension Center, Parlier, California.
4. Robert Reynolds and Barbara Jost, Contract Officers, California Air Resources Board Research Division, Sacramento, California.

Disclaimer Statement

CONCLUSIONS

Results of various air pollutant treatments on SJ-2 and SJ-5 cotton varieties led to the following conclusions:

1. The two varieties of cotton tested, Acala SJ-2 and Acala SJ-5, respond quite differently to oxidant-type air pollutants, both in terms of symptom expression and fruiting response. Foliage on the SJ-2 variety exhibited toxicity symptoms earlier and were more chlorotic at maturity than were comparable SJ-5 foliage. Variety SJ-2 produced less bolls and, therefore, less raw cotton when exposed to ambient or 2/3 ambient levels of oxidant. SJ-5 yields on the other hand, were not reduced by ambient levels of oxidant, but were very significantly reduced by the 2X ambient levels of oxidant. This indicates that even though SJ-5 appears to tolerate the levels of oxidant pollution present in the valley in 1978 significant deterioration of air quality leading to higher oxidant levels or longer duration of present levels could be expected to have a detrimental effect on this variety too. Comparison of 1978 air analysis data with comparable data from 1975, 1976 and 1977 indicate no significant difference.
2. Variety SJ-2, which accounts for 2/3 of the cotton planted in the valley, is currently suffering significant crop reduction due to air pollution. Cotton in the ambient chamber produced 13% less bolls, 15% less lint and 13.5% less seed than was produced by comparable plants in the filtered chambers at Parlier. It should be remembered that 10 to 15% of the ambient ozone is removed by the air handling equipment in the ambient chambers so actual damage at this location was probably somewhat greater than indicated.
3. In addition to the significant reduction in yields of SJ-2 associated with ambient or higher levels of oxidants, there is also an indication of potential reduction in quality of the cotton fiber produced. Cotton fibers of both varieties grown in the filtered chambers were more elastic than those coming from the partially or non-filtered chambers. The data also indicated that doubling existing ambient levels of oxidant would result in very significant deterioration of quality with lint to seed ratio, fiber length, and uniformity effected.

4. The response curve (Figures 5 and 6) for Acala SJ-2 within the ozone dose range used in essentially a straight line with a decline of approximately 5% per 1000 pphm hours of ozone using the .05 ppm threshold for computing dose. If a threshold of .005 ppm is used, the curve approximates a straight line function between 0 and 14,000 pphm hours with a decline in production of approximately 1% per 1000 pphm hours. The SJ-5 variety did not respond to ambient levels of ozone so the shape of the response curve between ambient and twice ambient ozone levels cannot be determined from the data available.
5. Yellowing, bronzing, abscission of lower leaves and interveinal chlorosis considered by many to be "normal" for cotton growing on the east side of the valley are all expressions of oxidant injury. Such symptoms were almost nonexistent on cotton plants growing in the filtered chambers.
6. Although the 1978 cotton growing season was a poor one in the San Joaquin Valley with yields typically 30 to 40 percent below normal due to late spring rains and low temperatures, cotton growth and production in the enclosed plots was normal in all respects. By comparison cotton plants in the outside ambient or control plots were abnormally vegetative due to the aforementioned unfavorable growing conditions. Excessively vegetative cotton does not bloom or set bolls when it should. Comparisons should be made, therefore, only between chambered treatments when assessing the effects of the several oxidant levels. Because cotton growth, flowering and boll set in the chamber - covered plots were comparable to those under field conditions in normal growing seasons results of these tests should be a valid indication of responses to be expected under field conditions most years in the San Joaquin Valley.

INTRODUCTION

Cotton is usually the leading money crop in the San Joaquin Valley with an annual return to the valley's growers of over six hundred million dollars and a cash value after ginning and processing of over one billion dollars.* The only other crops of comparable value are Thompson seedless grapes and alfalfa hay. A map of California cotton acreage is reproduced in Appendix A.

Cotton has generally been considered among the more tolerant crops so far as phototchemical air pollution is concerned, primarily because it does not exhibit symptoms of ozone injury so commonly found on other broad-leafed crops such as beans or lettuce. Taylor and Merserau (1963) and Ting and Dugger (1968), investigated the effects of ozone on cotton and identified symptoms associated with repeated exposure and factors influencing ozone sensitivity. Attempts by V. T. Walhood (1977) to demonstrate a measureable effect of air pollutants on cotton growth at Shafter using filtered and non-filtered chambers in 1967 and 1968 were unsuccessful owing to problems with cabbage loopers in 1967 and relatively low ozone concentrations in both 1967 and 1968.

Brewer and Ferry (1974), using filtered and non-filtered plastic greenhouse chambers placed over existing commercial stands of cotton at various valley locations, demonstrated that cotton production was reduced significantly by ambient levels of ozone at several valley locations. Maximum deduction (30% with SJ-1) was measured at Parlier, but similar reductions were found near Hanford in Kings County, near Porterville in Tulare County, and near Arvin and Mettler in Kern County. Initial comparisons of SJ-1 with SJ-2 and later comparisons of SJ-2 with SJ-2 and SJ-4 indicated increasing ozone resistance in each succeeding selection (Brewer, 1979). Heggestad (1977) has found that even SJ-1 has more ozone tolerance than eastern or midwestern varieties tested at Beltsville. This is undoubtedly due to the fact that development and selection of the California varieties has been done largely at Shafter and near Porterville so that considerable selection pressure has been exerted for ozone tolerance.

---

* In 1978, cotton lint and seed production for California totaled approximately $690,453,000; in 1976, cotton production totaled $920,821,000; and in 1977 production totaled $833,552,000.

The California Acala variety selection SJ-2, which the previously mentioned comparisons indicated is somewhat more tolerant to ozone than SJ-1 but less tolerant than SJ-3, SJ-4, or SJ-5, is still the principal variety planted in the valley accounting for between two-thirds and three-fourths of the total acreage in 1977 and 1978.* The newer variety SJ-5 accounted for 10% of San Joaquin Valley cotton acreage in 1978 and 23% of the acreage in 1979.

The second most important crop in the San Joaquin Valley is grapes with the Thompson Seedless variety accounting for two-thirds of the grape acreage. Part of this project was devoted to determining the between-vine variation so that a future air pollution study with Thompson Seedless grapes would have a sound statistical background. The preliminary work with grapes is summarized in Appendix C.

Objectives

The objectives of this project were:

1. To determine whether the two principal varieties of cotton, SJ-2 and SJ-5 are being damaged by existing levels of oxidant-type air pollution in the San Joaquin Valley.
2. To determine several points on the ozone dose-plant response curve for currently grown varieties of cotton so that the economic impact of changes in ambient ozone levels, for the better or worse, can be predicted.
3. To establish a statistical baseline for Thompson seedless grapes to be used in a future air pollution experiment.

MATERIALS AND METHODS

To accomplish the above objectives, two varieties of cotton were grown under five different air pollutant regimes at the Kearney Horticultural Field Station located near Parlier, California, about 15 miles southeast of Fresno. Activated carbon filters were used to remove oxidants from air where lower than ambient levels were desired and electrically generated ozone was used to raise oxidant levels above ambient levels. Specially designed open-top plastic growth chambers were used to contain the desired ozone levels and maintain uniform growing conditions that closely approximated field conditions.

---

* Tom Cherry, Secretary, California Planting Cotton Seed Distributors, 2816 K Street, Bakersfield, California.

Air Treatments

The five different treatments, each replicated three times, used in these experiments were:

1. Ambient - Outside Plot
2. Ambient Air - Growth Chamber
3. Carbon Filtered Air - Growth Chamber
4. Two-thirds Ambient, One-third Filtered Air - Growth Chamber
5. Twice Ambient Ozone - Growth Chamber

All of the chamber test plots (Figure 1) were 12 feet square with three double rows of cotton running north and south parallel with the air ducts. The outside ambient plots were 16 feet by 18 feet (twice the square footage of the chamber plots) and consisted of four double rows of cotton. Each double row consisted of one row of SJ-2 and one row of SJ-5. The various treatments were distributed among the plots as shown in Figure 1.

Plot Preparation

Twelve of the plots used in 1978 with cotton were planted to sugar beets in 1977. The additional three were established to the south of the original 12 using materials left over from preparation of the original plots a year previous. This involved removing all of the original soil to a depth of 12 inches from an area 14 feet by 14 feet (or 18 feet by 20 feet in the case of outside plots) for each plot; combining this original soil in a large pile, then mixing the composite 50/50 with a Grangeville loam for refilling the excavated plots. Two cubic feet of lime neutralized sphagnum peat and six cubuc feet of steer manure were blended into each 12' x 12' plot to improve tilth and fertility. The outside plots, which had twice the square footage, received twice the amount of peat and manure. The resulting blend provided an excellent medium for plant growth, was uniform to the excavated depth from plot to plot and did not suffer from the several shortcomings of the original Kearney Field Station soil, namely poor moisture retention and impeded surface water penetration. Soil samples were taken prior to planting, during the course of the experiment and after the cotton had been harvested. Results of analyses of these samples are shown in Table 1 (Appendix B).

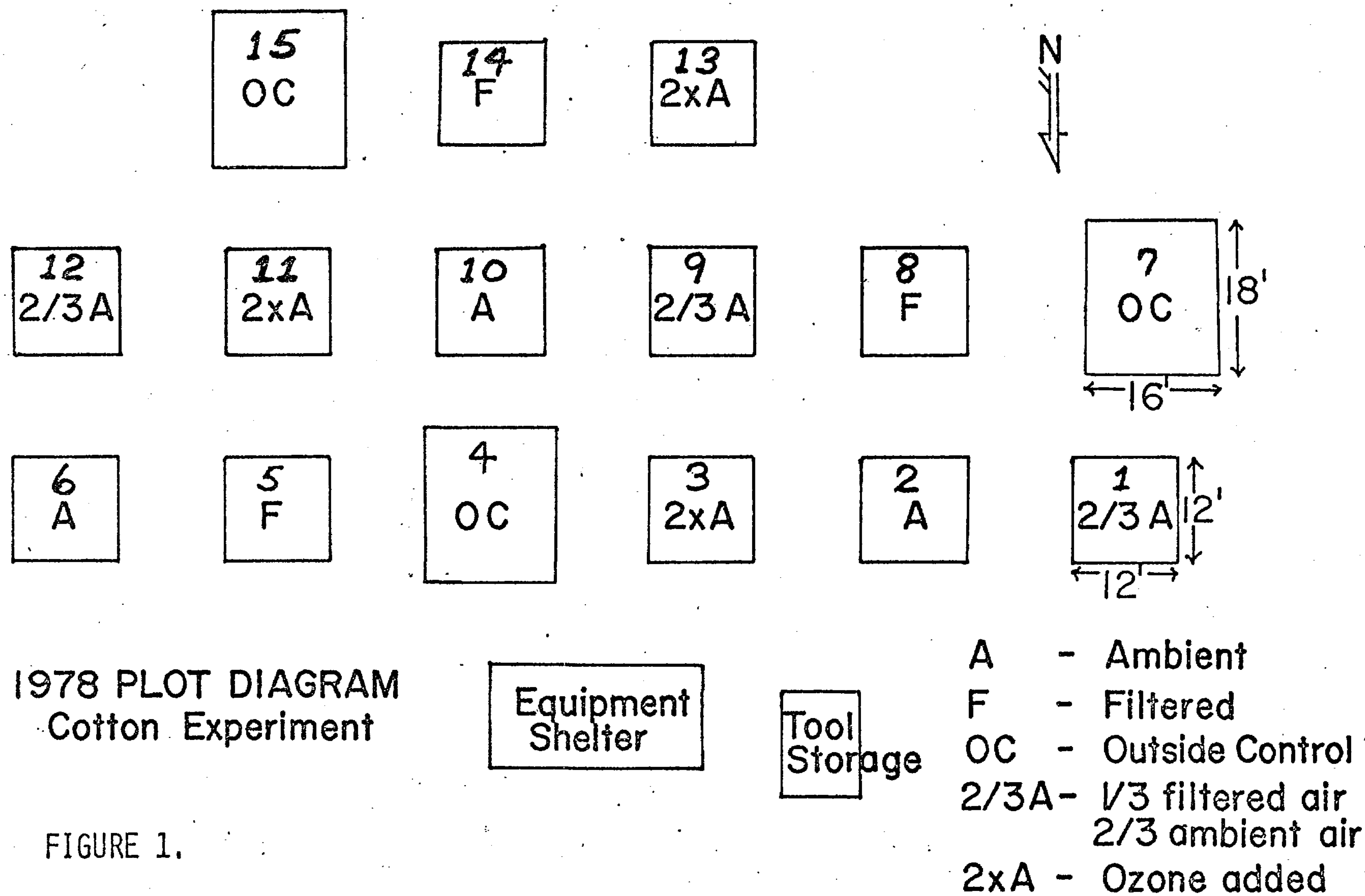

15
OC
14
F
13
2xA
N
12
2/3A
11
2xA
10
A
9
2/3 A
8
F
7
OC
18'
16'
6
A
5
F
4
OC
3
2xA
2
A
1
2/3 A
12'
12'
1978 PLOT DIAGRAM
Cotton Experiment
Equipment Shelter
Tool Storage
A - Ambient
F - Filtered
OC - Outside Control
2/3A - 1/3 filtered air 2/3 ambient air
2xA - Ozone added

FIGURE 1.

Chamber Design

The open top plastic covered growth chambers used in this study with cotton in 1978 were essentially the same as those tested on sugar beets in 1977 (Brewer, 1978). These chambers (see Figure 2) taper from a 12 foot square base to a ten foot circular open top, eight feet above the soil surface. Motor driven blowers delivered approximately 1600 CFM of air through perforated six and eight inch PVC pipe lying on the soil surface between the raised double row beds. Slots in the eight inch PVC pipe were modified (made crosswise rather than lengthwise) in 1978 to provide more uniform air distribution across the beds while at the same time flushing out the chambers with fresh air twice per minute. This is essential to resist intrusion of outside air through the top and prevent excess temperature and humidity building in the chambers.

Each of the blowers providing filtered air were equipped with three 24" x 24" x 8" filterfold filter units each containing 75 pounds of activated carbon granules. Coarse and fine fiberglass filter pads located in front of the carbon filters were used to prevent dust from plugging the carbon filters. Blowers supplying air for the "two-thirds ambient" treatment had only one carbon filter and were equipped with an adjustable slot which was used to force one-third of the air entering the unit through the carbon filter. Ambient treatment blowers had only a coarse metal screen ahead of the blower. Commercial Dwyer inclined-tube manometers were used to monitor blower and filter performance. Blower speed was adjusted with variable pitch pulleys to insure that ambient blowers without filters provided no more air than the filtered units.

Side wall panels on the open top chambers were glazed with 8 mil. clear calendered vinyl obtained from Hartwig-Hartoglass Corporation in Woodstock, Illinois. Absorbance measurements made on several available clear plastics in 1977 (see A6-161-30 Final Report) indicated that the vinyl was superior to the other clear plastics tested in light transmission over the 4 to 7 micron spectrum. One serious disadvantage of plastic glazing materials, static charge which attracts and holds dust, was overcome by daily rinsing and weekly scrubbing with a brush and mild detergent.

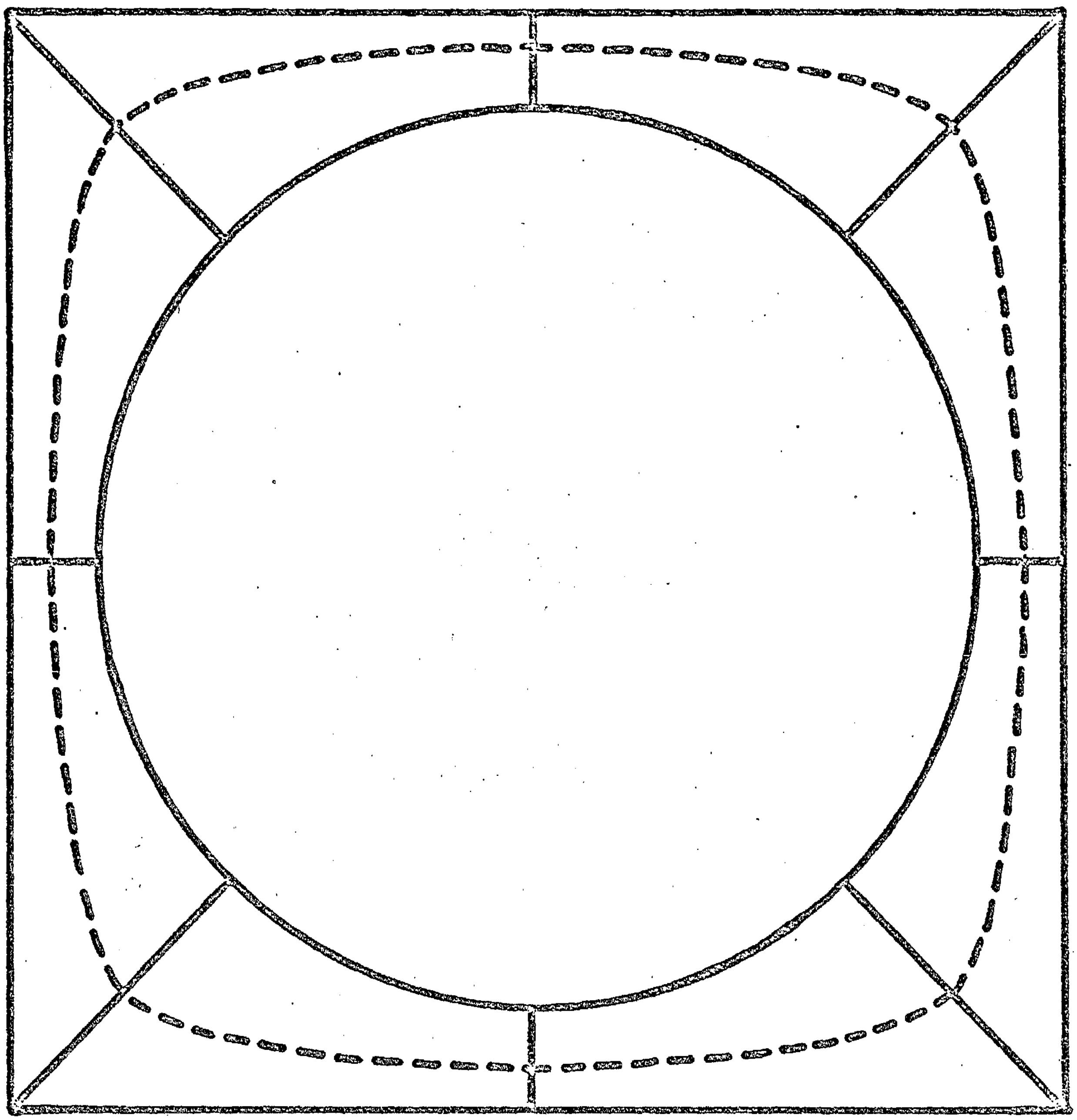


Figure 2. Overhead view of open top growth chamber showing 12' square base and 10' circular open top.

Instrumentation

Ozone

Four Dasibi ozone monitors were used to monitor ozone concentrations at plant height in each of the growth chambers as well as in the middle of one of the outside plots. Each machine was assigned to a specific treatment (ambient, filtered 2/3 ambient, or 2X ambient ozone) and an electrically switched series of solenoid valves sequentially sampled for two minute intervals each of the chambers receiving a particular air treatment. Outputs from the four Dasibi monitors were logged on a multipoint potentiometric recorder. Analog chart records so produced were read point by point weekly and the ozone exposure dose calculated.

All of the Dasibi instruments used in this study were calibrated once during the season by ARB staff personnel and our ozone data were compared with that obtained by the Fresno APCD monitoring station less than a half mile to the east.

Air Temperature

Air temperatures in plots receiving the four different treatments were monitored on a continuous basis using copper-constantin thermocouples for sensing and a 24 point Esterline Angus type T potentiometric recorder to log the data. Air temperatures in the incoming air duct and at plant canopy level (about 30 inches above ground surface) were monitored throughout the growing season. A perforated styrofoam cup was used to shield the plant canopy thermocouples from direct radiation effects.

In addition to the thermocouple sensors, several revolving drum hygrothermographs were placed within the plant canopy in chambers receiving different treatments to record temperature and humidity conditions. Relative humidity within the plant canopy was also determined periodically with a solid state electronic humidity sensor (Weather Measure HMS-14). This device was also used to calibrate the stranded hair type hygrograph sections of the hygrothermographs.

Soil Moisture

Porous ceramic tipped soil moisture tensiometers manufactured by Irrometer Company, Riverside, California were used to measure soil moisture stress at 12 inch and 24 inch depths in all of the experimental plots. Irrigation frequency and duration was based upon the moisture tensions indicated by these tensiometers. After the initial post-planting irrigation, irrigation was begun when the upper instrument indicated tensions in excess of 75 centibars and was continued until the lower instrument indicated water had penetrated to the 24 inch depth. When the tensiometers indicated differences in moisture tensions between the various plots, supplemental water was applied to the drier plots to correct the differences.

Plant Moisture Tension

Soil moisture tensions as determined by soil tensiometers is an important factor in plant growth, but under some conditions (salinity, high temperatures, low humidity) may be poorly related to actual moisture tension in the leaves and other plant tissues. Direct estimates of leaf moisture tension using a pressure chamber technique have been found by Jordan (1970) and Grimes (1978) to be extremely effective in early season water management of cotton. Timing of the initial irrigation of cotton after planting is extremely important in determining the growing and fruiting performance. If irrigation water is supplied too early, vegetative growth will be encouraged at the expense of fruiting, but withholding supplemental moisture too long reduces both vegetative growth and fruiting. Grimes et. al. (1978) has determined that for soils of the type used in this experiment, the first irrigation should not be applied until the plant water stress reaches 15 $\pm$ 2 bars. A PMS pressurized cylinder was used in these studies to measure leaf moisture potential and determine timing of first irrigation. In this procedure a section of leaf and stem are sealed in a high pressure cylinder with just the tip of the stem protruding. Nitrogen or air under pressure is introduced by a precision valve until sap just begins to flow from the cut stem. The pressure measured in atmospheres or bars shown on the pressure gauge at this instant is equal of the moisture stress.

Light Intensity

Light intensities at various locations within the chambers and at different times of the day were measured with a Lambda quantum sensor* which measures primarily photosynthetically active radiation (PAR). Light measurements were made several times during the growing season to check on the uniformity of the various chambers and on the transparency of the PVC plastic. No differences between chambers were found, nor was deterioration of the plastic found to influence light intensities.

Air Movement

Air movement within the chambers was measured periodically using a Weather Measure W-141 hot wire anemometer. Measurements were made at various heights and distances from the openings in the PVC air ducts. To improve air distribution across the plots, the long axis of the oblong holes in the center two ducts were changed from parallel to crosswise the length of the pipe. Air movement within the parially enclosed chambers was quite comparable to that in the outside plots, thereby indicating that the flux of pollutants through the plant canopy was also comparable to outside or field conditions.

Cultural Practices and Growing Conditions

The cotton seeds were planted in 42 inch raised beds with two rows per bed and three beds per chamber (Figure 3). The east row in each bed was planted to SJ-2, the west row to SJ-5. All plots were seeded April 21 and had emerged by April 28 with good stands in most plots. Plot 1 (northernmost plot) had the poorest germination, but extra seedlings from other plots were transplanted into the empty spaces (10 to 15% of total row length). On May 12 chambers were installed on plots 5, 8, 14 (filtered air) and 1, 9, 12 (1/3 filtered air) and the filtered air systems started. The remaining ambient air and 2X ambient plots were enclosed the following week so that all blowers were in operation by May 19. The 2X ambient treatment as such was not started until July 27 because of delays in delivery of the ozone generator.

---

* Lambda Instrument Co., Lincoln, Nebraska.

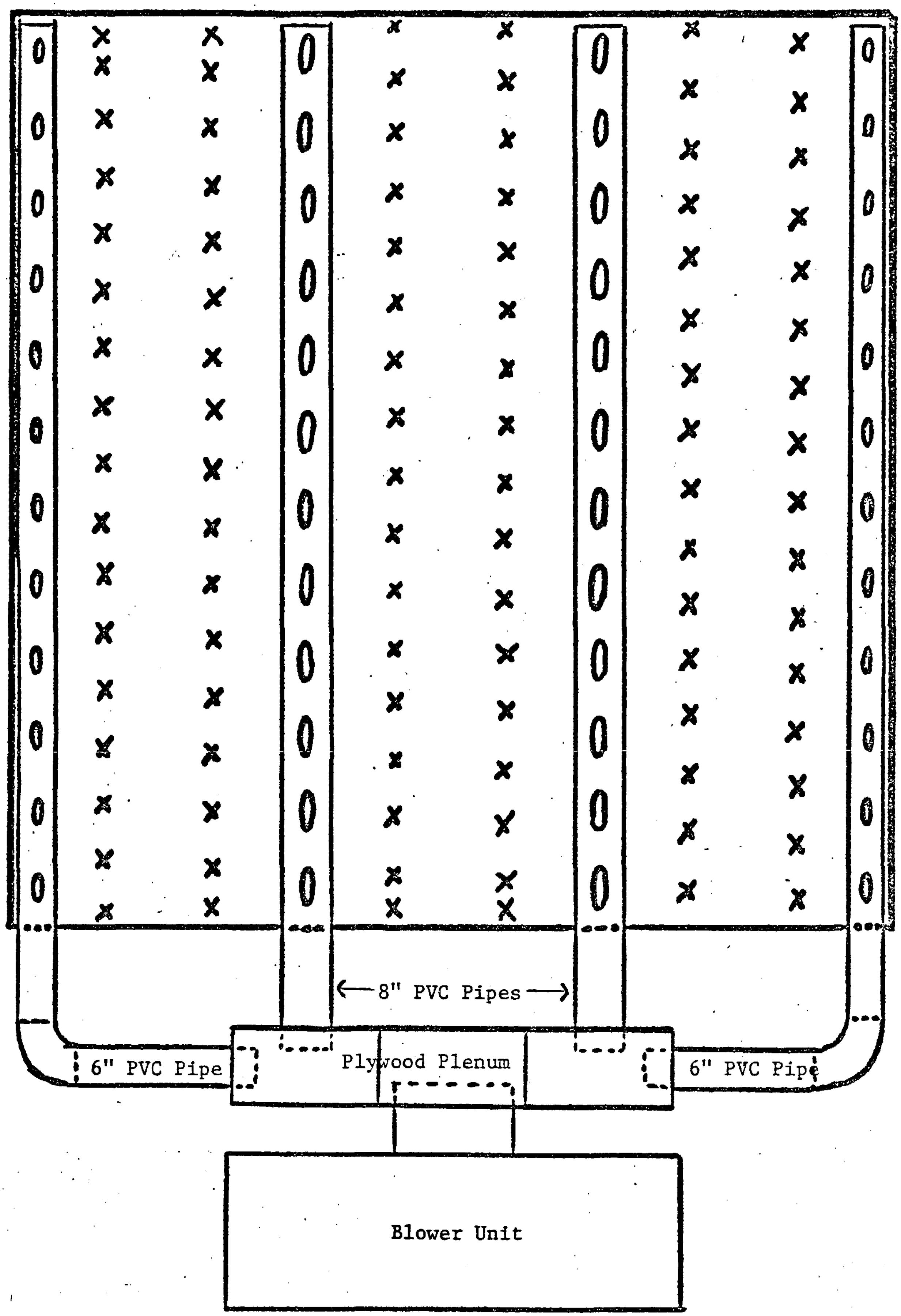


Figure 3. Layout of cotton rows in relation to air ducts in open top growth chambers. Base of chamber is 12 feet square.

On May 22 and 23 all plots were thinned to allow 8 inches between plants resulting in 17 plants per 12 feet of row or approximately 50 plants of each variety per chamber. Outside plots, which were double the size of the chamber plots, had twice as many plants per plot.

Due to the heavy spring rains that continued into May 1978, the pressure bomb tests for leaf moisture tension did not indicate tensions in excess of the 15 bars considered optimum for first irrigation until June 28. From June 29 to July 1, deep irrigation was applied using bi-wall drip tubing. During this time, most of the plants of both varieties in the chambers were in the early "squaring" stage with occasional blossom appearing throughout. By July 1, plants in the outside plots were considerably less mature than those in chamber plots, probably due to the slightly higher night temperatures in the chamber environment.

Although Dacthal preemergence herbicide was used to suppress weed growth between the plots, all weeding in the chambers and outside plots was by hand. Mites and lycus never reached damaging levels during the season, but all plots were sprayed twice with Omite during August to suppress a potential mite problem. Aphid infestations were effectively controlled by spraying all plots with an aphicide, Piremor.

Air temperatures were monitored continuously in each chamber as well as in one of the outside plots. Temperatures within the air duct were measured as well as shielded temperature within the plant canopy. Air duct temperatures were essentially the same as the outside ambient until temperatures exceeded 35^{o} C (95^{o} F). At ambient temperatures above 35^{o}, air temperatures within the ducts were approximately 1^{o} C higher than outside ambient. Air temperatures within the plant canopy also ranged 1 to 2^{o} C above outside ambient at night, probably due to the reflection of radiated heat by the dew-covered plastic walls. Relative humidities within the chambers' plant canopies were essentially the same as at similar locations in the outside plots throughout most of the growing season. Somewhat more dew settled on plants grown in the outside plots late in the season due to lower air velocities over these plots at night.

Light Intensity

Reflection off the curved plastic walls caused light intensities in the chambers to range from slightly below outside plot readings in the early morning and late afternoon to slightly above outside readings at midmorning and midafternoon. At midday, light intensities inside the chambers were essentially the same as outside, as would be expected with open top chambers. Actual light intensity readings made with a quantum photometer are shown in Table 2 in Appendix B. Chamber #1 had been constructed the previous year to its plastic had been exposed for most of two seasons when these measurements were made. Plastic on chamber #8 was in its first season. There were no indications that deterioration of the PVC plastic had influenced the transparency of the plastic to PAR (photosynthetically active radiation).

Air Movement

Measurements with a hot wire anemoneter indicated air velocities ranging from 10 to 90 FPM within the chambers. Velocities in the outside chamber ranged from nearly 0 during still periods to 200 FPM during a brisk breeze with an average of approximately 100 FPM. Actual measurements within the plant canopy are shown in Table 3 (Appendix B).

Ozone Concentrations and Dose

Ozone concentrations in the outside air and in the various chambers were monitored continuously with Daisbi ozone analysers. Table 4 shows the relative ozone concentrations in the various treatments on three typical smoggy midsummer days in 1978. (See footnote below.)

The maximum peak daily outside ambient ozone concentrations for the period May 5 through October 19, 1978 are shown in Table 5. The chamber treatment concentrations were related to these as follows:

Note: No attempt was made to determine other pollutants such as SO_2 in the Parlier area since no known sources of any consequence exist within a 15 mile radius. The maximum hourly SO_2 concentration during July, August and September at the Olive Avenue sampling site in Fresno, 20 miles to the northwest, was .02 ppm. Measurements of SO_2 at Parlier in 1979 indicated less than measureable amounts (0.01 ppm) of SO_2 in ambient air at all times.

Ambient Chamber	.9	X	Outside Ambient
2X Ambient Chamber	1.9	X	Outside Ambient
1/3 Filtered Chamber	.6	X	Outside Ambient
Filtered Chamber	.26	X	Outside Ambient

The highest hour long mean ambient ozone concentration measured was 16.0 pphm on August 3; the lowest maximum was 4.0 pphm on August 26. 1978.

Table 4. Typical ozone concentrations (ppm) in plots receiving different treatments.

Air Treatments	Day 1	Day 2	Day 3
Outside Ambient	.120	.097	.110
Ambient Chamber	.110	.085	.103
2X Ambient Chamber	.218	.189	.201
1/3 Filtered Chamber	.070	.058	.062
Filtered Chamber	.036	.026	.031

Ozone Dose

The hourly peak ozone concentration data (Table 5) collected on site during the 1978 growing season was used to calculate dose exposure based on thresholds of .005, .05 and .10 ppm ozone. Table 6 contains a summary of the ozone dose data. It should be noted that the 2X ambient treatment was not begun until the newly purchased ozone generator was placed in operation on July 27. Had there been ozone enhancement during May and June, the accumulated dose would have been considerably higher.

RESULTS AND DISCUSSION

Plant Responses

Detailed visual observations of all plots were made once a week from planting until harvest. Presence or absence of common pests such as aphids or worms, symptoms of nutrient deficiency, moisture

Table 5. Peak hourly ambient ozone concentrations near an outdoor cotton plot, May 5 through October 19, 1978. Concentrations are expressed as pphm.

	Month					
Day	May	June	July	August	September	October
1	-	10.3	8.5	10.0	6.9	8.6
2	-	10.6	6.1	10.8	9.0	8.2
3	-	9.0	7.9	16.0	7.3	12.2
4	-	6.0	NR	11.6	10.0	11.8
5	5.6	13.4	11.0	13.0	16.0	11.4
6	5.9	11.8	10.5	12.6	3.4	14.8
7	7.4	11.0	9.0	9.4	4.8	12.5
8	7.0	11.2	11.0	10.6	5.4	11.6
9	9.0	8.0	10.2	13.2	5.9	13.3
10	8.8	6.0	8.8	11.0	3.9	13.8
11	7.4	8.0	7.8	10.8	6.6	13.6
12	5.9	9.2	10.8	7.3	6.4	13.0
13	11.4	9.0	13.8	5.4	7.2	14.4
14	11.0	8.0	10.9	7.4	6.4	12.7
15	8.8	9.4	7.7	8.2	6.5	11.8
16	6.0	9.6	7.7	6.0	9.4	7.8
17	5.7	11.2	9.0	5.6	9.0	5.5
18	9.5	8.0	9.0	9.0	6.7	11.4
19	8.3	11.2	9.0	10.3	5.7	9.4
20	9.0	13.0	11.2	8.1	6.3	-
21	11.1	13.0	10.8	8.0	5.5	-
22	9.2	13.0	13.8	4.6	11.2	-
23	7.6	11.8	14.5	6.8	13.4	-
24	5.7	7.0	13.7	7.4	11.0	-
25	5.5	8.8	10.0	6.6	10.6	-
26	5.5	7.4	7.3	4.0	10.8	-
27	5.6	8.0	11.8	6.8	8.2	-
28	8.8	9.8	13.0	12.0	12.8	-
29	8.5	8.4	9.0	13.0	8.0	-
30	9.2	11.0	11.8	7.4	7.8	-
31	8.2	-	12.3	9.0	-	-

Table 6. Ozone dose (pphm-hours) for the various treatments used on cotton at Parlier, California, 1978.

Threshold	Treatment	May	June	July	August	September	October	Total
0.005 ppm	Filtered Chamber	400	610	560	440	310	350	2670
	1/3 Filtered Chamber	1120	1580	1500	1240	980	930	7350
	Ambient Chamber	1840	2540	2430	2050	1650	1510	12020
	Ambient Outside	2160	2780	2850	2410	1950	1770	13920
	2X Ambient Chamber	1840*	2540*	2610	3450	2000	2430	14870
0.05 ppm	Filtered Chamber	18	57	0	5	1	0	81
	1/3 Filtered Chamber	42	190	176	612	82	198	850
	Ambient Chamber	440	830	834	675	448	690	3917
	Ambient Outside	515	971	984	776	537	814	4597
	2X Ambient Chamber	440*	830*	959	2256	772	6137	6984
0.10 ppm	Filtered Chamber	0	0	0	0	0	0	0
	1/3 Filtered Chamber	0	0	0	0	0	0	0
	Ambient Chamber	5	46	62	53	2	12	180
	Ambient Outside	7	52	71	64	5	15	214
	2X Ambient Chamber	5*	46*	146	1193	107	149	1646

* Ozone generator was placed in operation July 27, 1978.

stress (or excess), squaring, flowering and general vigor were noted.

Visible Symptoms

Foliage, particularly lower leaves, in the plots receiving the 2X ambient ozone treatment began showing typical oxidant injury symptoms about ten days after the enhanced ozone treatments were started on July 27. These symptoms, which closely resemble natural late fall senescence, (interveinal chlorosis, blotchy yellowing, appearance of purple or brown interveinal spots, and finally a general bronzing of the entire upper leaf surface) are shown in Figure 4. Specific symptom expression was the same on both SJ-2 and SJ-5, but many more leaves were effected on SJ-2 than on SJ-5.

By mid-August, the sort of ozone toxicity symptoms observed earlier in the 2X ozone treatment and illustrated in Figure 4 began to appear on some SJ-2 plants receiving ambient ozone concentrations, both out-of-doors and in the ambient treatment chambers. All SJ-2 plants did not respond the same - some were very chlorotic and bronzed while others remained apparently normal indicating considerable variation within variety in sensitivity. By comparison, all SJ-5 plants receiving the ambient ozone treatments remained free of foliar symptoms through August and most of September. By October 1, all of the plants receiving the ambient or 2X ambient ozone treatments showed some signs of senescence whereas similar symptoms were absent on plants of either variety receiving the filtered treatment and were extremely scarce in the 1/3 filtered-2/3 ambient treatment. By October 25, 1978 when the blowers were turned off and the plastic chambers removed, a few of the older SJ-2 leaves in the filtered chambers had begun to exhibit typical senescence patterns, although most SJ-2 and all SJ-5 foliage remained a healthy green.

Boll Set

Earlier studies with cotton in the valley (Brewer and Ferry, 1974) indicated that a reduced number of bolls being set, particularly early in the season, was the primary reason for lower yields in cotton exposed to ambient as compared with filtered air. Therefore, a boll

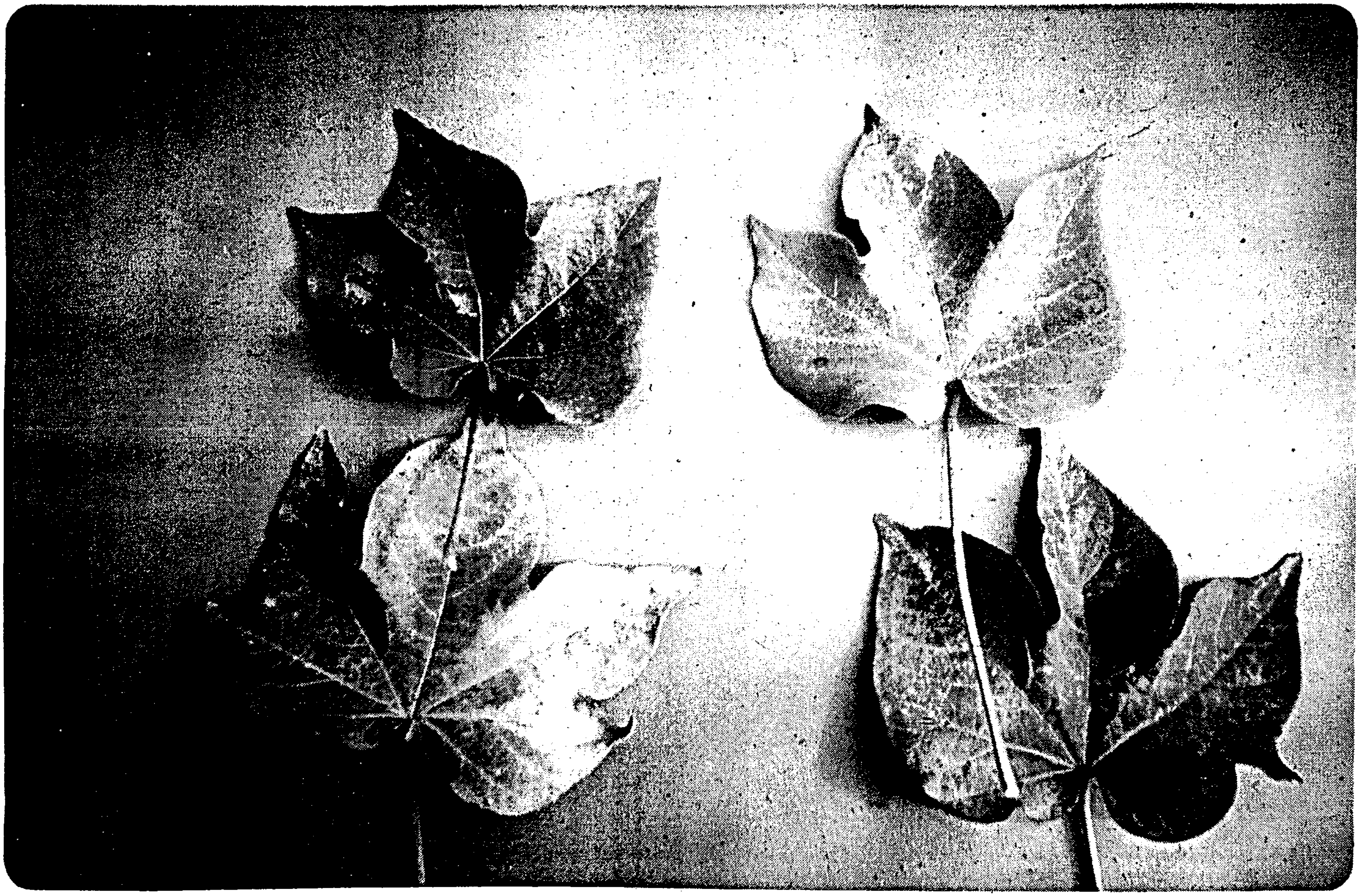


FIGURE 4. OXIDANT INJURY SYMPTOMS ON COTTON LEAVES.

count was made on August 17, before any bolls had matured. Counts of green bolls were also made at approximately monthly intervals thereafter as the mature bolls were picked. Results of the early boll count and the three pickings are presented in Tables 7 and 8 for varieties SJ-2 and SJ-5, respectively. Statistical analyses of these data using the Duncan (1955) Multiple Range Test indicated that SJ-2 boll set was significantly greater with 2/3 filtered or 100% filtered air than with the ambient or 2X ambient treatments. The data indicated 6% less bolls set on the 2X ambient plants compared with ambient plants, but this difference was not significant.

For SJ-5 there were no significant differences among the ambient, 2/3 ambient, filtered or outside treatments, but the 2X ambient treatment significantly reduced boll set 11 to 21% below that in the other four treatments.

Raw Cotton Yields

The yields of raw cotton produced in the 15 plots receiving the five different treatments used in this study are presented in Tables 9 and 10. These data indicate a significant response by both varieties to the high ozone treatment (2X ambient) and a significant response by SJ-2 to ambient levels of ozone as well. If the data from plot 1 are eliminated because of the observed late season wilting due to sandy soil underneath the plot, removing 1/2 of the ozone contained in ambient air also produced a significant response (approximately 12% increase over the ambient plots in production). In the case of variety SJ-5, it would seem that the ambient levels of ozone encountered during the 1978 growing season were not limiting.

Lint and Seed Production

All of the cotton of each variety from each plot was combined for ginning at the U. S. D. A. Cotton Research Station at Shafter, California on November 29, 1978. Before ginning, the samples are brought to uniform moisture content and all foreign materials such as leaves, twigs. etc. are removed. Miniature gin equipment was used to separate the cotton lint from the seed and return both fractions for weighing and

Table 7. Boll counts and pickings for approximately 100 SJ-2 plants, 1978.

Treatment	8/17 Green	9/26 Picked	10/27 Picked	11/27 Picked	11/27 Green	Season Picked	Season Total***
2X Ambient	458	496	188	12	18	714a*	732a
Ambient	546	475	268	20	45	763ab	783ab
2/3 Ambient	555	430	367	23	48	820b	893b
Filtered	620	526	319	20	28	865b	893b
Outside	437**	84	480	55	78	619c	697a

* Values with different subscripts are significantly different at .05 level of probability.
** Plants excessively vegetative due to heavy late spring rains.
*** Including green bolls which would not mature.

Table 8. Boll counts and pickings for approximately 100 SJ-5 plants, 1978.

Treatment	8/17 Green	9/26 Picked	10/27 Picked	11/27 Picked	11/27 Green	Season Picked	Season Total***
2X Ambient	344	382	134	14	31	530a*	561a
Ambient	482	437	216	21	33	674b	707b
2/3 Ambient	489	379	227	14	69	620b	689b
Filtered	486	399	213	22	24	634b	658b
Outside	261**	103	428	62	54	593b	647b

* Values with different subscripts are significantly different at .05 level of probability.
** Plants excessively vegetative due to heavy late spring rains.
*** Including green bolls which would not mature.

Table 9. "Raw Cotton" production (grams) by approximately 100 SJ-2 cotton plants exposed to varying amounts of ozone. Bracketed values are means of two rather than three plots.

Treatment	Plot No.	9/22	10/27	11/27	Plot Total	Treatment Mean
Filtered	5	1793	1144	89	3026	
Chamber	8	2122	998	26	3146	2873a
	14	1328	1029	90	2447	
1/3 Filtered	1*	1402	951	34	2387	2637ab
2/3 Ambient	9	1663	1033	58	2754	(2763)a
	12	1140	1519	113	2772	
Ambient	2	1532	988	49	2569	
Chamber	6	1532	940	41	2513	2471b
	10	1508	735	90	2333	
2X Ambient	3	1296	477	43	1816	
Chamber	11	1220	632	20	1872	1901c
	13	1449	524	42	2015	
Outside	4	265	1579	402	2246	(2020)bc
Ambient Plot	7	434	1318	43	1795	1667c
	15**	27	659	275	961	

* Excess moisture stress due to sandy subsoil.
** Excess vegetative growth due to wet subsoil.

Table 10. "Raw Cotton" production (grams) by approximately 100 SJ-5 cotton plants exposed to varying amounts of ozone. Bracketed values represent means of two rather than three plots.

Treatment	Plot No.	9/22	10/27	11/27	Plot Total	Treatment Mean
Filtered Chamber	5	1275	757	90	2122	
	8	1564	396	29	1989	2045a
	14	1055	887	84	2026	
1/3 Filtered 2/3 Ambient	1*	1251	411	42	1704	2026a
	9	1434	668	64	2166	(2187)b
	12	1078	1108	23	2209	
Ambient Chamber	2	1232	802	57	2091	
	6	1335	848	41	2224	2177ab
	10	1594	536	88	2218	
2X Ambient Chamber	3	990	474	45	1506	
	11	1140	359	32	1531	1522c
	13	1111	376	44	1531	
Outside Ambient Plot	4	250	1493	380	2123	(1827)a
	7	371	1127	35	1532	1583c
	15**	31	750	313	1094	

* Excessively dry, sandy subsoil.
** Excessively wet subsoil resulting in excessively vegetative growth.

Table 11. Lint yields - grams per plot - 1978.

	Treatments							
	Filtered Air		1/3 Filtered Air		Ambient Air		2X Ambient Air	
Rep.	SJ-2	SJ-5	SJ-2	SJ-5	SJ-2	SJ-5	SJ-2	SJ-5
1	968	721	747	583	798	696	587	490
2	1007	684	863	710	812	738	590	494
3	792	663	894	742	731	749	667	510
Mean*	922a	689x	878ab	678x	780b	728x	615c	498y

* All mean values of the same variety not sharing the same subscript are significantly different at .05 level.

Table 12. Cotton seed production - grams per plot - 1978.

	Treatments							
	Filtered Air		1/3 Filtered Air		Ambient Air		2X Ambient Air	
Rep.	SJ-2	SJ-5	SJ-2	SJ-5	SJ-2	SJ-5	SJ-2	SJ-5
1	1902	1288	1515	1041	1629	1284	1151	916
2	1955	1200	1736	1327	1568	1369	1182	956
3	1511	1244	1756	1405	1442	1342	1244	934
Mean*	1789a	1244x	1669ab	1257x	1546b	1331x	1192c	935y

* All mean values of the same variety not sharing the same subscript are significantly different at the .05 level using Duncan's multiple range test.

Table 13. Percentage of lint and seed in ginned cotton samples and ratio of lint to seed.

Variety	Treatment	% Lint	% Seed	Lint/Seed Ratio
SJ-2	2X Ambient	32.3	62.7	.515a*
	Ambient	32.1	62.0	.516a
	2/3 Ambient	31.6	63.3	.499a
	Filtered	32.1	62.3	.515a
	Outside Plot	32.6	61.8	.527a
SJ-5	2X Ambient	32.3	62.7	.515a
	Ambient	33.4	61.6	.546b
	2/3 Ambient	33.4	62.0	.540b
	Filtered	33.7	60.8	.554b
	Outside Plot	34.5	60.8	.567b

* All mean values of the same variety not sharing the same subscript are significantly different at .05 level.

Table 14. Micronaire and 50% span length of cotton fiber samples from various air pollution treatments.

Variety	Treatment	50% Span Length	Micronaire
SJ-2	2X Ambient	51a*	4.20a
	Ambient	52a	4.68b
	2/3 Ambient	56b	4.80b
	Filtered	53b	4.48b
	Outside Plot	54b	4.76b
SJ-5	2X Ambient	50a	4.11a
	Ambient	53b	4.39b
	2/3 Ambient	53b	4.55b
	Filtered	53b	4.37b
	Outside Plot	53b	4.37b

* All mean values of the same variety not sharing the same subscript are significantly different at .05 level.

testing. Lint and seed yields for the chamber treatments are presented in Tables 11 and 12 for varieties SJ-2 and SJ-5, respectively. Statistical analyses of these data indicated that exposure of SJ-2 plants to the ambient ozone dose produced significant reductions of approximately 15% in lint production and 13.5% in seed production. Doubling the ozone concentration resulted in reductions of 33% and 22%, respectively. With SJ-5 the only significant responses were a 27% reduction in lint production and a 25% reduction in seed production associated with the 2X ambient treatments.

Lint and Seed Quality

Ginned cotton samples processed by the U.S.D.A. Cotton Research Station are routinely subjected to a number of standardized tests and measurements which collectively indicate the quality of the seed and fiber samples. The criteria tested and a brief explanation of its significance follows:

1. Lint Percent - The proportion of lint ginned from a sample expressed as a percentage of the raw cotton. These data are in Table 13.
2. Lint to Seed Ration - Weight of lint divided by weight of seed. See Table 13.
3. 50% Span Length - The length in inches in the test speciment spanned by 50% of the fibers - a test of fiber length. See Table 14.
4. Micronaire - The fineness of the lint measured by a micronaire machine and expressed in standard micronaire units which for cotton ranges from 3 for very fine to 5 for very coarse. See Table 14.
5. T_1 - Fiber strength measured by a stilometer with a bundle of fibers held between two jaws separated by 1/8 inch. Strength is expressed in grams per grex. These data are in Table 15.
6. E_1 - The elongation of the fibers when tested for strength in the T_1 test expressed as a percentage. An indication of elasticity. See Table 15.
7. Uniformity Index or Ratio - A measure of the uniformity of fiber lengths determined by dividing 50% span length by 2.5% span length and multiplying by 100. These data are in Table 16.

Table 15. Fiber strength (T_1) and Elasticity (E_1) values for cotton samples from various air pollution treatments.

Variety	Treatments	T_1	E_1
SJ-2	2X Ambient	2.39	7.13a*
	Ambient	2.44	7.27a
	2/3 Ambient	2.53	7.23a
	Filtered	2.22	8.80b
	Outside Plot	2.32	8.10ab
SJ-5	2X Ambient	2.56	7.20a
	Ambient	2.54	7.47a
	2/3 Ambient	2.40	7.70ab
	Filtered	2.56	8.20b
	Outside Plot	2.44	7.90ab

* All mean values of the same variety not sharing the same subscript are significantly different at .05 level.

Table 16. Uniformity ratios* of SJ-2 and SJ-5 cotton gin samples as influenced by air pollution treatments.

Variety	Treatments	Uniformity Index (U_1)
SJ-2	2X Ambient	46.7a*
	Ambient	47.3a
	2/3 Ambient	46.7a
	Filtered	47.0a
	Outside Plot	47.0a
SJ-5	2X Ambient	45.3a
	Ambient	46.3b
	2/3 Ambient	46.3b
	Filtered	46.3b
	Outside Plot	47.0b

* Ratio expressed as percent of 50% span length to 2.5% span length.

Results of these quality tests can be summarized as follows:

1. Lint-to-seed ratio - There were no significant effects of the treatments on SJ-2 lint to seed ratios, but the high ozone treatments (2X ambient) significantly reduced the SJ-5 lint to seed ratio.
2. Span length of fibers - The 50% span length was significantly less with the ambient and 2X ambient treatments with variety SJ-2, but with SJ-5 only the 2X ambient treatment had a significant effect.
3. Micronaire - Both SJ-2 and SJ-5 samples from the 2X ambient plots showed reduced micronaire values.
4. Fiber strength and elasticity - There were no significant effects on fiber strength of either variety, but elasticity values for fiber samples from filtered plots were significantly greater than for the ambient and 2X ambient treatments.
5. Uniformity - There were no significant differences among the treatments so far as uniformity of SJ-2 samples were concerned, but the 2X ambient treatment signficantly reduced the uniformity index for SJ-5.

SUMMARY

Tables 17 and 18 summarize the primary responses by SJ-2 and SJ-5 cotton to the various air treatments used in these experiments. Although the two varieties responded differently, SJ-5 being more resistant to ambient levels of oxidant air pollution, both were similarly reduced in both boll set and raw cotton production by artificially increased ozone levels. Figures 5 and 6 illustrate these same data graphically. The response curves for SJ-5 beyond ambient levels of ozone are broken because it cannot be determined from the data at hand where this variety will begin to respond negatively to increased ozone, although it is evident that there is a strong negative response at the highest ozone dose.

Table 17. Summary of SJ-2 responses to various air treatments.

Treatments	Boll Set % of Filtered	Raw Cotton Yield % of Filtered	Visible Symptoms† 10/25
Filtered	100	100	*
1/3 Filtered	100	92	**
Ambient	88	86	***
Outside	78	70	***
2X Ambient	82	66	****

Table 18. Summary of SJ-5 responses to various air treatments.

Treatments	Boll Set % of Filtered	Raw Cotton Yield % of Filtered	Visible Symptoms† 10/25
Filtered	100	100	*
1/3 Filtered	105	99	*
Ambient	107	106	**
Outside	98	89	**
2X Ambient	85	74	***

† Symptom Ratings — * = less than 10%
** = 10–20%
*** = 20–50%
**** = 50–75%

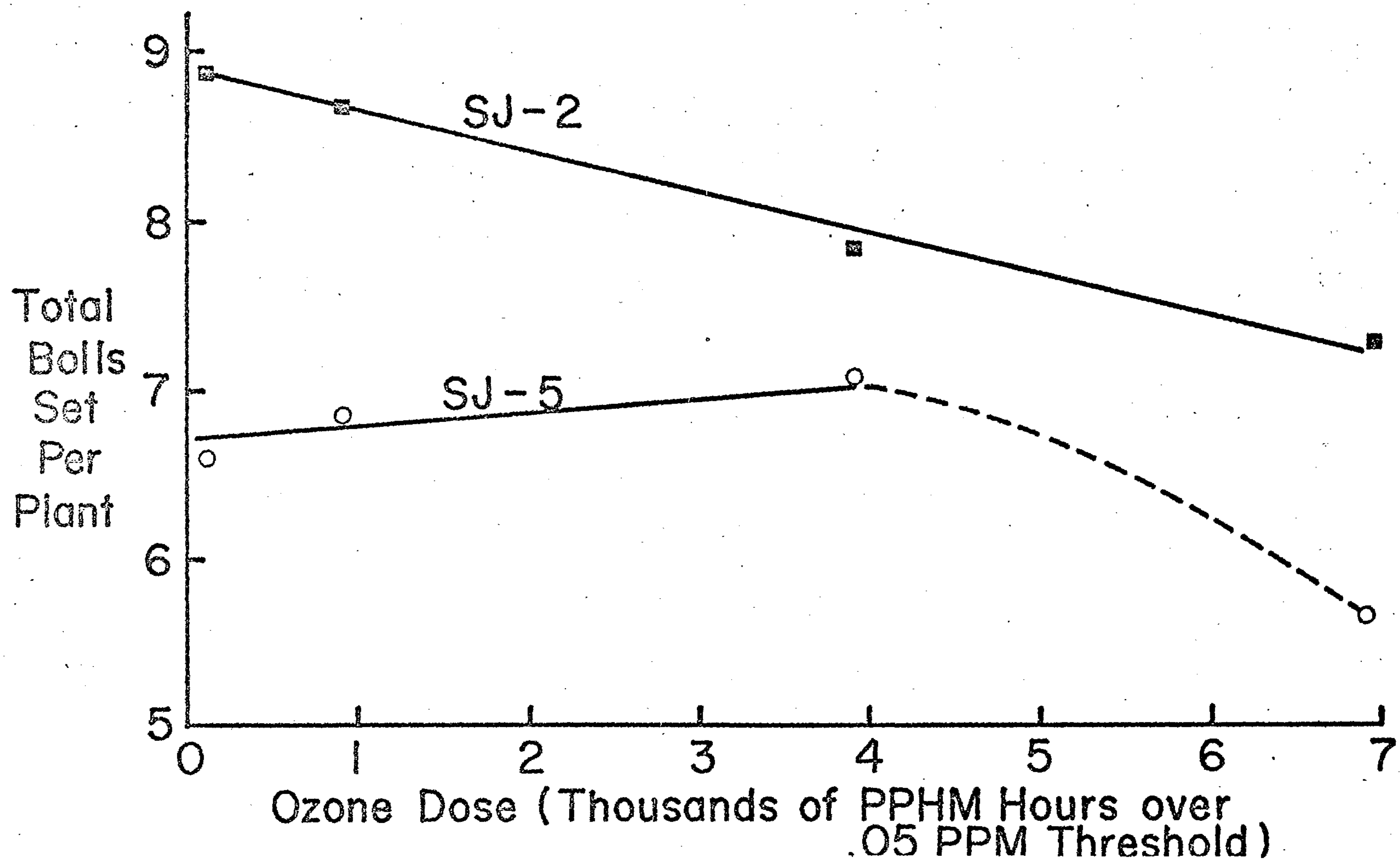


Figure 5.

The effects of ozone dose on boll set by SJ-2 and SJ-5 cotton plants. The broken response curve for SJ-5 between 4000 and 7000 PPHM. Hours indicates that the data available are not sufficient to determine the actual shape of this segment of the total response curve, and therefore this represents a reasonable estimation.

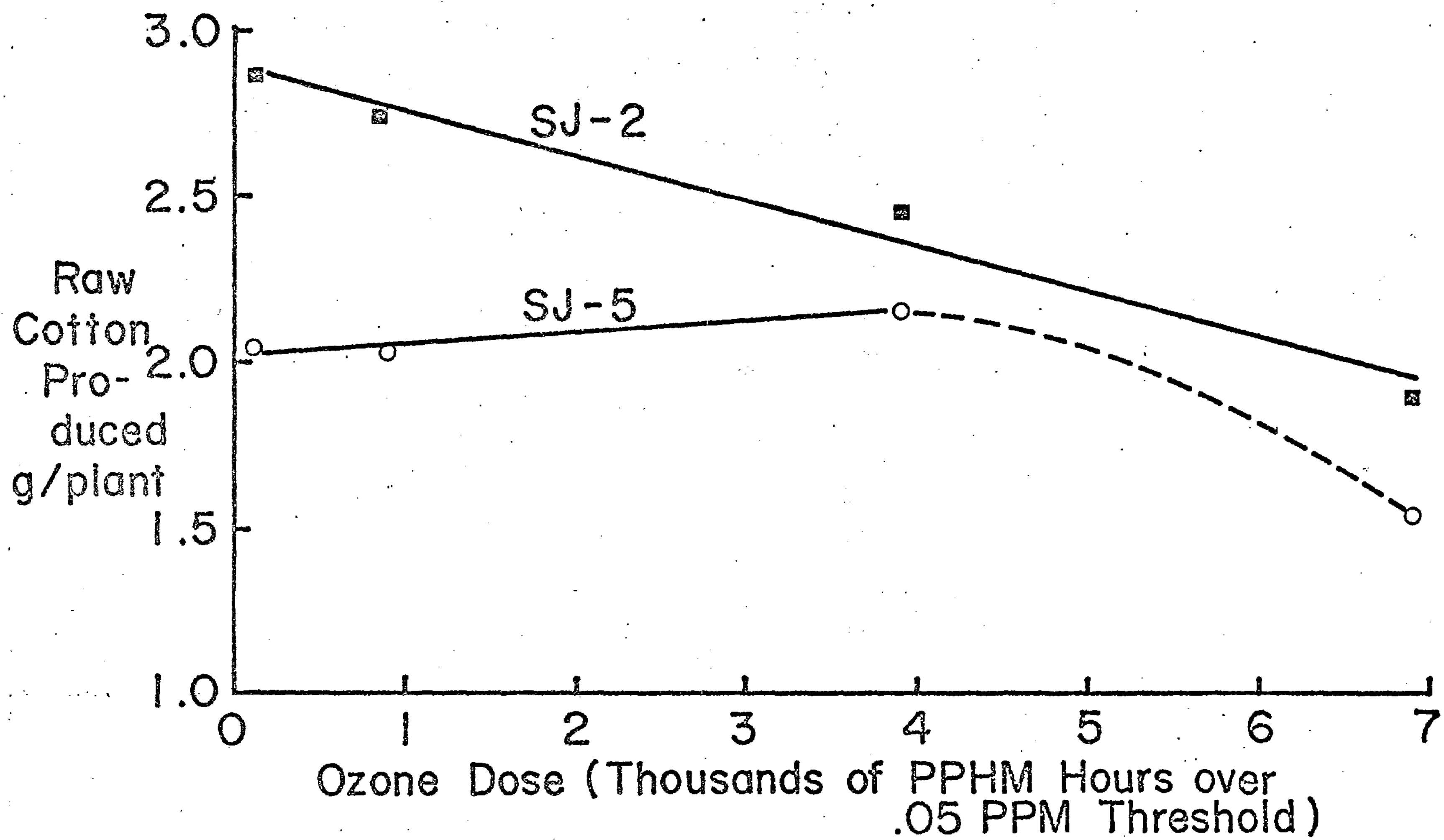


Figure 6.

The effects of ozone dose on raw cotton (lint plus seed) produced by SJ-2 and SJ-5 cotton. The broken response curve beyond 4000 PPHM hours is only an estimate of the probable response by this variety within this ozone dose region. The response data obtained are not sufficient to more accurately plot this part of the curve.

The range of ozone toxicity symptoms developed in this experiment can be appreciated by studying Figures 7 and 8. These photos were taken within hours after the chambers were removed from the test plots. The left or outer row in both cases had been outside the respective chamber and, therefore, was indicative of the outside ambient plants. In Figure 7, the inner rows were in a carbon-filtered atmosphere, in Figure 8 the inner rows were exposed to the 2X ambient or high ozone treatment. The row nearest the plot wall (second row from left in the pictures) was Acala SJ-5; the next row to the right was SJ-2. The outside row was also SJ-2.

Applicability of Results

The 1978 San Joaquin Valley cotton growing season was an extremely poor one for most cotton growers, the result of an unusually cool and wet spring. The unseasonably late rains and low temperatures in April and May delayed plantings, reduced stands and produced overly vegetative cotton plants in many areas with subsequent yield reductions of 30 to 40 percent.

It should be pointed out, however, that due to a fortunate set of circumstances the cotton in the chambered plots grew, flowered and set bolls normally in this experiment. Tarps placed over the newly prepared plots provided protection from the last spring storm just prior to planting. An exception was plot 15, the southernmost Outside Control or Ambient plot, which was excavated to a depth of 12 inches at the time of the storm. The effects of this excess moisture carried into the growing season, resulting in excessively vegetative growth and very late bloom and boll development. Slightly lower temperatures in the outside plots was probably the cause of delay in bloom and boll set observed in all of the outside plots. Although cotton performance in the outside plots was subnormal compared to most growing seasons, it was not unlike conditions existing in the field this particular season. Cotton performance in the chambers, on the other hand, while obviously different from that in outside plots was normal in all respects and would, therefore, be comparable to field grown cotton most growing seasons. It is our opinion, therefore, that comparisons between the various treatments in the <u>enclosed plots</u> provide a valid indication of the effects of the oxidant treatments on field grown cotton. Due to unusual circumstances (late rains, cool temperatures, and overly vegetative growth) cotton growth and production in the outside plots was so atypical that it should not be compared with that in the chamber-covered plots.

Figure 7: Contrast between filtered (center) and outside row of cotton after chambers were removed 11/25/78.

Figure 8: Severity of ozone toxicity symptoms on 2x ambient cotton foliage (center) compared with ambient levels (left) after chambers removed 10/25/78.

REFERENCES

1. Brewer, Robert F. and G. Ferry. 1974. Effects of Air Pollution on Cotton in the San Joaquin Valley. California Agriculture 28(6), p. 6-7.

2. Brewer, Robert F. 1978. The Effects of Present and Potential Air Pollution on Important San Joaquin Valley Crops: Sugar Beets. Final Report for ARB Agreement A6-161-30. 36 pages.

3. Brewer, Robert F. 1979. Air pollution Effects on Crops in the San Joaquin Valley Air Basin, in Proceedings Conference on Air Pollution Effects on Vegetation in Northern California sponsored by California Air Resources Board and University of California, Davis Extension. October 16. 1978. Published by California Air Resources Board, p. 26-30.

4. Duncan Multiple Range Test. Duncan D.B. 1955. Multiple Range and Multiple F Test. Biometrics 11:1-42.

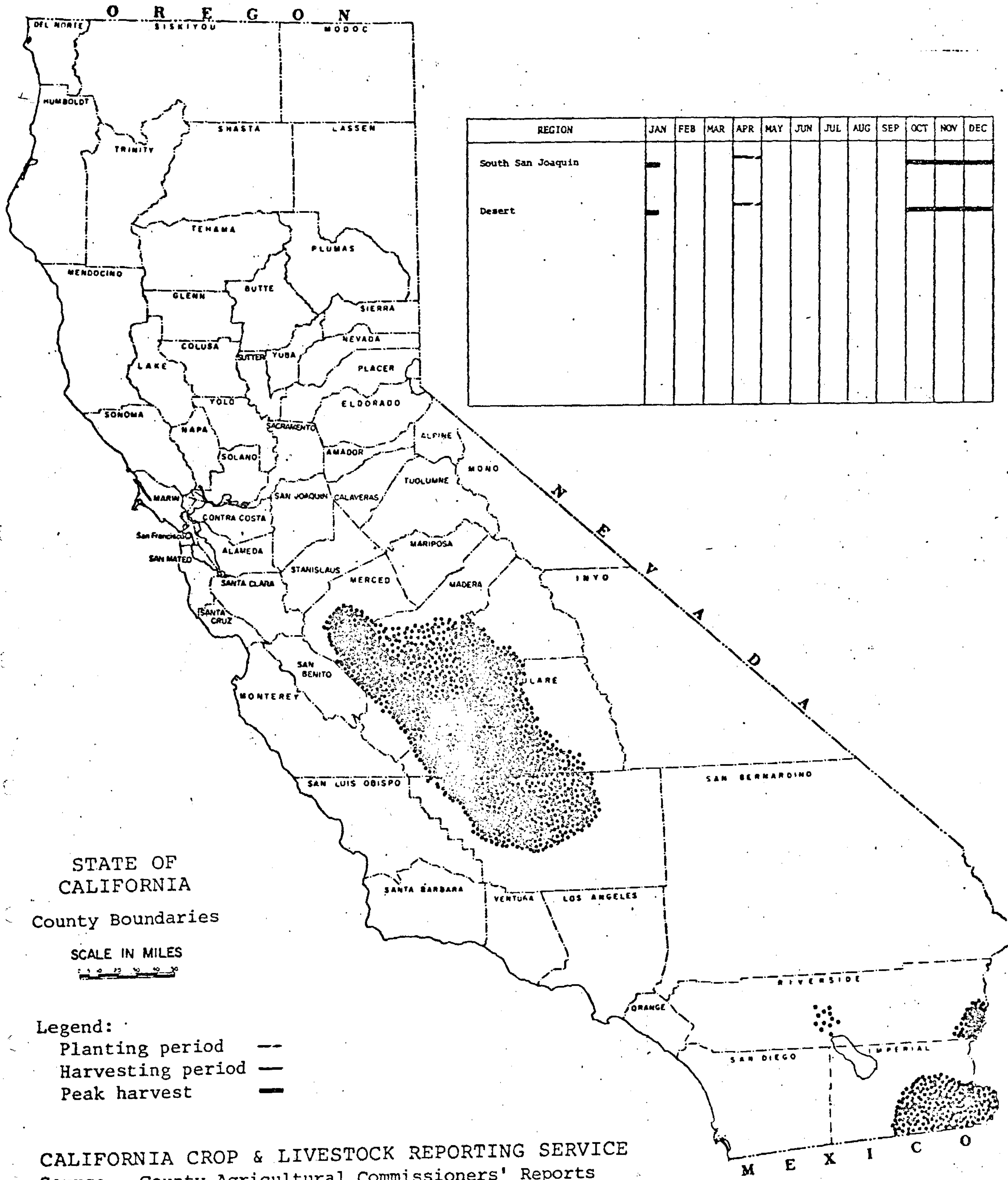
5. Grimes, D. W., W. L. Dickens and H. Yamada. 1978. Early-Season Water Management for Cotton. Agronomy Journal. Volume 70. November-December 1978, p. 1009-1012.

6. Taylor, D. C. and Merserau. 1963. Smog Damage to Cotton. California Agriculutre 17(11), p. 2-3.

7. Ting, I. P. and W. M. Dugger. 1968. Factors Affecting Ozone Sensitivity and Susceptibility of Cotton Plants. J. Air Poll. Control Association 18, p. 810-813.

8. Walhood, V. F. 1977. Results of Air Pollution Experiments at Shafter, California. 1967, 1968. Private Communication.

COTTON LINT 1977 (SEED INCLUDED)
TOTAL ACREAGE = 1,418,515
1 dot = 1,000 acres



STATE OF CALIFORNIA
County Boundaries

SCALE IN MILES

Legend:
Planting period
Harvesting period
Peak harvest

CALIFORNIA CROP & LIVESTOCK REPORTING SERVICE
Source: County Agricultural Commissioners' Reports

Table 1. Results of soil analyses made on samples taken from each plot 4/17/78, 9/7/78, and 11/22/78.

Plot	pH			E.C.*			NO_5N			P_2O_5			K_2O		
No.	4/17	9/7	11/22	4/17	9/7	11/22	4/17	9/7	11/22	4/17	9/7	11/22	4/17	9/7	11/22
1	8.0	7.7	7.9	1.0	1.6	.52	8	5	2	34	31	18	28	38	45
2	7.8	7.8	7.9	1.1	1.7	.68	6	6	2	36	32	22	28	34	37
3	8.0	7.8	7.8	1.0	1.5	.58	4	8	2	33	25	19	28	34	37
4	7.8	7.7	7.8	1.7	2.4	.65	10	12	2	33	32	19	28	41	42
5	8.0	7.8	8.0	1.4	1.8	.52	12	10	2	29	31	21	28	38	40
6	7.7	7.7	8.0	12.	1.3	.60	13	12	2	32	28	24	28	44	40
7	7.8	7.7	7.9	2.0	2.4	.60	10	13	2	30	34	22	32	44	44
8	8.0	7.8	8.0	1.2	2.0	.56	9	4	2	30	31	23	28	38	44
9	8.0	7.8	7.9	1.2	1.6	.48	10	6	2	29	27	26	28	34	40
10	7.9	7.7	8.0	1.4	3.0	.50	18	12	2	30	28	25	32	38	40
11	7.8	7.7	8.0	1.8	4.0	.60	6	12	2	36	29	22	42	41	38
12	7.8	7.9	7.9	1.4	1.8	.52	11	12	2	34	31	21	28	38	40
13	8.0	8.1	8.2	2.7	1.6	.96	4	4	8	36	38	33	38	44	43
14	8.2	8.2	8.2	2.5	1.9	.88	8	4	2	34	32	32	28	38	46
15	8.4	8.1	8.0	2.0	1.4	.76	12	4	2	36	29	25	38	38	43

* E.C. is an abbreviation for electrical conductivity of the soil solution which is a measure of salt content or salinity.

Table 2. PAR Light Intensity Readings (X 10 Lux) using a Lambda Quantum Photometer, 10/12/78.

Plot	Time	Area within plot (see diagram below)							
		NW	N	NE	E	SE	S	SW	W
Outside	11:00	1300	1100	1300	1300	1300	1300	1300	1300
Chamber #1	11:05	1900	1850	1250	1400	1600	1550	1450	1900
Chamber #8	11:10	1900	1800	1150	1350	1600	1400	1350	1800
Outside	14:00	1400	9100	1300	1300	1400	1100	950	800
Chamber #1	14:05	1300	1450	1450	1150	1150	1100	1000	900
Chamber #8	14:10	850	1400	1350	1350	1150	1200	1000	1000

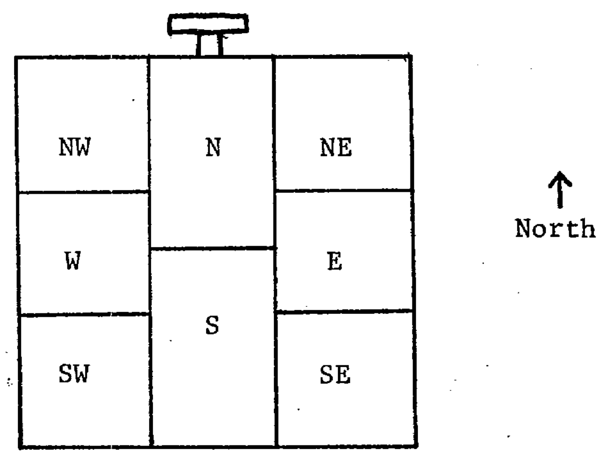
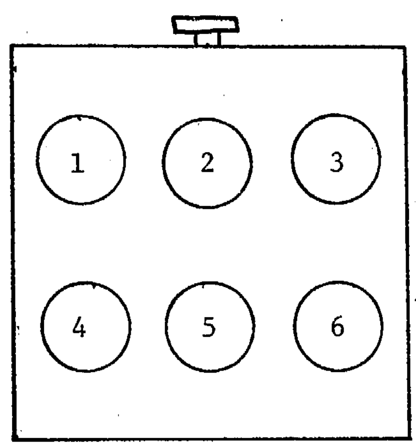


Table 3. Air movement (feet per minute) measured 10/20/78 at 1, 2, and 3 feet above ground level in open plots (outside) and inside growth chambers. All values represent the average of 3 plots at the location indicated (see plot diagram below).

	Height		
Location	1 ft. Level	2 ft. Level	3 ft. Level
Outside 1	50	75	90
Outside 2	75	90	100
Outside 3	75	90	110
Outside 4	60	70	85
Outside 5	75	95	105
Outside 6	80	100	90
Chamber 1	40	40	35
Chamber 2	80	50	40
Chamber 3	90	60	40
Chamber 4	60	60	50
Chamber 5	60	50	70
Chamber 6	35	40	50



Plot Location

Note: No attempt was made to determine other pollutants such as SO_2 in the Parlier area since no known sources of any consequence exist within a 15 mile radius. The maximum hourly SO_2 concentration during July, August and September at the Olive Ave. sampling site in Fresno, 20 miles to the northwest, was .02 ppm. Measurements of SO_2 at Parlier in 1979 indicated less than measurable amounts (.01 ppm) in ambient air at all times.

Appendix C

GRAPE EXPERIMENT

The northernmost row of Thompson Seedless grapes in Block 37 at the Kearney Field Station was assigned to this project in the fall of 1977. Harvested prunings from the 1977 and 1978 production years were weighed and measured as were the grapes produced during the 1978 season. These vines had been previously pruned to 6 canes per vine with a uniform number of buds per cane. Statistical analyses of the pruning and fruit production data were used to estimate the confidence level for different size plots and numbers of replications. Results of these pretreatment calculations indicated that despite wide variations from cane to cane and vine to vine, as experimental design using 9 vines (3 replications of 3 vines each) should reveal differences exceeding 10% at the .10 confidence level with one year's data. With 4 replications, it should be possible to measure a 10% difference with a .05% confidence level the first year and smaller differences in succeeding years. It was decided, therefore, to utilize 8 chambers each covering 3 vines in a long-term study to determine whether present levels of pollution are affecting Thompson Seedless grape production. Specially designed open top plastic covered chambers were constructed during the winter of 1978-1979 so that they would be in place before new shoot growth started in early April. Each chamber (see Figure 9) was 24 feet long, 10 feet wide and 10 feet high and covered 3 vines. Electric motor powered blowers capable of supplying 4,600 cubic feet of air at .5 inch static pressure supplied a constant flow of air into the double north walls of the chambers. The inner plastic panel on this double-panelled wall was perforated with approximately 100 one-inch circular holes which provided a gentle flow of air into the chambers. Half of the blowers were equipped with activated carbon filters and half were not. Fiberglass dust filters protected the carbon filters from plugging by field dust from neighboring agricultural operations. Weekly washings with mild detergent followed by rinsing with clear water kept the plastic chambers relatively free of dust on the plastic walls.

Ozone concentrations in the filtered and non-filtered chambers and in the air outside the chambers was measured continuously using a Dasibi ozone meter housed within a dust proof and air-conditioned shelter.

In spite of windstorms that damaged several of the chambers so that they needed reglazing, delays in funding which held up purchase of two additional blowers, and delays by P. G. & E. in providing the necessary electrical power, all of the units were placed in operation on April 30, 1979. At this time new shoot growth was less than six inches in length, and flowering had not begun. Subsequent growth and fruit development in these chambers by the Thompson Seedless grapes was normal in all respects.

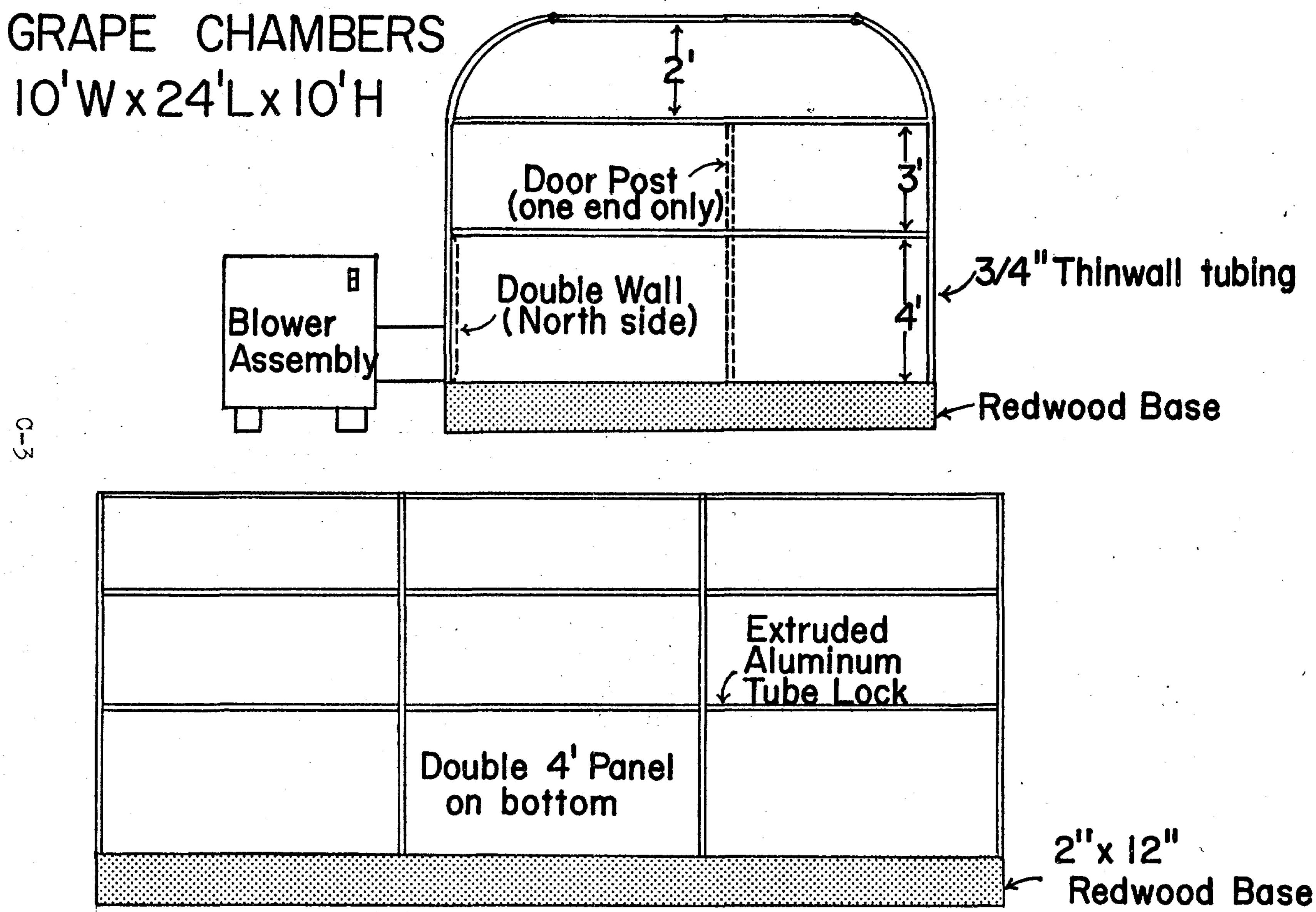


Figure 9. End and side views of open top plastic covered chambers built for pollution exclusion experiment with grapes.