gated to enhance development of *Ramularia* leafspot. No leafspot developed on those plants that had been selected from nursery stock free of symptoms and only five leafspots developed on plants treated with benomyl, while 223 and 329 cases of leafspot were counted per 20 plants in treatments 3 and 4, respectively, neither of which received a fungicide application. *Ramularia* leafspot was significantly reduced by applications of benomyl or by selecting nursery stock free of leafspot symptoms.

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TABLE 1. EFFECT OF FUNGICIDE SPRAYS ON CONTROL OF **RAMULARIA** LEAFSPOT ON 'TIOGA' STRAWBERRY, SANTA ANA, CALIFORNIA, WINTER 1970

Fungicide	Rate/100 gal.	Disease index March 23
Benomyl	50 w.p. 8 oz.	0.1 a*
Thiabendazole	60 w.p. 1 lb.	0.7 b
Captafol 4F	1.5 qt.	0.9 b
Chlorothalonil	75 w.p. 2 lb.	1.1 b
Anilazine	50 w.p. 3 lb.	1.6 c
Captan	50 w.p. 3 lb.	2.1 d
Hexachlorophene 25% EC	0.5 pt.	2.9 e
No treatment		3.1 e

* Means followed by the same letter are not significantly different at the 1% level, using Duncan's multiple range test.

TABLE 2. EFFECT OF FUNGICIDE DIPS ON CONTROL OF **RAMULARIA** LEAFSPOT ON 'TIOGA' STRAWBERRY, SANTA ANA, CALIFORNIA, WINTER 1972

Fungicide	Rate/100 gal.	Field-No. leafspot/ 20 plants-Feb. 17	Yield (g)
Thiophanate-methyl	70 w.p. 16 oz.	0 a*	412 a*
Benomyl	50 w.p. 4 oz.	0 a	399 a
Benomyl	50 w.p. 8 oz.	0 a	390 ab
Thiophanate-methyl	70 w.p. 8 oz.	0 a	381 ab
Benomyl	50 w.p. 16 oz.	0 a	372 abc
Captafol 4F	1 pt.	201 b	347 bcd
Captafol 4F	1 qt.	185 b	331 cd
No treatment		480 c	327 d

* Means followed by the same letter are not significantly different at the 5% level, using Duncan's multiple range test.

TABLE 3. FUNGICIDE DIPS VS. SPRAYS FOR THE CONTROL OF **RAMULARIA** LEAFSPOT ON 'TIOGA' STRAWBERRY, WATSONVILLE, CALIFORNIA, WINTER 1972

Fungicide	Rate/100 gal.	No. Leafspot/ 10 leaves February 16
	(Dips)	
Thiophanate-methyl	70 w.p. 6 oz.	0 a*
Thiophanate-methyl	70 w.p. 12 oz.	0 a
Benomyl	50 w.p. 8 oz.	0 a
Benomyl	50 w.p. 16 oz.	0 a
	(Sprays)	
Thiophanate-methyl	70 w.p. 12 oz.	8 b
Thiophanate-methyl	70 w.p. 6 oz.	12 b
Benomyl	50 w.p. 8 oz.	15 bc
Benomyl	50 w.p. 16 oz.	15 bc
Thiabendazole	60 w.p. 16 oz.	22 c
Chlorothalonil	75 w.p. 1.5 lb.	63 d
Zineb (Cosanil)	25%, sulfur 20%, Cu 5% 3 lb.	86 e
Copper Count N	Cu 8% 2 pt.	101 f
Castle Copper	53% 1.5 lb.	128 g
Copper Sorba	Cu 4% 2 qt.	139 g
No treatment		199 h

* Data significant 1% level.

Effects of AIR POLLUTION ON COTTON *in the San Joaquin Valley*

R. F. BREWER · G. FERRY

Cotton grown in smog-free carbon filtered air produced 20 to 30% more raw cotton compared with similar cotton growing in non-filtered air at Parlier, Hanford and Cotton Center. At Five Points, on the west side of the valley, the difference in favor of filtered air was about 10%. Vegetative growth was apparently not influenced by the presence or absence of the oxidants removed by carbon filters, but senescence was delayed several weeks in the fall by the removal of existing pollutants. All these experiments were conducted with Acala SJ-1 cotton. Future experiments will be conducted with newly released SJ-2 and T-1307 and soon-to-be-released T-4852, to determine their relative tolerance to air pollution as compared with SJ-1. Breeding for smog resistance seems to be the most practical means of living with this problem, which from all indications to date, is serious in many parts of the San Joaquin Valley.

PHOTOCHEMICAL AIR POLLUTION, commonly referred to as "smog" has been present in the San Joaquin Valley for at least 20 years—in the mid 1950s oxidant-type leaf injury on sensitive weeds and garden plants was found near Fresno and Bakersfield. Although California Air Resources Board air monitoring data indicates a slight reduction in pollution levels since reaching a peak in 1969, Visalia had only one July day in 1972 during which the oxidant concentration was not above the .08 ppm level considered potentially injurious to plants and animals by federal and state air pollution control authorities. In 1973, Visalia had no non-smoggy days in July. Fresno was somewhat better off with 18 smoggy days during July of 1972 and 16 such days during July of 1973. Parlier, about half way between Fresno and Visalia, had 24 smoggy July days in 1972 and 25 days during July 1973.

The impact of this air pollution on agronomic and horticultural crops in the San Joaquin Valley is relatively unknown. Long term studies at the University of California Air Pollution Research Center at Riverside have indicated 25 to 64% reductions attributable to air pollution in citrus and grape production in western San Bernardino County, where pollution levels averaged two to three times those now found in Fresno, Tulare or Kings counties. The studies described here were designed to determine whether existing air pollution in the valley was sufficient to measurably influence the growth and fruiting of Acala SJ-1 cotton.

The experiment consisted of placing pairs of filtered and non-filtered plastic-covered greenhouse shelters over established plots of cotton at three valley locations in 1972 and at four locations in 1973. The 1972 sites were at the University of California Kearney Horticultural Station near Parlier, the Floyd Wisecarver ranch near Hanford, and the University of California West Side Field Station near Five Points. In 1973, an additional site was established at the Leon Wilcox ranch near Cotton Center in Tulare County. The greenhouse shelters were modifications of the same units used previously by Thompson and Taylor in Southern California on Citrus and grapes. All the greenhouses were equipped with electric motor-driven blowers which changed the air in each house twice each minute. One of each pair of blowers was equipped with activated carbon filters which effectively removed oxidants such as PAN (peroxyacyl nitrate), ozone and nitrogen dioxide.

Each greenhouse unit covered a 12 by 12 ft square area, consisting of four rows of 18 plants each, or a total of 72 plants. Irrigation at all locations except Parlier

was accomplished by raising the foundations of the houses to berm-top level thereby allowing the furrows to pass through the houses. At Parlier, yard-type sprinklers were used to irrigate the cotton inside the units and portable oscillating sprinklers were used on the outside cotton. At least one 12 by 12 ft outdoor plot was established at each location to determine the influence of the greenhouses on cotton growth and production.

The greenhouse and outdoor plots were surrounded on all sides by cotton plants not measured in the experiment. Vacuum gauge-type tensiometers at 12-inch and 24-inch depths in all plots insured that available soil moisture was the same in all treatments. Multipoint potentiometric temperature recorders equipped with copper constant-on thermocouples monitored air, leaf and soil temperatures in both of the greenhouses and in the outside plot at each location. Temperatures in the greenhouses averaged approximately 2°F higher than the outside plot on warm days (temperatures above 95°F), and 1 to 2°F warmer at night during the fall months. There was no significant difference in day or night temperatures between the filtered and non-filtered greenhouse units. Pest control was a problem in the greenhouses, especially during the 1973 growing season. Mites and loopers seemed to flourish in the greenhouse atmosphere, especially the carbon-filtered greenhouse.

Growth and boll set

Plant height, squares, blooms and boll set were recorded for each plant at approximately two-week intervals, from June 15 to September 15, when the first picking of mature bolls was made. After September 15, only the height and number of green and mature bolls were recorded. Table 1 contains growth, flowering and boll set data obtained during July of 1972. These data illustrate the pronounced effect of the filtered air treatment on the number of bolls set per plant at Parlier and Hanford. Later in the season plants in the filtered air at Five Points also set more bolls than those in non-filtered air.

One obvious effect of the carbon-filtered air on cotton plant growth at all locations was the retention of vigor and color during late summer and early fall. Plants in the filtered air were green and continuing to bloom and mature bolls weeks after those in the outdoor plot and non-filtered greenhouse had turned color and become senescent. This late season vigor was responsible for most of the yield differences found at the West Side location and approximately one-fourth of the differences found at Parlier and Hanford.

These plastic-covered greenhouses were used in the cotton fields for air pollution tests at West Side Field Station.

Table 2 contains the yield data for all plots for 1972 and 1973. In both years the maximum differences between yields of plants receiving filtered and non-filtered air were found at Parlier and the least differences were found at Five Points on the west side of the valley. Yields and response to the treatments were very similar at Hanford and Cotton Center in 1973, with aproximately 20% fewer bolls and a similar reduction in lint and seed produced in non-filtered, as compared with carbon-filtered air. This pattern of response correlates rather well with the typical distribution of oxidants in the valley, as determined by Air Resources Board monitoring stations. Air pollution monitoring stations have been in operation at the Kearney and West Side Field Stations for several years and also for many years in the cities of Fresno and Visalia. A temporary monitoring station was in operation in Hanford during the summer of 1972. It is significant that the period of maximum air pollution in the valley (July and August) is also the period when cotton plants are setting bolls.

The apparently strong influence of the greenhouses on growth and production, as indicated by the differences between the outside plots and the ambient houses in 1973, was due to severe problems with mites and cabbage loopers in the greenhouses at Cotton Center, Hanford and Five Points. The low yield of the outside plot at Parlier in 1973 was due to excessive vegetative growth and delayed fruiting.

Samples from all plots were taken to Shafter and subjected to standard quality tests after ginning. Results of these tests indicated no significant effects of the treatments on percent or quality of lint. Seed index and grade was similarly not influenced by the presence or absence of air pollution in these tests.

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TABLE 1: HEIGHT, FLOWERING AND BOLL SET PER PLANT FOR COTTON IN AIR POLLUTION EXPERIMENT, JULY 1972

Location	Plot	Height	Squares	Bolls
		cm		
Hanford	Outside	94	15.3	5.2
	Ambient air	116	13.3	5.1
	Filtered air	115	15.5	6.2
Parlier	Outside	74	9.2	2.0
	Ambient air	75	12.6	3.9
	Filtered air	73	10.1	6.1
Five Points	Outside	91	18.6	2.6
	Ambient air	102	13.5	2.7
	Filtered air	98	11.5	2.6

TABLE 2: COTTON YIELD DATA FOR AIR POLLUTION PLOTS, 1972 AND 1973

		1972 Yields		1973 Yields	
Location	Plot	Bolls/ plant	Wt. of lint & seed	Bolls/ plant	Wt. o lint & seed
			gm		gm
Parlier	Outside	7.5	58.6	10.2	44.:
	Ambient air	7.6	55.3	8.6	55.:
	Filtered air	9.5	68.3	12.4	78.(
Hanford	Outside	15.0	101.8	9.4	65.!
	Ambient air	14.6	99.0	7.4	47.(
	Filtered air	18.8	124.3	9.5	58.:
Five Points	Outside	11.1	75.3	12.2	83.:
	Ambient air	11.0	76.9	9.8	63.!
	Filtered air	12.7	82.9	10.9	67.:
Cotton Center	Outside	. . .	. . . .	8.2	49.:
	Ambient air	. . .	. . . .	6.0	30.:
	Filtered air	. . .	. . . .	7.5	41.(