Control of
RAMULARIA LEAFSPOT OF STRAWBERRY

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Benomyl or thiophanate-methyl applied as dips to strawberry nursery plants before planting provided significantly better control of Ramularia leafspot than all other materials tested. Benomyl in southern California and thiophanate-methyl or benomyl in northern California gave the best leafspot control when fungicides were applied as sprays after planting. Selecting leafspot-free plants or obtaining plants from nurseries following a benomyl spray program prevented leafspot developing in fields in southern California. Most fungicides tested were either phytotoxic or gave ineffective control of leafspot.

RAMULARIA LEAFSPOT (*Mycosphaerella fragariae*) causes severe stunting of plants and reduces yields in California strawberry fields. Experiments reported here compared fungicide dusts with dips of plants obtained from nurseries and with fungicide sprays applied after planting.

In early trials (1969–1970) for the control of *Ramularia* leafspot, *Botrytis* storage rot, *Rhizoctonia*, etc, various fungicides were compared either as plant dusts or dips. Fungicides evaluated in these trials included PCNB, benomyl, thiabendazole, captafol, chlorothalonil, anilazine, thiram, dicloran, folpet, and dichlone. Summer plants harvested from the nursery in February were treated with fungicide, stored at –2°C, and rated in August before planting. Ratings were also made of these plants after planting in the lathhouse. Winter plants harvested from the nursery in October were treated with fungicides, and immediately planted in pots and placed on the lathhouse floor.

Benomyl dusts and dips were significantly better than all other materials for control of *Ramularia* leafspot, *Botrytis* storage mold, and lack of phytotoxicity to roots and foliage of strawberry, 'Tioga' and 'Fresno' varieties were more sensitive to effects of fungicides than 'Shasta.'

Fungicide trial

Two Tioga strawberry plants per 6-inch claypot were winter-planted for a fungicide spray trial on November 1, 1969. The experiment was replicated five times with six pots per replicate. Plants were placed in a lathhouse and misted with water for 5 minutes every hour to enhance development of leafspot. Fungicide sprays were applied on January 19, February 2 and 16, March 2 and 16. Rates (table 1) are per 100 gal of water and sprays were applied for full coverage of plants. A disease index rating was made on March 23, 1970, on a scale of 0 to 5 (5 = leaves completely covered with lesions). Benomyl was significantly better than all other materials for the control of *Ramularia* leafspot. Captan, a standard commercial fungicide, provided relatively poor control. Captafol, while providing some control, caused bronzing of foliage with repeated applications.

Dip trials

Tioga strawberry nursery plants naturally infected with *Ramularia* were obtained from a high elevation commercial nursery in northern California. Plants were dipped for five minutes in the fungicide mixture and planted immediately in the field at South Coast Field Station, Santa Ana, California. Plots were replicated four times using 20 strawberry plants per replication. Sprinkler irrigation was used during the first three months of the leafspot trial.

Benomyl and thiophanate-methyl applied as a plant dip before planting provided excellent control of leafspot in both field and lathhouse, and yields were significantly increased (table 2). Captafol, both at 1 pt and 1 qt, was phytotoxic to foliage in field and lathhouse, and control of leafspot and yield of strawberries was not significantly different from the untreated plants.

'Tioga' strawberry nursery plants infected with *Ramularia* were also obtained from a commercial high elevation nursery in northern California. Comparison was made between plants dipped in fungicides before planting versus fungicide sprays applied to foliage after planting. Possible control of other strawberry pathogens such as *Rhizoctonia* and *Botrytis* was also studied. Ten strawberry plants were used per plot and replicated four times. Plants were dipped for five minutes in the fungicide mixture on November 2, 1971 and immediately planted along with the other plants used for the fungicide spray treatments. Spray treatments were begun on November 9 and repeated at 14-day intervals throughout the growing season. Rohm and Haas B1956 spreader-sticker was added (4 oz per 100 gallons) to each foliage fungicide. Eight sprays were applied before leafspot data were taken on February 16, 1972.

Fungicide dips of thiophanate-methyl or benomyl applied at planting were significantly better than all other materials tested (table 3). Dipped plants were vigorous, and developed to at least twice the size of the control plants. There was a suggestion of control of other pathogens, such as *Rhizoctonia*. Further, these same materials were significantly better than all others when applied as sprays. Chlorothalonil caused stunting, bronzing and russeting of sprayed leaves. Copper materials were generally ineffective.

Commercial field spray

Benomyl was applied to a commercial 'Tioga' strawberry field near Santa Ana, California, to evaluate its effectiveness as a spray for control of *Ramularia* leafspot. Nursery plants were planted on November 1, 1971, in plots consisting of two single rows approximately 270 ft long and replicated four times. Treatments consisted of benomyl 50 wp 16 oz per 100 gal and a no-treatment check plot. Benomyl applications were made on November 15, December 10 and January 7, and leafspot counts were taken on January 14, 1972. Benomyl plots average 9.4 leafspots per 20 plants, while controls averaged 214.4 leafspots.

Ramularia leafspot is prevalent in some northern California strawberry nursery fields and consequently may be carried on transplants to commercial strawberry fields. Comparison was made at Santa Ana of plants obtained from a nursery with benomyl fungicide spray applications, from two nurseries where leafspot control was nil or inadequate, and from a nursery free of leafspot symptoms. Twenty 'Tioga' strawberry plants were planted per plot on October 28, 1971, replicated four times and sprinkle-irrigated 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

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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