FUNGICIDAL CONTROL

of

Fusicladium eriobotryae (Cav.) Sacc.

by

Adib T. Saad

A Thesis Submitted to the Graduate Faculty
of the School of Agriculture in Partial Fulfillment of
The Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Split Major: Plant Pathology-Entomology

Approved:

Frank L. Smith
In Charge of Major Work

A. S. Jammoul

Namy Khalidy

R. H. Porter

Edwin MacKrow
Chairman, Graduate Committee

American University of Beirut

1959

CONTROL OF LOQUAT SCAB

Saad

ABSTRACT

Experimental studies were conducted in a commercial loquat orchard in Saida, in the southern part of Lebanon, for two consecutive years to investigate the serious disease problem of loquat scab and to obtain sufficient information concerning efficacy of fungicides and timing and frequency of application to adequately control the fungus.

The purpose of the work during 1957-58 was to evaluate the efficacy and compare the effectiveness of five fungicides, Dithane Z-78, Fermate, Coprantol, Orthocide 83 and colloidal sulfur. Taking into consideration scale control, fruit finish and phytotoxicity, Orthocide 83 proved to be most efficient followed by colloidal sulfur and Fermate. Ditahne Z-78 and Coprantol proved to be less efficient and were undesirable from the growers' standpoint although they showed statistically significant difference from the check.

Little phytotoxicity was apparent during this particular study. Sulfur showed slight russetting of fruits.

The objective of the 1958-59 experiment was to compare the effectiveness of various spray schedules using Orthocide 83 and colloidal sulfur. Weather conditions were very unfavorable for loquat scab infection, and consequently from the data collected no definite conclusions concerning the comparative value of the spray schedules under study

could be made. Considering observations on time of initial infection and other environmental conditions concerned, spray applications should start early in December and continue to about the second half of February with an interval of two weeks between applications. Severe phytotoxicity, manifested as russetting on the fruits, was observed on trees sprayed with sulfur.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The pathogen Fusicladium eriobotryae is confined to the loquat, Eriobotrya japonica, a tree fruit of far-Eastern origin which is generally distributed in suitable areas throughout Asia and, to a lesser extent, the rest of the world (1,24). It possesses an especial attraction for flavor and character of the fruits. It is a close relative of the apple and pear with a distinctive flavor which has been likened to that of the sweet cherry by some authors (28).

This plant was first introduced into Lebanon from Izmir, probably about 1859 (1). Loquats in Lebanon are grown commercially along the coastal area in the same regions as the citrus fruits. Saida, in the southern part of Lebanon, ranks first in having about 75 percent of the total number of loquat trees grown (23). Other commercial orchards are mainly in Damour, Beirut and Batroun regions. Because of its ornamental appearance, the loquat is often planted in gardens at higher elevations.

Loquat is a fruit of considerable importance in Lebanon. The statistical reports prepared by the Ministry of Agriculture in 1958 give the total area to be 5000 dunums with a production of approximately 4500 tons. Compared to the production in previous years, (as shown in Table I), it appears that the industry is constantly expanding. Most of the fruit exported goes to the Arab countries, namely U.A.R., Iraq, Saudi Arabia, Kuwait and Bahrein. Small quantities are exported to Nigeria, Malta and French Africa.

Table I. Area, production and export of Lebanese loquats (2,23)

Year	Area in dunums	Production in tons	Export in tons
1955	3200	3200	1147
1956	4000	3500	1180
1957	4300	4000	1216
1958	5000	4500	

Horticulturally the loquat varieties are divided into two general types. The more important varieties now grown in Lebanon are locally selected. The varieties described below are the important ones cultivated.

1. "Ahmar Bakir" (Early Red), the earliest to mature. The fruit is pyriform, medium to large in size, ranging up to 6 centimeters long by 4 centimeters broad. The surface is yellowish orange, tinged with red in the fully ripe fruit. The flesh is pale orange, and the flavor is sweet and pleasant (1).
2. "Al-Abyad" (The White) variety, also commonly known as "Mustakawi" and "Raziani". This ranks second to the Early Red and matures about two weeks later, around the middle of April. The fruit is medium in size with an oval shape. The surface is yellowish and the flesh is white. The flavor is pleasant and the fruit is juicy (1).

There are, in addition, about five varieties

Table I. Area, production and export of Lebanese loquats (2,23)

Year	Area in dunums	Production in tons	Export in tons
1955	3200	3200	1147
1956	4000	3500	1180
1957	4300	4000	1216
1958	5000	4500	

Horticulturally the loquat varieties are divided into two general types. The more important varieties now grown in Lebanon are locally selected. The varieties described below are the important ones cultivated.

1. "Ahmar Bakir" (Early Red), the earliest to mature. The fruit is pyriform, medium to large in size, ranging up to 6 centimeters long by 4 centimeters broad. The surface is yellowish orange, tinged with red in the fully ripe fruit. The flesh is pale orange, and the flavor is sweet and pleasant (1).
2. "Al-Abyad" (The White) variety, also commonly known as "Mustakawi" and "Raziani". This ranks second to the Early Red and matures about two weeks later, around the middle of April. The fruit is medium in size with an oval shape. The surface is yellowish and the flesh is white. The flavor is pleasant and the fruit is juicy (1).

There are, in addition, about five varieties

cultivated in Lebanon to a lesser extent. These are the varieties: "Al-Asfar" (The Yellow), "Al-Mawi" (The Juicy), "Al-Khudari", "Al-Ijacy" and "Al-A'di" (1)

Although most commonly eaten as a fresh fruit, the loquat can be utilized in several ways. It may be stewed and used as sauce, or it may be made into excellent jellies and jams and is well received by those acquainted with the delicate flavor. The bright yellow or orange color of the loquat fruit makes it especially attractive as a fresh table fruit (28,33).

The loquat scab disease is well established in many countries growing loquats. Klindic and Milatoric (20) reported, "Specimens of loquat from the island of Korcula, Southern Dalmatia, and Yugoslavia, were severely infected by Fusicladium dendriticum var. eriobotryae in 1950. The disease, which is believed to have been introduced from Italy has properly been spreading in the country for a considerable time; it was also observed in 1950 on the island of Lussin in the Northern Adriatic and near Dubrovnik." Many workers have reported its occurrence in U.S.A. (California mainly), Australia, Italy, Portugal, Turkey, Greece, Switzerland and Yugoslavia (5,20,22,27,28,32). The disease occurs also in South Africa, and was noticed in Montpellier (France), mainly on the leaves (1). The disease was recorded in New South Wales by Cobb (4).

In Lebanon the disease is most serious in Saida

although infected specimens of fruits and leaves have been received from Batroun.

Abou Nasser reported that the disease has appeared for the first time in Saida during 1939 on the fruits, leaves, and even on the shoots of the loquat tree (1).

Loquat scab is one of the most widespread and destructive diseases of the loquat orchards. The range of its occurrence closely parallels that of the loquat culture throughout Lebanon and is most serious in Saida. The aggregate loss from scab disease each year is enormous and can be estimated as an average annual loss amounting to about 60 thousand Lebanese pounds. Infestation in some years runs up as high as 40-50 percent.

These losses are due in part to fruit destruction by the organism and in part to the reduction in marketability as a result of the unsightly appearance of scabbed fruits.

There is no locally obtained scientific information available for the establishment of standard procedures for the control of this disease. As a result, some growers have their orchards sprayed sporadically while others practice no control measures. In general, the orchards are sprayed by agricultural service companies which own the machinery and supply the fungicides and insecticides. The operators of these companies admit frankly that they do not have sufficient information concerning efficacy of fungicides and timing and frequency of application to adequately control the fungus during years of severe attack.

The purpose of this study is two-fold:

1. To determine the comparative effectiveness of various fungicides.
2. To use the best of these materials in programs designed to indicate the most effective and economical spray schedule or schedules to use.

During the crop year 1957-58 five fungicidal materials were tested under orchard conditions to determine which gave the best control of the fungus. The two best of these were then applied at various times during the crop year 1958-59 to determine the best spray schedule for each of the two fungicides.

REVIEW OF LITERATURE

The disease is not confined to any one part of the above ground portion of the loquat tree, it attacks the leaves, the shoots and the fruits.

Birmingham (4) describes the symptoms on the leaves as more or less circular to irregular, dark green, velvety, amphigenous spots, few to numerous sometimes involving most of the leaf. The affected tissues become desiccated and brittle and break off easily. Cristinzio (9) states that young leaves when infected become distorted, thickened, lacerated at the edges and quickly fall. The older leaves will contain holes and ragged edges where necrotic lesions have fallen out, but the leaves remain attached.

The shoots and the very young twigs are also attacked by the scab fungus, but not so commonly as the leaves and fruits. Lesions on the shoots develop first as small, dark, rough spots which ultimately spread and fuse, forming large elongated blotches (4). The shoots may be covered with mycelium of the fungus to the extent that growth might cease (1,9).

The most serious aspect of the disease is the attack on the fruits. The loss as a result of scab attack on the leaves and twigs in Lebanon is negligible compared to the loss resulting from the attack on the fruits. Popenoe (28) reports that fruits are attacked when they are half grown with brownish black spots, which soon extend and enlarge to

cover a good portion of the fruit. Such a condition results in arrested development of fruit and a disfigured appearance. Later the fleshy part of the fruit becomes desiccated and the skin seems to cling to the seeds. A large portion of the crop may, in years of heavy infestation, be rendered absolutely unsalable. Smith (34) states that scab lesions develop on young fruits as dark, velvety fungus spots and cause fruits to be more or less deformed. Symptoms are similar to pear and apple scab caused by a closely related fungus.

The fungus causing loquat scab is known as Fusicladium eriobotryae (Cav.) Sacc. (42). Hughes (16) thinks this fungus should be referred to as Spilocaea eriobotryae (Cav.) comb. nov. of which the following are synonyms: "=Basiascum eriobotryae Cav. in Atti. Inst. Botan: Pavia, II, 1:433, 1888. =Fusicladium eriobotryae (Cav.) Cav. apud Briosi and Cavara in I funghi parassiti d. piante coltivate od utili, no. 186. 1892. =Fusicladium melanconioides Ferraris nom. nov. in Ann. Mycol. 7:284, 1909." "The generic name Basiascum was published by Cavara (vide supra) for the single type species Basiascum eriobotryae and this author subsequently transferred it to Fusicladium." (16). "The Briosi and Cavara exsiccatum no. 186 (I. M. I. 7582) is authenticated for this species name ... Subcuticular mycelium is produced and this becomes locally thickened to form a pustule on which the characteristic Spilocaea conidiophores are produced. v. Hohnel in 1923 considered this to be a form of Fusicladium dendriticum

but he did not reduce Cavara's species to varietal rank." (16).

Many workers have reported its name as Fusicladium dendriticum var. eriobotryae (9,11,12,13,22). D'Oliveira and D'Oliveira (13) reported that they have worked on the cytology of the primordial stages of perithecial formation in Venturia eriobotryae. Nobody else has reported that he has found the perfect or sexual stage of Fusicladium eriobotryae.

Cristinzio (9) found that the fungus, on the host, forms stroma 20-60 microns thick, bearing conidiophores that measure 10-48 by 5-8 microns with conidia 16-30 by 5-7 microns.

D'Oliveira (11) studied conidial fructifications of the Fusicladium species causing scab on pome fruits. He concluded, conidia may be produced directly on the vegetative mycelium or on differentiated conidiophores. The manner of conidiophore growth in Fusicladium eriobotryae is intermediate between that of Fusicladium dendriticum and Fusicladium pirina. In Fusicladium pirina "the first conidium is formed terminally on hypha, or laterally on a protuberance of an intermediate mycelial cell. The conidium remains attached to the conidiophore, which continues to grow so that the originally apical position of the conidium becomes a lateral one. From the tip of the new growth a fresh conidium is produced and the process successively repeated." The conidia of Fusicladium dendriticum on the other hand, "are invariably produced apically on the conidiophore, and at the production of each conidium a new ring is formed. This is believed to

represent the authentic type of Fusicladium conidiophore development."

D'Oliveira also found that conidia may be formed in chains relatively long and abundant in Fusicladium eriobotryae. In old cultures the chains may be branched like those of Cladosporium and Hormodendrum. The conidial dimensions in nature ranged from 11-30 by 6.5-10 microns (mostly 18-20 by 8-9 microns). The corresponding figures in culture being 7-58 by 5-11 microns (mostly 15-20 by 7-8 microns). Fusicladium eriobotryae was found to produce both biseptate and pluriseptate conidia, the latter type rare.

Menon (22) reported that specimens of Fusicladium eriobotryae on loquats were received from Ticino Switzerland, but all attempts to grow the fungus in pure culture were unsuccessful.

D'Oliveira (11) found that Dox's agar plus maltose proved to be the most suitable medium for growing Fusicladium species for study.

The fungus is usually confined to the epidermal cells forming a stroma which ruptures the cuticle and bears conidiophores with conidia (9).

Kirby (19) found that the amount of apple scab (a disease very much related to loquat scab) occurring in any year of 25 years' counts was proportional to the amount of rainfall in spring.

Cristinzio (9) stated that loquat scab is most prevalent in coastal areas during the warm rainy seasons especial-

ly in orchards on compact, wet soils.

In Lebanon, along the coastal areas, infection appears in December when the temperature is mild and rainfall is heavy. It was observed that crowded orchards suffered more than orchards with well-spaced trees (1).

The most widely used method of control reported throughout the world for this disease is the application of Bordeaux mixture (1,11,34).

Birmingham (4) recommends the use of 6-4-40 Bordeaux mixture just prior to blossoming then 1:35 lime-sulfur immediately after petal drop until the fruit is half grown. After this, Bordeaux mixture is again used if weather conditions require. Abou Nasser (1) recommends another spray schedule of 3 applications (before blossoming, after setting and 10-15 days after the second spray) using 50 grams of Bordeaux mixture plus 100-150 grams of wettable sulfur per 18 liters of water. Birmingham and Salerno (4,31) found that sanitation and the removal and destruction of infected material proved of value to reduce inoculum.

The cause of apple scab, Venturia inaequalis (Cke.) Wint. (Fusicladium dendriticum), is a very close relative and similar in many characteristics to Fusicladium eriobotryae. Apple scab has been investigated at length due to its great importance throughout much of the world. Because of its similarity to loquat scab, and because of the shortage of literature on control of loquat scab, a brief review of the most important control measures for apple scab is presented in this study.

Apple scab control passed into rapidly changing trends correlated with the introduction of new fungicides. Prior to 1940 lime-sulfur and inorganic coppers were most commonly used (15,18). The trend then changed to a considerable increase in the use of elemental sulfur and a corresponding decrease in the use of lime-sulfur and Bordeaux mixture (15). Lime-sulfur is regarded as most likely to cause serious injury to fruit and foliage (3,17). Bordeaux mixture, the first important spray used against this disease, and other copper containing sprays are generally regarded unsafe for use during the critical period of scab infection and often causes severe russeting of fruit and injury to the leaves (3,17). With the recent introduction of organic fungicides the grower today has a wide choice of spray materials which may be used effectively according to the stage of growth, the possibility of injury, the degree of protection required, the presence of additional diseases requiring control, and compatibility with insecticides used (7,15).

Captan (N-trichloromethylthio-cyclohex-4-ene-1:2-di-carboxyimide) 50 percent wettable powder used at concentrations of 45 grams per 20 liters proved extremely effective as a scab fungicide giving an excellent fruit finish (3,6,7,29,37). Reich (29) lists a disadvantage with the use of captan which promotes mildew and is phytotoxic to some varieties.

Ferbam (Ferric dimethyldithiocarbamate) 76 percent at 35 grams per 20 liters is very effective against scab (3,6,7,

25,29,35,40). Ferbam also gave complete control of quince rust and cedar-apple rust (6,25). Discretion is necessary to avoid applying it in summer where dark residue might prove to be a handicap in the sale of fruit (6).

Zinc dimethyldithiocarbamate was tried with good results giving better fruit setting with smooth fruit skin (29).

Other important protectants tried and proved of value in scab control are mainly the organic mercury preparations, which have some eradicative properties. Some other fungicides also have an eradicative action and may be applied several days after infection occurs. These have the ability of "burning out" young lesions and some have a protective period also. Eradicants and protectants are sometimes combined in the spray tank to achieve a dual-purpose effect or used separately in a combined schedule with well timed applications (7,25,41).

The more important eradicants worked with and proved to be of value are the organic mercuries, such as Tag, Coromerc and Puratized Apple, (7,25,35,41). Dinitro-o-cresol is useful as an early spring ground spray to kill the overwintering scab fungus (3,6).

Swales and Williams (39,40) found that the addition of suitable non-ionic surfactants, like Triton B-1956, will measurably increase the effectiveness of the spray mixtures most commonly used for controlling apple scab. Application of 50 gallons per acre of spray mixture with surfactants used was as effective as 75 gallons per acre without surfactants.

In addition to the effectiveness of the chemicals used, timeliness and thoroughness of spray applications are of paramount importance. A few well timed sprays may give as good or better control than more sprays improperly timed (3,7). Eight fungicide applications timed to protect the new growth during infection periods proved sufficient for the control of apple scab in orchards having an abundant primary inoculum in years favorable for disease development (14).

MATERIALS AND METHODS

A. Experiment of 1957-58.

The experimental study run during the year 1957-58 was to evaluate the efficacy of various fungicides for the control of loquat scab.

Five different spray materials were used:

1. Dithane Z-78 (Zineb) containing 65 percent zinc ethylenebisdithiocarbamate.
2. Fermate (Ferbam) containing 76 percent ferric dimethyldithiocarbamate.
3. Coprantol (Copper oxychloride) containing 50 percent copper.
4. Orthocide (Captan) containing 83 percent N-trichloromethyl mercapta-4-cyclohexene-1,2-dicarboximide.
5. Colloidal Sulfur. A wettable powder containing 75-80 percent free sulfur.

All the above mentioned materials were first made into a thick paste by adding a little water and stirring well in a small container. The paste was then diluted and poured into the spray tank while filling. This preliminary wetting of the powder to a paste form then diluting in the spray tank has the advantage of forming a suspension of uniform consistency. All sprays were applied promptly after pouring into the tank of a small power sprayer.

The spray materials were used at the rates recommended for pome fruits by the manufacturers. The concentrations

used for the different fungicides are shown in Table II as grams per 20 liters.

Table II. Rates of fungicidal applications

Treatment No.	Fungicide	Concentrations grs/20 liters	
		Pre-blossom	Blossom and post-blossom
1	Dithane Z-78	40	40
2	Fermate	36	18
3	Coprantol	20	10
4	Orthocide 83	40	20
5	Sulfur	96	96
6	Check	-	-

Dithane and sulfur were used at the same rate throughout the spray schedule. On the other hand Fermate, Coprantol and Orthocide were used at two different rates. The concentrations were reduced to half for post-bloom applications to avoid any injury to the fruits and leaves that might result from phytotoxic effects of the higher rates of the 3 above mentioned fungicides.

Triton B-1956 a spreader-sticker, was added to each treatment at the rate of 4 grams per 20 liters.

The sprays were applied by means of a small power sprayer with a tank capacity of 60 liters and a maintained pressure of approximately 100 pounds per square inch. The trees were sprayed from all sides with care to insure thorough and even coverage of leaves and fruit clusters.

Weather conditions and dates of applications are shown in Table III. The treatments were initiated before the flower buds opened and were continued during the blossoming period and after fruit set.

Table III. Number, dates, and weather conditions under which applications were made.

Application No.	Date	Weather conditions	Remarks
1	November 5	Fine weather throughout the experiment when applications were made	It rained 3 1/2-4 hours after application
2	November 15	"	
3	November 27	"	Rained heavily the following day, also rained before applications
4	December 11	"	
5	December 21	"	
6	January 8	"	
7	January 22	"	
8	February 6	"	
9	February 13	"	
10	February 26	"	

Each treatment was replicated five times in a randomized blocks design. There was one tree per replication per treatment.

Infection data were collected 22 days after the last

spray application. This was about two weeks before the peak of harvest. The loquats on any given tree ripen over a period of approximately three weeks. The fruits should be left on the tree until they are fully ripe. Data were collected in the field by moving around the individual trees and counting healthy and scabbed fruits. To help make the counting operation easier and more accurate hand counters were used. All fruits on small trees were counted but in the case of big trees examinations were made at random of a minimum of 250 fruits from all sides of the tree. For each tree in addition records were made of percentage scabbed leaves by counting 200 leaves at random from all sides of the tree and examining them for the number of scabbed ones.

The experiments were conducted in a commercial orchard owned by Mr. Fuad Kalash and located in Saida, Lebanon. It is situated in an area where loquat scab disease has been well established and where the incidence and severity of infection are always greater than in any other area in Saida and its environs. The trees are typically non-uniform, in age, size and vigor.

The soil of the orchard is heavy. Three years after the trees were planted the ground was covered with 10 centimeters of sand which was then incorporated with the soil. The addition of sand was to improve the structure and texture of the soil. No rock or excessive stones are present. No known system of planting could be ascribed to the orchard.

All throughout the study no sprays were applied for the control of insects or diseases other than scab. During the year 1956-57 three sulfur spray applications were made in an unsuccessful attempt to control scab disease. In the year 1957-58 four spray applications were made on the trees not included in this experiment; three of these were of wettable sulfur and one was of coprous oxide. Again, they were unsuccessful.

The orchard was irrigated 5-6 times during the summer, from July to October, about once every twenty days.

No chemical fertilizers were added, but, goat manure was applied, as the only way of improving soil fertility, once per year at the rate of twenty kilograms per tree.

Cultivation of weeds is done twice per year. No plowing is practiced but the land is prepared for irrigation every year. The trees are from 7-10 years old. The yield, according to the grower, ranges from 120-250 kilograms per tree in good bearing years.

B. Experiment of 1958-59.

As previously stated in the introduction, the objective of 1958-59 experiment was to compare various spray schedules using materials of known values. The materials and methods used are in many respects similar to those used for the experiment of 1957-58.

Two spray materials, Orthocide 83 and colloidal sulfur were each used in six spray schedules as shown in Table IV. The two fungicides were used at the same rates

Table IV. Loquat scab control schedules evaluated at Saida in 1958-59

Treatment No.	Treatment	Spraying dates									Spray Schedule No.
		Oct. 23	Nov. 7	Nov. 22	Dec. 5	Dec. 18	Jan. 2	Jan. 17	Feb. 3	Feb. 17	
1	Orthocide	x	x	x	x	x	x	x	x	x	I
2	"	x		x		x		x		x	II
3	"		x		x		x		x		III
4	"			x		x	x		x	x	IV
5	"		x		x	x	x		x		V
6	"					x	x	x	x	x	VI
7	Sulfur	x	x	x	x	x	x	x	x	x	I
8	"	x		x		x		x		x	II
9	"		x		x		x		x		III
10	"			x		x	x		x	x	IV
11	"		x		x	x	x		x		V
12	"					x	x	x	x	x	VI
13	No treatment	N O N E									VII

as in the previous year. Triton X-100 was used as a spreader-sticker in all applications. The techniques of spraying and of data collecting were the same as in 1957-58.

The design used for this experiment was the randomized blocks layout. Five blocks were chosen for the five replications. Thus every treatment was represented once in every block. The allocation of the treatments to the particular units within a block was a purely random one. Blocks were chosen to contain trees of uniform size, age and productivity.

Data were collected twice; once 2 to 3 weeks before peak harvest and once at peak harvest.

RESULTS AND DISCUSSION

A. Experiments of 1957-1958

As stated earlier, the 1957-58 tests were conducted to evaluate several fungicides for loquat scab control under orchard conditions and using only one spray schedule. Three organic fungicides, Captan, Ferbam and Zineb, and two inorganic fungicides, copper oxychloride and sulfur were used.

The season was characterized by abundant rainfall and moderate temperatures, as shown in Figures 1 and 2. There was very severe infection of fruits and leaves by the scab fungus during the fruiting season. This is very probably due to the fact that Fusicladium eriobotryae is highly favored by rainfall for its spread and by moderate temperatures for infection and development. Cristinzio (9) stated that loquat scab is most prevalent during the warm rainy seasons. Kirby (19) also found that the amount of apple scab - a disease very much related to loquat scab - occurring in any one year of twenty five years' counts was proportional to the amount of rainfall in spring. Abou Nasser (1) stated that in Lebanon, along the coastal areas, infection appears severe when the temperature is mild and the rainfall is heavy.

The original inoculum was very abundant all over the orchard in the form of conidia that over-summered on the old leaves and fruits which were left on the trees without being picked during the harvest season of 1957. The infes-

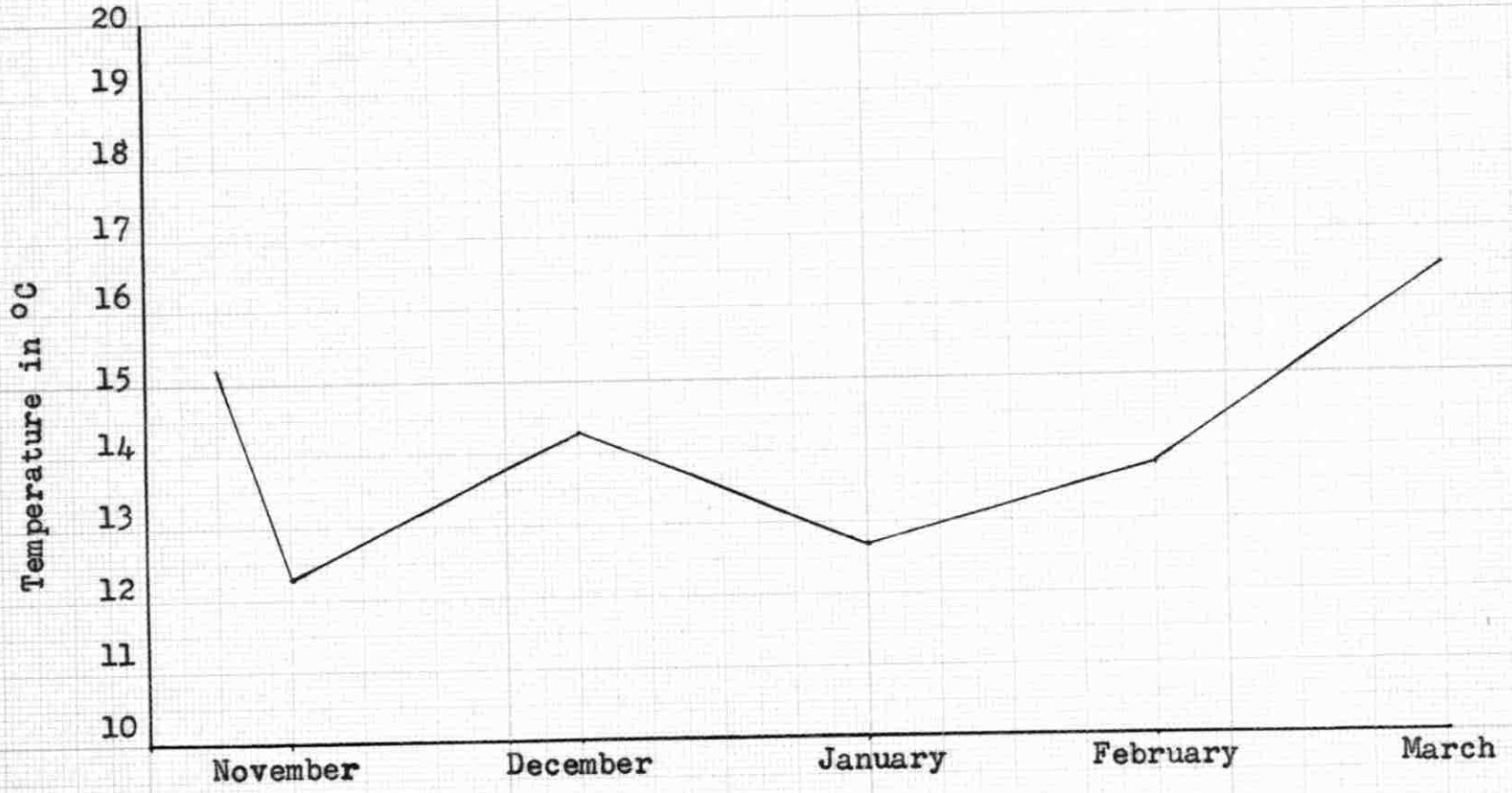

Figure 1. A graphic summary records of average monthly temperature in degrees C for the coastal areas during the Spraying season of 1957-58. (Records taken from Bulletin Climatologique Mensuel, Nos. 2, 3, 4, 5, 6, 7, Ministére des Travaux Publics, Observatoire de Ksara, Liban, 1957-58).

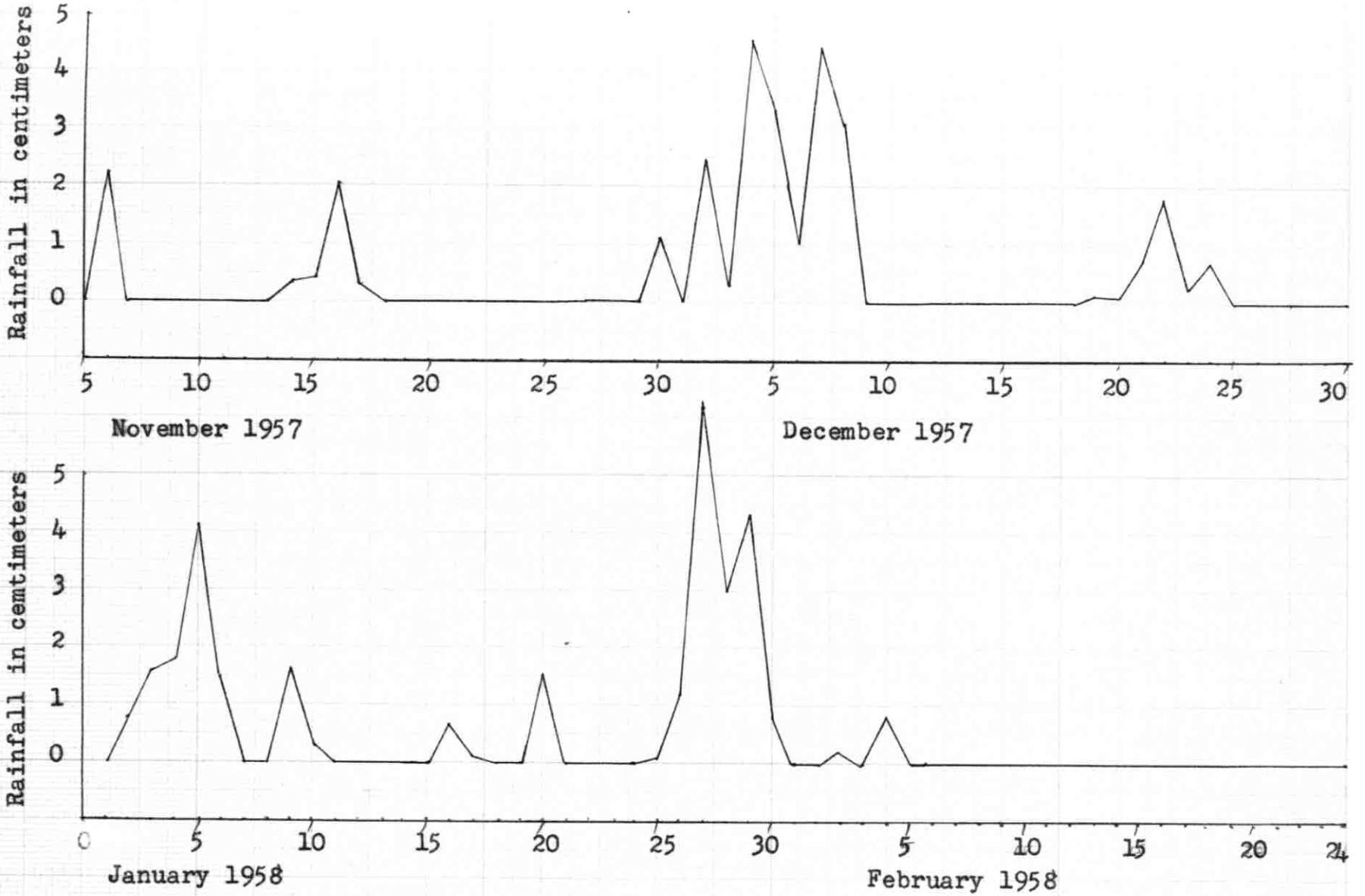

Fig. 2. A graphic summary of daily rainfall records during the spraying season. (Records from, Bulletin Climatologique Mensuel, Nos. 3,4,5,6, Ministère des Travaux Publics, Observatoire de Ksara, Liban, 1957-58)

tation during 1956-1957 was very severe and some few trees had almost all of their fruits left on them as a result of being greatly damaged by scab and rendered unsalable. Another factor that favored an abundance of inoculum was the lack of sanitation practices in the orchard. Thus an abundant inoculum coupled with the favorable weather conditions that prevailed during late November and throughout December helped to initiate the high incidence of infection as evidenced by data collected from the unsprayed units.

The physical conditions of the orchard play an important role in modifying the magnitude of infection. In this particular orchard the trees are not spaced far enough from one another, and no appropriate measures of pruning or sanitation are practiced. Such conditions favor the growth and development of the organism. Having the trees closely planted and compact the spread of the disease is greatly enhanced due to the larger percentage of spores reaching susceptible cites of action.

No experimental studies were ever conducted to investigate the case as to when and under what conditions initial infections would take place under conditions prevailing in Lebanon. Only visual observations could be mentioned here as to the date when infection starts in late fall. Abou Nasser (1) reports that infection appears in December when the rainfall is heavy. The writer observed new lesions appearing on the young leaves of the current shoots towards the middle of December.

It was observed that the disease at harvest time was apparently related to the time of initial infections. On trees that had shown relatively early leaf and fruit infections the losses at harvest time due to fruit infection were very great. On trees, or on individual branches of trees, where initial infection had occurred after mid-season, i.e. after early January, the damage due to fruit infection was less severe with a corresponding reduction in losses.

The results of the treatments are summarized in Tables V through IX. Table V shows the percentage of scabbed fruits (see Figure 3) for each treatment unit and the mean percentage for each treatment.

The number of fruits counted varies greatly amongst treatment units because it was governed by the size of the tree and the number of fruits present on the tree. In the case of the smaller trees all fruits were counted. In the case of the larger trees representative samples were counted; but in no case were less than 250 fruits counted unless the tree had fewer fruits than that number.

Statistical analyses of treatments including the check were made by use of the analysis of variance. Results of the analysis are shown in Table VI. A similar analysis of variance for the chemical treatments alone, omitting the check, was calculated as shown in Table VII.

The critical difference for the means of the treatments was calculated to compare them individually.

Table V. Summary of results of spraying experiment for the control of loquat scab - 1957-1958

Treatment and Replication	Counted fruits No.	Scabbed fruits No.	Scabbed fruits Percent
Dithane Z-78			
A	118	31	26.27
B	96	26	27.08
C	342	31	9.06
D	320	7	2.19
E	210	3	1.43
Mean			13.21
Fermate			
A	122	0	0.00
B	272	12	4.41
C	492	9	1.83
D	340	7	2.06
E	267	6	2.25
Mean			2.11
Coprantol			
A	91	19	20.88
B	268	130	48.51
C	431	309	71.69
D	75	3	4.00
E	350	19	5.43
Mean			30.10

Table V (Cont'd)

Treatment and Replication	Counted fruits No.	Scabbed fruits No.	Scabbed fruits Percent
Orthocide 83			
A	132	3	2.27
B	275	20	7.27
C	402	15	3.73
D	370	6	1.62
E	373	5	1.34
Mean			3.25
Sulfur			
A	550	19	3.45
B	87	8	9.20
C	343	8	2.33
D	452	5	1.11
E	550	11	2.00
Mean			3.62
Control			
A	130	83	63.85
B	150	101	67.33
C	312	255	81.73
D	296	267	90.20
E	241	184	76.35
Mean			75.89

Table VI. Analysis of variance of fruit infection

Source of error	d.f.	Sum of squares	Mean square	F value
Blocks	4	1037.077	259.269	1.449
Treatments	5	20650.537	4130.107	23.077^{++}
Error	20	3579.360	178.968	
Total	29	25266.974		

F_{05} for treatments = 2.71

F_{05} for blocks = 2.87

Critical difference between treatments = 17.65

Table VII. Analysis of Variance of fruit infection for chemical treatments only.

Source of error	d.f.	Sum of squares	Mean square	F value
Blocks	4	1600.023	400.006	2.501
Treatments	4	2809.630	720.408	4.392^{+}
Error	16	2559.085	159.943	
Total	24			

F_{05} for treatments = 3.01

F_{05} for blocks = 3.01

Critical difference between treatments = 16.68

Captan 83 wettable used at the concentration of 40 grams per 20 liters for preblossom applications and at the rate of 20

Fig. 3. Scab lesions on loquat fruits. These lesions are brownish black, raised, velvety spots, which may coalesce to cover a large portion of the fruit.

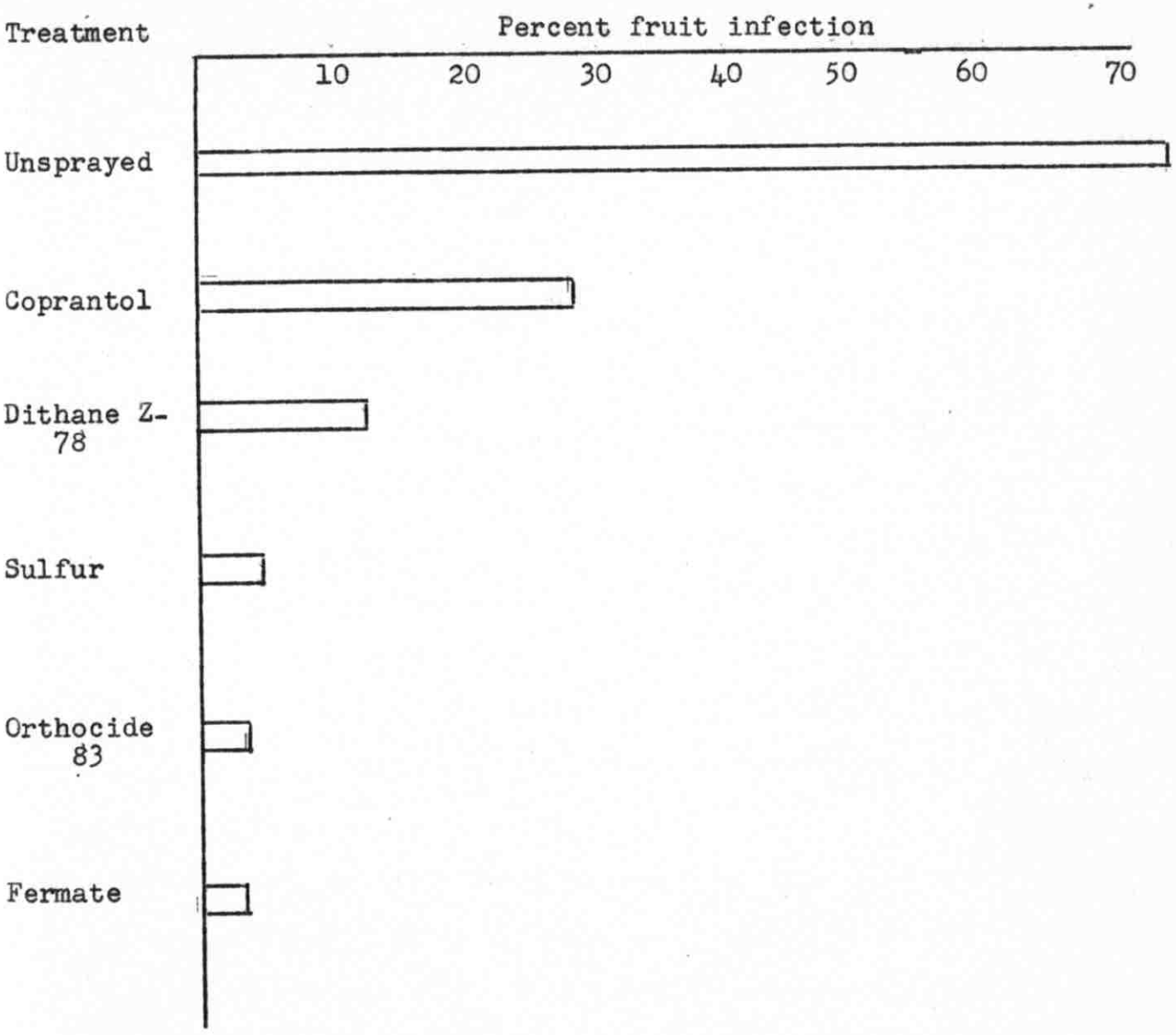

Fig. 4. Mean percentage of fruit infection for each treatment during 1957-58.

grams per 20 liters for the blossom and post-blossom applications gave excellent control of loquat scab under the conditions stated for this experimental study. It has the advantage of effectively controlling the disease and of leaving a very desirable fruit finish. No residue was noticed on fruits at harvest time and no phytotoxic effects were revealed on any of the trees receiving this treatment when the recommended concentrations were used. These results conform very well with results obtained by many workers on the control of apple scab disease which is very similar to loquat scab. Burrell (6) found that Captan is a very good protectant which generally permits the development of excellent fruit finish. Reich (29) lists a disadvantage with the use of Captan which promotes mildew and is phytotoxic to some varieties. In Lebanon no powdery mildew was ever noticed on loquats and the writer did not observe any phytotoxic effects of this fungicide on the loquat trees sprayed with it during two consecutive years.

Ferbam 76 percent, used at the rates of 36 and 18 grams per 20 liters for preblossom and post-blossom applications respectively gave excellent control of the disease but had some limitations and disadvantages on loquat fruits. Ferbam has the advantage of being very adhessive, but it has the disadvantage of leaving a black residue on the fruits thereby decreasing their market quality. For this reason the last two cover sprays on the trees under the Ferbam treatment in this study were of colloidal sulfur.

Burrell (6) reported that care should be taken to

grams per 20 liters for the blossom and post-blossom applications gave excellent control of loquat scab under the conditions stated for this experimental study. It has the advantage of effectively controlling the disease and of leaving a very desirable fruit finish. No residue was noticed on fruits at harvest time and no phytotoxic effects were revealed on any of the trees receiving this treatment when the recommended concentrations were used. These results conform very well with results obtained by many workers on the control of apple scab disease which is very similar to loquat scab. Burrell (6) found that Captan is a very good protectant which generally permits the development of excellent fruit finish. Reich (29) lists a disadvantage with the use of Captan which promotes mildew and is phytotoxic to some varieties. In Lebanon no powdery mildew was ever noticed on loquats and the writer did not observe any phytotoxic effects of this fungicide on the loquat trees sprayed with it during two consecutive years.

Ferbam 76 percent, used at the rates of 36 and 18 grams per 20 liters for preblossom and post-blossom applications respectively gave excellent control of the disease but had some limitations and disadvantages on loquat fruits. Ferbam has the advantage of being very adhessive, but it has the disadvantage of leaving a black residue on the fruits thereby decreasing their market quality. For this reason the last two cover sprays on the trees under the Ferbam treatment in this study were of colloidal sulfur.

Burrell (6) reported that care should be taken to

avoid applying Ferbam in late summer on apples where a dark residue might handicap sale of fruits.

Colloidal sulfur gave as good control as that of Captan and Ferbam; however, it has the disadvantage of burning the delicate epidermis of the loquat fruits. The sides of fruits exposed to direct sunlight showed russetting (see Figure 5), a condition which lowered their market value considerably. Sulfur has been reported before to behave similarly when used for the control of apple scab.

Dithane Z-78 65 percent used at a concentration of 40 grams per 20 liters did not prove as effective as Orthocide 83, Fermate or sulfur for controlling the fruit scab. Dithane Z-78 gave a smooth clean fruit finish with no phytotoxicity to any part of the loquat tree.

Coprantol 50 percent, used at the rate of 20 and 10 grams per 20 liters for pre-bloom and post-bloom applications respectively, was the least effective amongst the five chemical treatments with the added disadvantage of its being difficult to mix.

Statistical analyses of the data show that the differences between treatments and check are highly significant. Between the chemical treatments also there are significant differneces. The grouping of treatments on the basis of critical difference between them, indicates that Orthocide 83, Fermate and colloidal sulfur gave significantly better control than did Coprantol. There was no significant

Fig. 5. Russet lesions on loquat fruits. This russetting appears as rough corky brown blemishes on the surface of the fruit. Only the epidermal cells are affected.

difference between these three and Dithane Z-78, nor between Dithane Z-78 and Coprantol. It is evident from the data that Orthocide 83, Fermate and colloidal sulfur, under the conditions of this experiment gave obviously better results from the growers' standpoint than did the other chemical treatments.

Under repeated visual observations it has been noticed that the trees receiving any of the chemical treatments appeared in general much healthier than the checks and they had a better overall color cast, which is indicative of the better growing conditions made possible by a degree of protection from fungus pests.

A very minor disease occurring in the orchard exclusively on the leaves was the Phyllosticta leaf spot. This was checked almost completely and trees towards harvest time showed very little or even non of the Phyllosticta leaf spots evident.

Data collection was made on the severity of infection of loquat scab on leaves. Leaves bearing scab lesions (see Figure 6) were counted out of 200 leaves from each tree and the percentage of scabbed leaves was calculated. Table VIII and Figure 7 show leaf infection data. Analysis of variance for leaf infections is shown in Table IX.

Statistical analysis of leaf infection data shows that there are no significant differences due to treatments.

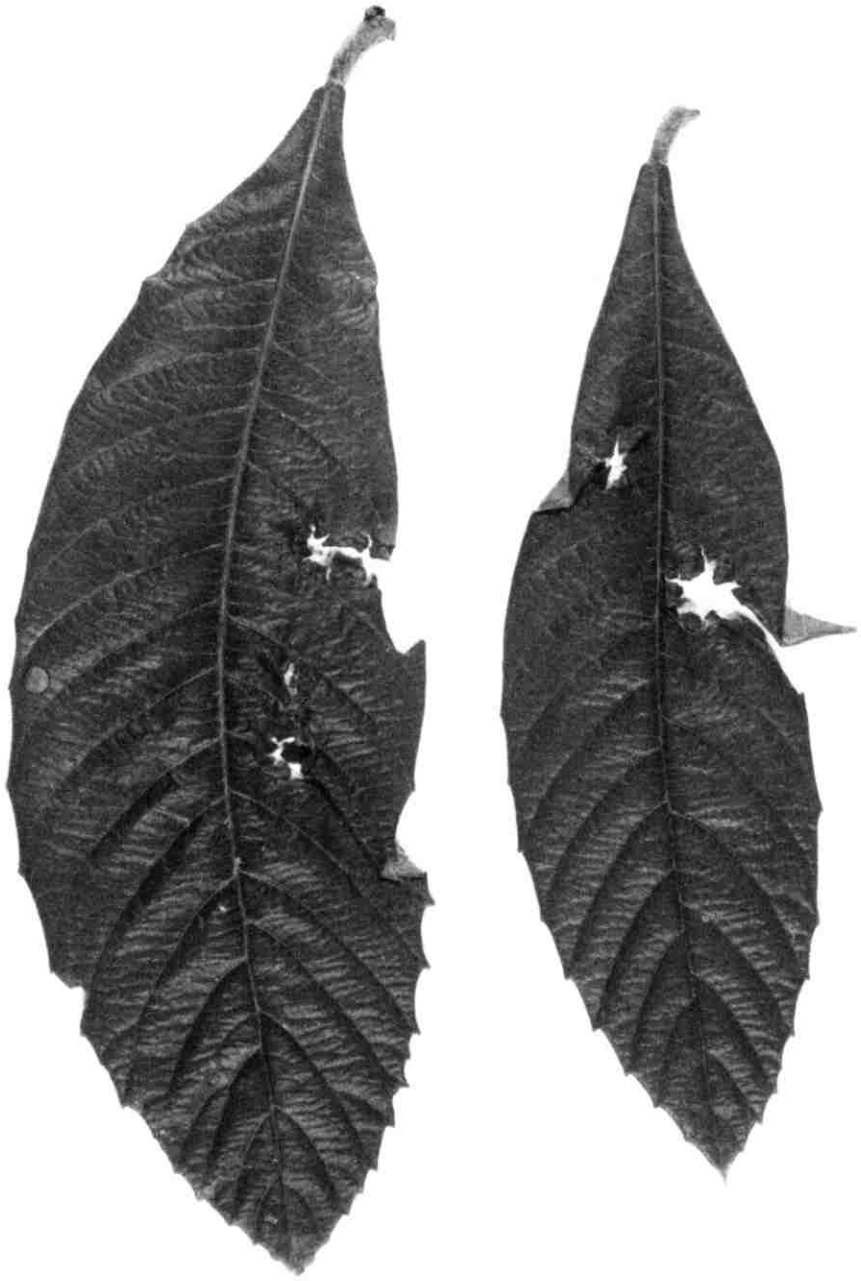

Fig. 6. Scab lesions on loquat leaves. These spots are circular to irregular, olive green to dark grey in color, velvety, and may coalesce and later become dessicated and drop out leaving a ragged appearance.

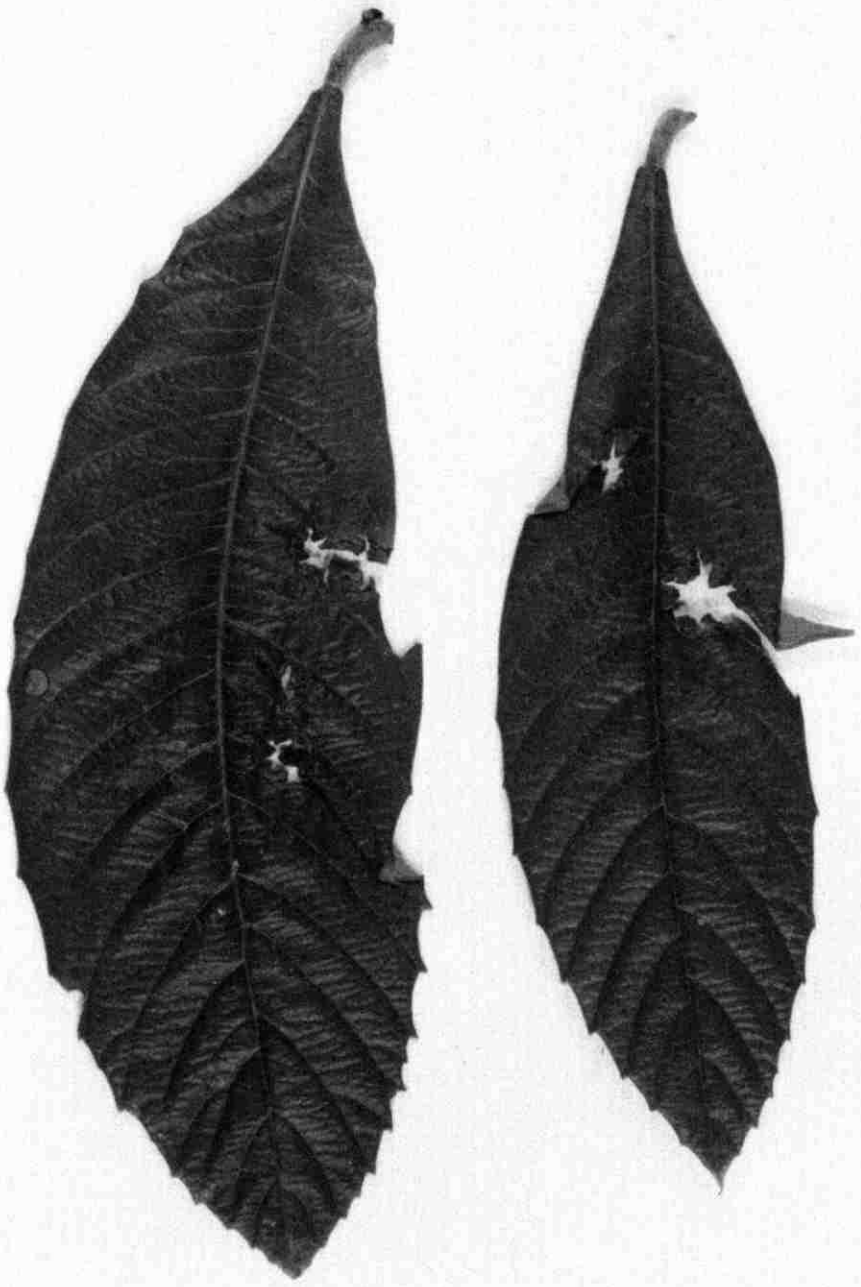

Fig. 6. Scab lesions on loquat leaves. These spots are circular to irregular, olive green to dark grey in color, velvety, and may coalesce and later become dessicated and drop out leaving a ragged appearance.

Table VIII. Summary of results of spraying experiments for the control of loquat scab 1957-1958 (on leaves)

Treatment No.	Counted leaves No.	Scabbed leaves No.	Scabbed leaves Percent
A1	200	1	0.5
B1	200	3	1.5
C1	200	2	1.0
D1	200	9	4.5
E1	200	10	5.0
Mean			2.5
A2	200	0	0.0
B2	200	1	0.5
C2	200	1	0.5
D2	200	0	0.0
E2	200	0	0.0
Mean			0.2
A3	200	0	0.0
B3	200	0	0.0
C3	200	1	0.5
D3	200	0	0.0
E3	200	1	0.5
Mean			0.2

Table VIII (Cont'd)

Treatment No.	Counted leaves No.	Scabbed leaves No.	Scabbed leaves Percent
A4	200	2	1.0
B4	200	1	0.5
C4	200	0	0.0
D4	200	0	0.0
E4	200	0	0.0
Mean			0.3
A5	200	0	0.0
B5	200	1	0.5
C5	200	0	0.0
D5	200	2	1.0
E5	200	5	2.5
Mean			0.8
A6	200	0	0.0
B6	200	0	0.0
C6	200	10	5.0
D6	200	13	6.5
E6	200	0	0.0
Mean			2.3

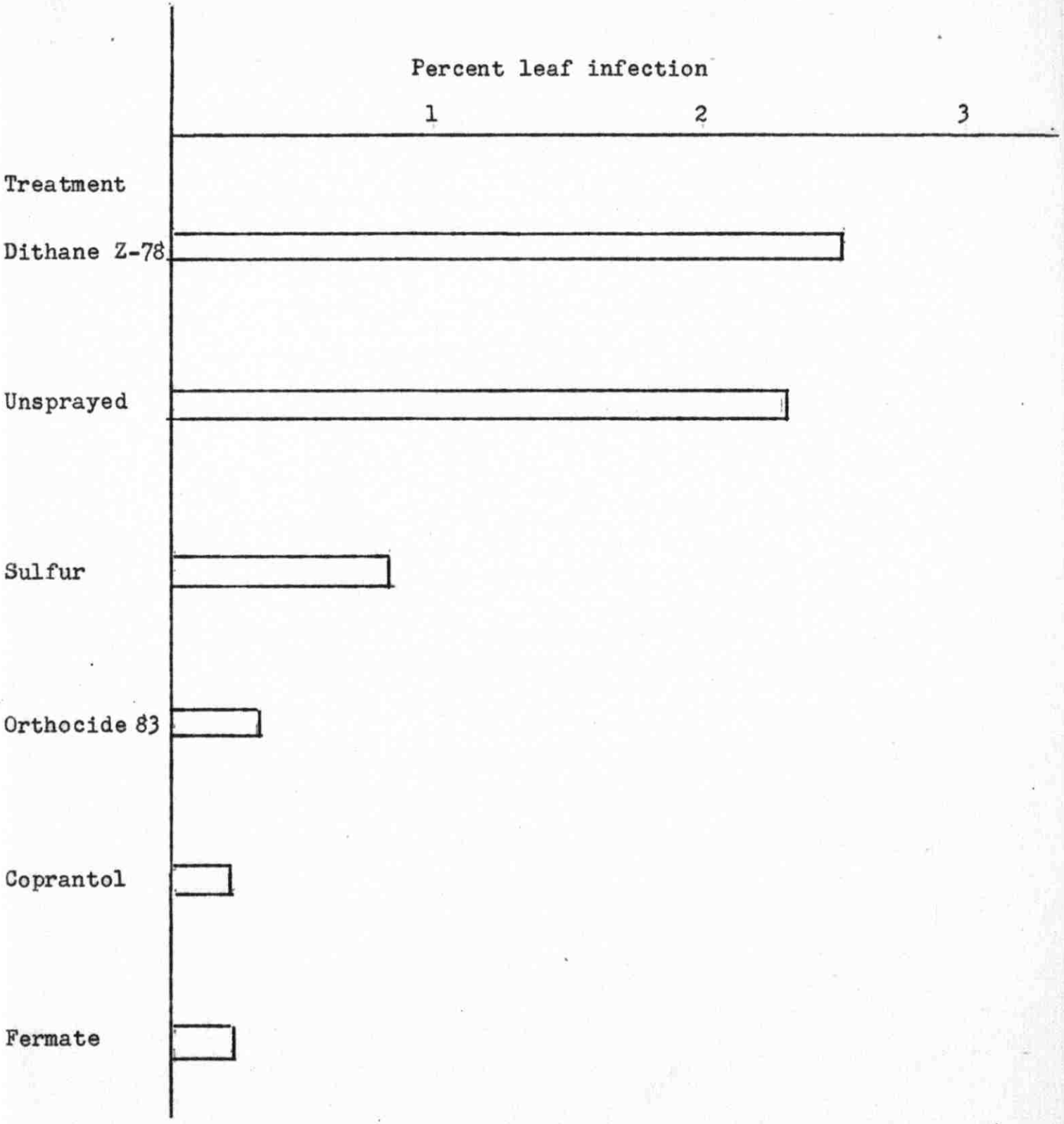

Fig. 7. Mean percentage of leaf infection for each treatment during 1957-58.

Table IX. Analysis of variance of the loquat scabbed leaves

Source of error	Degrees of freedom	Sum of squares	Mean square	F value
Treatments	5	28.675	5.735	2.191
Blocks	4	11.633	2.908	1.111
Error	20	52.367	2.618	
Total	29	92.675		

F_{05} for treatments = 2.71

F_{05} for blocks = 2.87

Critical difference between treatments = 2.134

B. Experiments of 1958-1959.

The purpose of the 1958-1959 investigation was to compare the effectiveness of various spray schedules in the control of loquat scab, using sulfur and Orthocide-83.

The season was characterized by scanty rainfall with relatively dry weather that prevailed early in the season in November and December of 1958 (see Figure 8). The temperature was moderate during November and December 1958 to very low during January and part of February 1959. Such dry weather during the early part of the season has greatly influenced loquat scab infection and development. The requirements for conidia dissemination and infection which depend mainly on rainfall were not met and such unfavorable

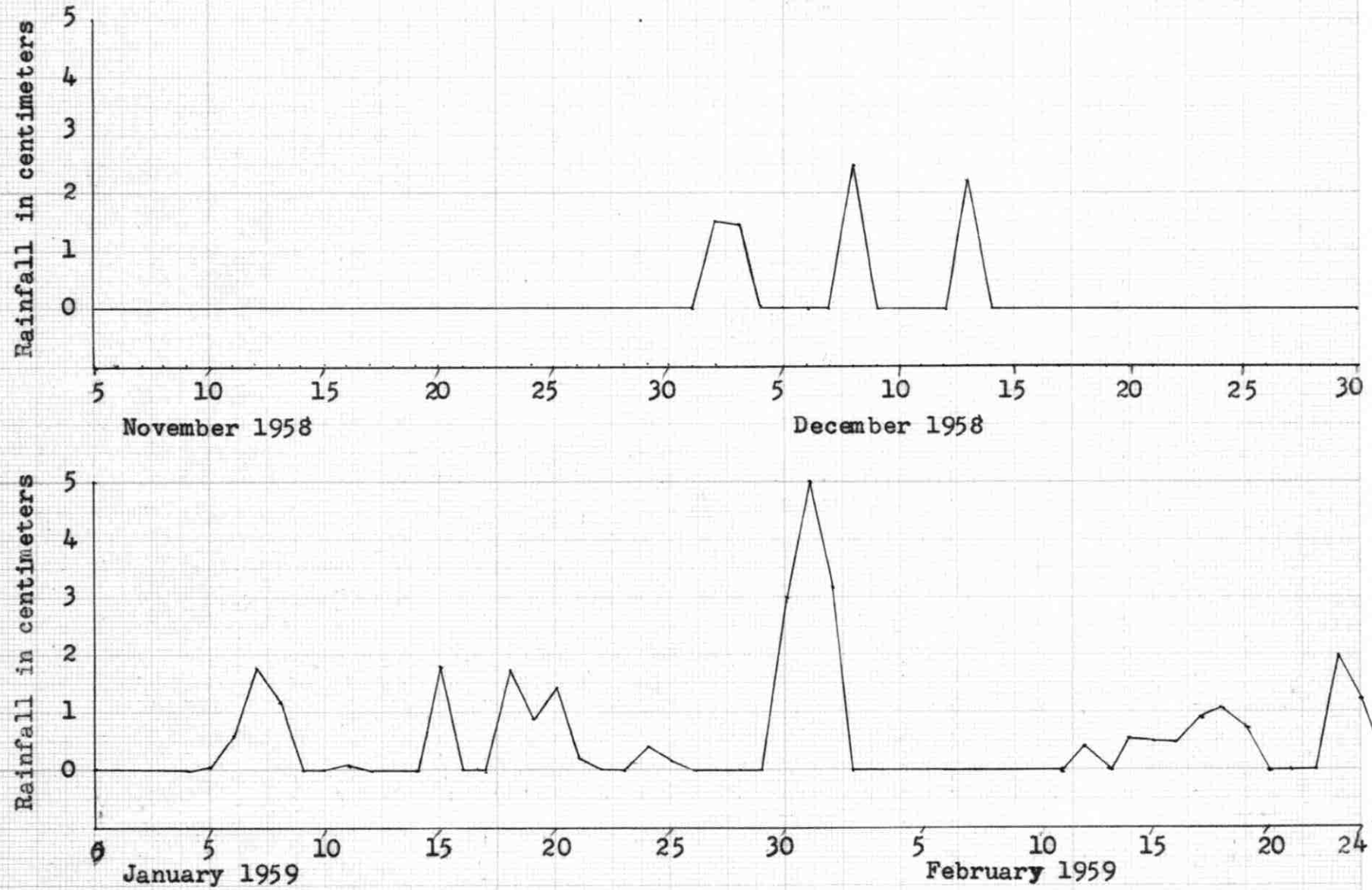

Fig. 8. A graphic summary of daily rainfall records in centimeters during the spraying season.(Records taken from, Bulletin Climatologique Mensuel, Nos. 3,4,5,6, Ministère des Travaux Publics, Observatoire de Ksara, Liban, 1958-59).

weather conditions in general retarded scab development to such an extent that new lesions were not noticed, even on the unsprayed checks, before the second week of January 1959.

Keitt and Jones (18) reported that conidia of Venturia inaequalis, causal agent of apple scab, whose imperfect stage is a closely related pathogen to Fusicladium eriobotryae, are very resistant to separation from their condiophores under dry conditions but easily detached when water is present. Frey and Keitt stated that "These results, in conjunction with those from the air filtration experiments, indicate that no important dissemination of conidia is to be expected in the absence of water, though undoubtedly some spores are dislodged by wind-whipping of leaves, fruits, or branches, by contact with wind-blown particles, and in other minor ways. It appears, therefore, that the important agency for dissemination of these conidia is meteoric water moving under the influence of wind and gravitation."

The initial inoculum was abundant as usual in the orchard. During the harvest season of 1958 many scabbed fruits and leaves were left on the trees with no sanitation measures practiced.

Towards the time of harvesting season infection was still very light compared to previous years.

Table X shows the percentage of scabbed fruits on the unsprayed trees. All the sprayed trees, regardless of the schedule of application were free of fruit and leaf infection.

Such a condition has resulted to a large extent from the effectiveness of the spray materials combined with the unfavorable weather conditions that prevailed, during early and late periods, which checked scab infection and development. Such an arrangement of spray schedules should be repeated before any definite conclusions can be drawn. However, from close observations it might be suggested that schedules number 4 and 6 would prove to be of value and economical to use. Schedule 7 is excellent for scab control but not economical and some early applications are not efficient because only very rarely do infections start as early as October or November.

Table X. Results of fruit scab infection on unsprayed trees 1958-59.

Tree No.	Counted fruits No.	Scabbed fruits	
		No.	Percent
A13	250	89	35.60
B13	350	37	10.57
C13	300	28	9.33
D13	250	34	13.60
E13	350	90	25.71

It should be stressed that caution be taken in using sulfur when hot spring days approach because this year sulfur injury, manifested as russetting, was very common and severe on treatments receiving sulfur in their schedules.

Captan again performed very efficiently with desirable effects on fruits and with no toxicity of any kind observed.

SUMMARY AND CONCLUSIONS

Loquat scab caused by Fusicladium eriobotryae is the most destructive disease of the loquat (Eriobotrya japonica) in Lebanon. It causes severe losses in the fruit crop, due primarily to fruit infection.

Investigations were conducted for two consecutive years to determine the relative effectiveness of five different fungicides, Dithane Z-78, Fermate, Coprantol, Orthocide 83, and colloidal sulfur, and also to determine economical and effective spray schedules for the control of this disease.

The experiments were performed in a commercial loquat orchard in Saida, the treatments were replicated five times in randomized blocks.

Spraying experiments conducted during 1957-58 to evaluate the efficacy of the five different fungicides gave the following results on disease control. All the five chemical treatments showed highly significant differnece from the check. Of the materials used Fermate, Orthocide 83, colloidal sulfur and Dithane Z-78 exhibited no significant differneces in their ability to control fruit and leaf infections. According to the growers' point of view Coprantol and Dithane Z-78 do not give satisfactory control. Taking into consideration fruit finish and phytotoxicity, the three remaining materials listed in descending order of desirability to use Orthocide 83, collidal sulfur and Fermate. Orthocide 83 gives an excellent control with a desirable smooth fruit

finish. Colloidal sulfur is economical and easily available on the market but has the slight disadvantage of producing russetting on fruits, a condition lowering their market value. Care should be taken towards late season not to spray during hot sunny days. Fermate gave excellent control effects but its use is messy to the workers applying it and it leaves an undesirable black residue on the fruits. If it is to be used, the last two sprays should be with Orthocide 83 or sulfur.

Field experiments of 1958-59 were performed in the same orchard with the purpose of comparing six different spray schedules using Orthocide 83 and colloidal sulfur. Weather conditions were very unfavorable for fruit and leaf scab infection. Infection on trees receiving either fungicide at any of the spray schedules was completely absent and consequently no definite conclusions could be drawn concerning the time and number of applications required for economical and adequate control. However, all treatments showed significant difference from the check. Considering observations on time of initial infection and other environmental conditions concerned, spray applications should start early in December and continue to about the third week in February with an interval of two weeks between applications. Frequency of application should be governed by the prevailing climatic conditions, particularly rainfall. Orthocide 83 again performed very well followed by sulfur which showed prominent russetting on fruits exposed to direct sunlight.

LITERATURE CITED

1. Abou Nasser, Adel, Zira'it Al-Akkidunieh, Assilsilah Azzi-ra'ieh No. 1, Al-Maktab Attejari, Beirut, 1957.

2. Al-Majlis Al-A'la Liljamarik, Ihsa'at Attejara Al-Khari-jieh, Beirut, 1955-1957.

3. Anderson, H.W., Diseases of Fruit Crops, McGraw-Hill Book Co., Inc., New York, 1956.

4. Birmingham, W.A., Two fungous diseases of the loquat, Agric. Gaz. New South Wales, xliii, 11, pp 863-867, 1932. R.A.M., 12:231-2, 1933.

5. Bremer, H., H. Ismen, G. Karel and M. Ozken, Beitrage zur Kenntnis der parasitischen Pilze der Turkei. I. Rev. Fac. Sci. Univ. Istanbul, Ser. B, xiii (2): 122-172, 1947. R.A.M. 26:533, 1948.

6. Burrell, A.B., A guide to apple scab control, Am. Fruit Grower, 76(2):17+, 1956.

7. Cation, D., Timing is important for successful apple scab sprays, Mich. State Agr. Exp. Sta. Q. Bul. 36:349-56, 1954.

8. Cohen, Sylvan L., Effectiveness of three phenyl mercury formulations for the control of apple scab, phyt. 41:657, 1951 (Abstr.).

9. Cristinzio, M., Alcune malattie crittogamiche del Nespolo del Giappone ed in particolare la "ticchiolatura". (Some fungal diseases of loquat and, in particular, scab.) - Ric. Oss.vz. Divulg. fitopat. Compania ed Mezzogiorno (Portici), iv, pp 25-50, 1935. R.A.M. 14:777, 1935.

10. Davis, R.A., Fruit-growing in South Africa, Central News Agency, Ltd., South Africa, 1928.

11. D'Oliveira, B., Apontamentos para o estudio do género Fusicladium. III. Fructificacao conidial dos Fusicladia dendriticum, Pirinum e eriobotryae (Indications for the study of the genus Fusicladium. III conidial fructification of Fus. dendriticum, F. pirinum, and F. eriobotryae), Rev. Agron., Lisboa, xxv, 2:140-164, 1937. R.A.M. 17:656-7, 1938.

12. _____., Phytopathological notes, Rev. Agron., xxiii, 1, pp. 50-51, 1935. R.A.M. 15:184, 1936.

13. D'Oliveira, B. and Maria D'Oliveira, Nota sobre os corpos M. do tricoginio e do anteridio nas Venturia inaequalis, V. pirine e V. eriobotryae. Agron. lusit., 8(4): 291-301,1946. R.A.M. 28:460, 1949.

14. Hamilton, J. M. and D. H. Palmiter, Orchard tests for apple scab control in New York State: I. Sulfur fungicides, N.Y. State Agr. Exp. Sta. Bul. 747, 1951.

15. Hilborn, M. T. and F. H. Lathrop, Organic fungicides in the control of apple scab and European red mite, Phyt. 41: 52-55, 1951.

16. Hughes, S. J., Some foliicolous hyphomycetes, Can. J. Bot. 31:560-576, 1953.

17. Keitt, G. W., Scab of apples, U.S.D.A., Yearbook 1953; 646-52, 1953.

18. _____., L. K. Jones, Studies of the epidemiology and control of apple scab, Wisconsin Agr. Exp. Sta. Res. Bul. 73, 1926.

19. Kirby, R. S., Relation of rainfall to occurrence of apple scab and sooty blotch, Phyt. 44:495, 1954 (Abstr.).

20. Klindic, O. and I Milatoric, Krastavost japanske Musmule, (Plant Prot., Beograd) 1951 (5):39-43, 1951. R.A.M. 31:335, 1952.

21. McNew, G. L. and N. K. Sundholm, The fungicidal activity of substituted pyrazoles and related compounds, Phyt. 39:721-751, 1949.

22. Menon, R., Studies on Venturiaceae on rosaceous plants, Phytopath. Z., 27(2):117-146. 1956. R.A.M. 36:278, 1957.

23. Ministére d'Agriculture, Departement de Statistique Agricole, Statistique Annuelle Agricole, 1955-58.

24. Naik, K. C., South Indian fruits and their culture, P. Varadachary and Co. 8 Linghi Chetty St. Madras, 1949.

25. Palmiter, D. H. and F. H. Emmerson, Fungicide mixtures as a possible means of improving apple scab and rust control, Phyt. 43:109, 1953, (Abstr.)

26. _____., and R. M.Smock, Preliminary report on fungicides in relation to apple yield and quality, Phyt. 41:659, 1951 (Abstr.).

27. Petri, L., Rassegna dei casi fitopatologici osservati nel 1939, Boll. Staz. Pat. veg., Roma, N.S., xx(1):1-70, 1940. R.A.M. 19:582, 1940.

28. Popenoe, W., Manuel of tropical and subtropical fruits, The Macmillan Co., New York, 1924.

29. Reich, Hans, Die vorteile und nachteile der Wichtigsten organischen fungizide dei der Fusicladium bekampfung, The 14th International Horticultural Congress Rep., pp. 819-926, Netherlands, 1955.

30. Rohm & Haas Company, Triton, Surface-active agents, Philadelphia, 1951.

31. Salerno, M., La ticchiolatural del Nespolo del Giappone, Tec. Agric., (1956) (7-8):356-359, 1956. R.A.M. 36: 479, 1957.

32. Sarejanni, J.A., S.D. Démétriades and D.G. Zachos, Rapport sommaire sur les principales maladies des plantes observées en Grece au cours de l'année 1957, Ann. Inst. Phytopath. Benaki, 6 (1):5-9, 1952. R.A.M. 33:208, 1954.

33. Schroeder, C.A., The loquat, Texas Avocado Society Year book 1949:69-73, 1949.

34. Smith, R.E., Diseases of fruits and nuts, Calif. Agr. Ext. Serv. Cir. 120:79, 1941.

35. Smith, F.O., and W.F. Buchholtz, Evaluation of apple fungicides for Iowa, Phyt. 41:32-33, 1951 (Abstr.).

36. Stevens F.L. Plant disease fungi, The Macmillan Company, New York, 1954.

37. Storey, I.F. and J.V. Ives, Spraying practice against apple scab on Bramley's seedling in the Wisbech area, 1953 and 1954. Plant Pathology 5:1-8, 1956.

38. Sturrock, D., Tropical Fruits, Arnold Arb. Harvard U. Jamaica Plain, Mass. U.S.A. 1940.

39. Swales, J.E. and K. Williams, Further note on surfactants in concentrate mixture for control of apple scab, Can. J. Plant Sci. 37:82-83, 1957.

40. _____. and _____, Non-ionic surfactants in concentrate mixtures for the control of Apple Scab, Can. J. Agr. Sci., 36:36-40, 1956.

41. Thurston, H.W., Jr., Organic fungicides on apples in 1950, Phyt. 41:660, 1951.

42. U.S.D.A. Index of plant diseases in the United States, Plant disease survey, Part V, p 933, Washington D.C., 1953.

ACKNOWLEDGMENT

The writer wishes to express his deep gratitude to Dr. Frank O. Smith for the suggestion of the problem, supervision, constant advice, criticism, and assistance in the preparation of the manuscript. He is also grateful to Mr. Fuad Kalash for the use of his loquat orchard for conducting the experiments. Acknowledgments are also due to all those who have helped to make this study and the writing of the manuscript possible, in particular Mrs. Sakhnini and Miss Suad Nujeim who helped in typing the manuscript.