above with an insecticide packet in each half. Another group had only one insecticide packet per tree and a third group had none.

Results and Discussion

Results from the early tests demonstrated that insect populations around the tree trunks were drastically reduced when one or more insecticide packets of the configuration described above were present within the wrap. Diazinon was seen to be somewhat more effective than Chlordane in eliminating insects at the vapor concentrations produced.

The results to date in the continuing long term test are presented in Table 1. It can be seen that wraps with two packets of insecticide are very effective in controlling ants within the wrap even after eleven months of exposure. Only 1.5% of these wraps were found to contain live ants. Even a single packet per wrap was found to have a significant effect in ant control with live ants found on 12% of the trees compared to 61% with live ants where no insecticide had been applied. Dead ants were found at the bottom of the wrap on 54% of the trees with two packets and on 28% of the trees with one insecticide packet. As expected no dead ants were found in the wraps in the group of trees without insecticide. Therefore the concentration of Diazinon vapor inside the central chamber of the wrap is lethal to ants depending upon its concentration, and that concentration is proportional to the surface area of the insecticide packets contained. Further, on all trees with wraps containing insecticide the number of ants seen was always very few, and none had nests at the base of the tree.

Future Work

In view of the number of uncontrollable variables in this application of insecticide, we believe that field tests such as those described here are the most meaningful way of determining the effective life of insecticide packets such as those described here are the most meaningful way inside tree wraps. The ongoing test discussed above may take several years to dissipate the insecticide if calculated vapor transmission rates apply in practice.

In order to enlarge our data base another combined life-effectiveness test involving nine hundred trees is now in place. In this test, the surface area of the packets has been increased 50% and the quantity of insecticide per packet has been doubled.

Table 1. Long term ant control with Diazinon vapor inside a semi-rigid tree wrap.

Surface area for vapor release in square inches	Diazinon per wrap in grams	Number with live ants in percent		Number with dead ants in percent	
		6 months	11 months	6 months	11 months
32	4	13	1.5	90	54
16	2	18	12	71	28
0	0	47	61	0	0

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PROGRESS OF CITRUS CANKER ON SOME SPECIES AND COMBINATIONS IN ARGENTINA[1]

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Abstract. **Citrus canker, caused by** Xanthomonas campestris **pv.** citri **(Hasse) Dowson strain "A", is spreading within citrus groves in Corrientes and in Entre Rios provinces, Argentina. Progress of disease was determined by recording incidence of disease on trees of several citrus species, varieties, and combinations. The proportions of diseased trees (y) plotted vs. time were asymmetrical sigmoidal curves. Thus, the Gompertz transformation was used to linearize the curves and to obtain estimates of epidemic rate (k). In a Corrientes citrus grove, disease incidence was followed on three citrus types on Trifoliate rootstock for 13 months. The infection rates (k) per month for incidence of citrus canker were 0.18 for Navel orange, 0.1 for Satsuma, and 0.06 for 'Comun' mandarin. At a rate of 0.18 per month (as for Navel orange) the proportion of diseased trees increased from 0.1% to 58% in 13 months. In an Entre Rios citrus grove, progress of disease incidence on trees was calculated for 22 months. The average infection rates (k) of canker per month were higher (k=0.13 and 0.24) among trees of 'Valencia Late' on Rough Lemon rootstock than among trees of 'Valencia Late' on Trifoliate rootstock (k=0.04 and 0.12) after low and high percentages of diseased trees were eradicated, respectively. For 'Ellendale' on Trifoliate the average infection rate (k) was 0.04 per month. Thus, the spread of citrus canker was affected by scion types, rootstocks, and percentage of previously eradicated trees.**

The rate of spread of citrus canker, caused by *Xanthomonas campestris* pv. *citri* (Hasse) Dowson *(X.c.c.)* strain "A", in groves has not been determined quantitatively. The eradication campaigns have precluded much gathering of information on spread. After citrus canker was introduced into a new geopraphical area, its spread was reported as "rapid" (4,5). The rate of spread of canker in a citrus

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grove is likely a function of rain and the velocity of concurrent wind (15). The wind-blown rain carries bacteria that ooze from existing lesions (15). Only young leaf tissues and fruit are susceptible to canker (14) so spread occurs mainly in the growing season (10, 14). Differential susceptibility of citrus types to canker is known. Grapefruit cultivars are considered very susceptible. Sweet oranges are susceptible and mandarins are resistant. 'Valencias' are intermediate between other sweet oranges and mandarins (6, 11).

In Argentina, strain "A" of *X.c.c.* was first observed in Misiones province in 1972 (DuCharme, personal communication). Systematic surveys to detect groves with canker were conducted in Entre Rios province in 1977 and 1978. Eradication of diseased trees was done in Entre Rios during that period but ceased in June 1978.

In this study, we report on the spread of citrus canker through groves in Corrientes and Entre Rios, Argentina. The influence of several scion types, rootstocks, and certain sanitation practices on such spread was determined.

Materials and Methods

The study was conducted in two citrus groves in the same citrus growing region in northeast Argentina. One grove was situated in the southeastern portion of Corrientes province, Departmento Juan Pujol. Six commercial plots were selected for intensive study. These were planted in 1974 at a plant spacing of 7x7 m. Four surveys were conducted in the period of April 1979 to May 1980. During this period, all infected shoots were cut and burned as had been done in Japan (6, 7, 10); no entire tree removal was practiced.

The second grove was located in Entre Rios province, Departmento Federacion, Colonia Ensanche, about 70 km south of the above grove. Survey information from five plots was analyzed for spread of citrus canker. The trees were planted in 1971 at a spacing of 8x4 m. Four surveys had been accomplished prior to this study (Table 2). As citrus canker was detected in each survey, the affected trees were removed and burned. Beginning with the fifth survey in May 1979, no eradication of trees was done; only the shoots with lesions were cut and burned. The eighth survey was completed in April 1981.

Each experimental plot in both groves had all trees of the same scion-rootstock combination and all trees were of the same age. Five citrus types (Navel, 'Valencia Late', 'Ellendale', Satsuma, and 'Comun' mandarin) were observed in this study (Table 1). These five types account for 65% of the > 7 million citrus trees in the Entre Rios area.

Trees in two plots were on Rough Lemon (*Citrus limon* (L.) Burm. f.) rootstock. All other trees were on Trifoliate (*Poncirus trifoliata* (L.) Raf.) rootstock.

In all surveys, the trees were thoroughly inspected for canker lesions. The trees in all plots were young, hence small in size, which facilitated the inspection. If a lesion of citrus canker was found, the tree was considered diseased. Disease was expressed as proportion incidence; i.e., the number of diseased trees divided by the total number of trees for a particular plot.

Citrus canker was assumed to be a compound interest disease (sensu Vanderplank (16)). As such, linearization of the proportion incidence vs. time would ease epidemic analysis. Both the logistic (2, 16) and Gompertz (2) transformations were used to linearize the disease progress curves. Since the curves were asymetrically sigmoidal, the Gompertz transformation provided the better statistical fit. The disease proportions (y) were thus transformed by: gompit $(Y) = -\ln(-\ln(y))$.

A straight line was fitted through the gompit (Y) values by linear regression. The slope of the regression line was an estimate of the average epidemic rate (k) (2).

Results and Discussion

The disease incidence values were satisfactorily linearized

Table 1. Citrus types, tree populations, and disease incidence in two Argentinian groves observed for the spread of citrus canker.

Province	Plot	Scion/rootstock[z]	Tree population[y]	Incidence[x]
Corrientes	20A & 21A	Navel orange (*Citrus sinensis* (L.) Osbeck)/T	1168	0.004
	11 & 24	Satsuma (*C. reticulata* Blanco)/T	1086	0.005
	15 & 18	"Comun" mandarin (*C. reticulata* Blanco)/T	2035	0.02
Entre Rios	12	Ellendale (*C. reticulata* x *C. sinensis*)/T	1182	0.003
	13A	Valencia Late (*C. sinensis*)/T	650	0.003
	13B	Valencia Late/R. L.	527	0.017
	16	Valencia Late/T	308	0.006
	21	Valencia Late/R. L.	2631	0.037

[z]Rootstocks were Trifoliate (T) and Rough Lemon (R. L.).
[y]Number of trees at start of observation in April 1979 (Corrientes) and at fifth survey in May 1979 (Entre Rios).
[x]Proportion incidence at start of experiment (Corrientes) and at fifth survey (Entre Rios).

Table 2. Accumulative proportion incidence of citrus canker during the first four surveys in the Entre Rios grove, Argentina.

Plot	Scion/rootstock[z]	No. of trees[y]	Date of Survey			
			Sept. 1977	Feb. 1978	April 1978	May 1978
12	Ellendale/T	1313	0.0	0.0	0.06	0.1
13A	Valencia Late/T	868	0.1 (13A and 13B)	0.1 (13A and 13B)	0.32 (13A and 13B)	0.25
13B	Valencia Late/R. L.	1179				0.55
16	Valencia Late/T	1352	0.0	0.0	0.02	0.03
21	Valencia Late/R. L.	2649	0.0	0.0	0.004	0.006

[z]Rootstocks were Trifoliate (T) and Rough Lemon (R. L.).
[y]Number of trees in September 1977. Infected trees were removed and burned after discovery in each of the four surveys.

with the Gompertz transformation (Fig. 1 and 2). With this linearization, the rate (k) values could then be used to make epidemic comparisons and other interpretations. The k values ranged from 0.04 to 0.24 in the experimental plots.

In the Corrientes grove, disease spread was faster on Navel orange (k = 0.18) than on Satsuma (k = 0.1) or on 'Comun' mandarin (k = 0.06). In Japan, Navel and Satsuma are considered to be susceptible and moderately resistant, respectively (10). Thus, our results reinforce this ranking of citrus types in susceptibility to canker. In the Entre Rios grove, the spread of canker in plots of 'Ellendale' occurred at a slow rate of k = 0.04. 'Ellendale' has genetic origin in mandarin and sweet orange (3), but the epidemic rate for 'Ellendale' was not much different from 'Comun' mandarin.

In the Entre Rios grove, canker spread in the four 'Valencia Late' plots at rates of k = 0.04-0.24. The spread of canker in the 'Valencia Late' plots was confounded with differences in rootstocks and sanitation practices. The disease spread faster (k = 0.13 and 0.24) in 'Valencia Late' trees on Rough Lemon rootstock than in 'Valencia Late' on Trifoliate rootstock (k = 0.04 and 0.12) after low and high percentages of eradicated trees, respectively. The rootstock

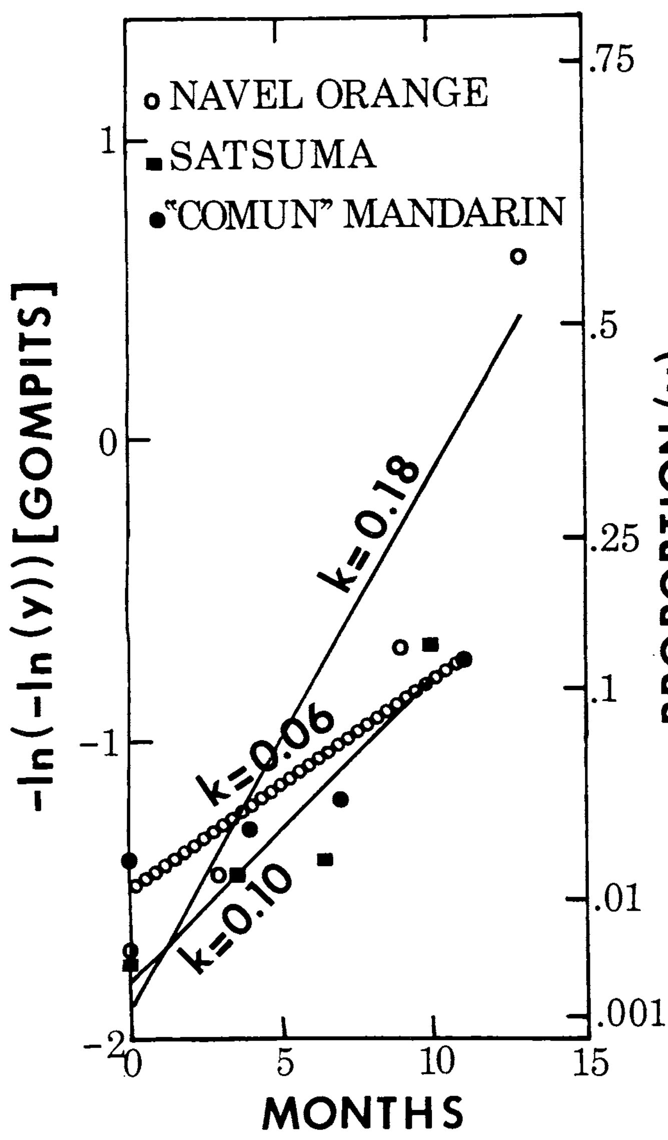

Fig. 1. Increase in incidence of citrus canker on trees in Corrientes grove, Argentina, since April 1979. The slope of the linear regression line of transformed disease proportions (y) is the average epidemic rate (k). The three citrus types were on Trifoliate rootstock.

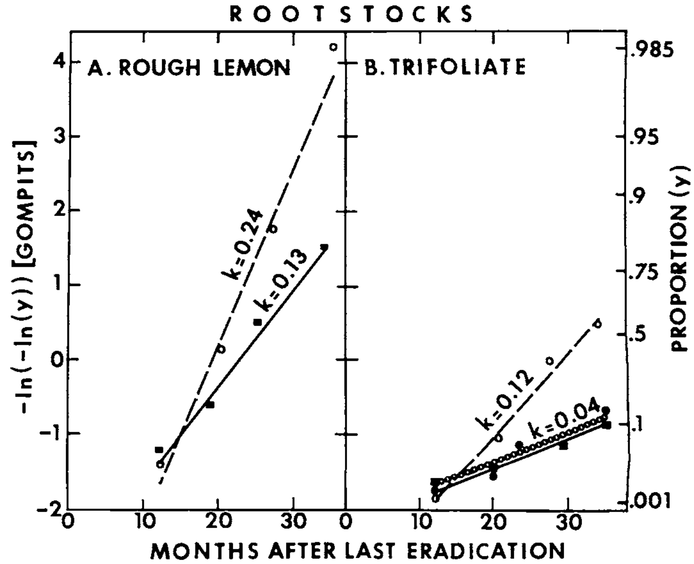

Fig. 2. Increase in incidence of citrus canker on trees in Entre Rios grove, Argentina. The slope of the linear regression line of transformed disease proportions (y) is the epidemic rate (k). A, 'Valencia Late' after 55% (– – – –) and 0.6% (——) of the trees in the plot were eradicated; B, 'Valencia Late' after 25% (– – – –) and 3% (——), and 'Ellendale' after 10% (● OOOOOO ●) of the trees in the plot were eradicated. Last eradication was in June 1978.

may have an indirect effect on the spread of citrus canker. Rough Lemon rootstock is known to cause the tree to have more growth than Trifoliate rootstock under similar cultural conditions (9). Trees on Rough Lemon rootstock may have longer or more frequent growth flushes than trees on Trifoliate. In these plots, trees on Rough Lemon rootstock were visibly larger than those on Trifoliate rootstock even though all other cultural practices were the same.

A low increase of disease incidence was present in all plots by 12 months after last eradication (Fig. 2). The subsequent average epidemic rate was faster in plots of 'Valencia Late' that received extensive eradication (>25%) compared to the rate in plots with little eradication (<3%) (Table 2, Fig. 2). Even though all trees with visible symptoms were removed after each of the first four surveys, it is very likely that the severely eradicated plots were widely contaminated with canker bacteria. Such contamination of neighboring trees and weeds is known to occur (15).

With the linearization of the incidence values by the transformation, extrapolation to earlier or later times is possible with confidence. If these regression lines are extrapolated toward initial epidemic stages (Fig. 2), then the epidemic seemingly began earlier in those plots which had only a low percentage of trees eradicated. Perhaps in the eradication process of carrying infected branches to a central site for burning, inadvertent inoculation of other standing trees took place.

Extrapolation of the regression lines to future time has good predictive value (1). As such, these predictions of future disease for specific scion-rootstock combinations may influence the decisions of growers on the worth of eradication procedures. It would not be profitable to selectively eradicate trees if present disease is high ($y > 0.05$) and rates are fast ($k > 0.1$). With these conditions over 40% disease incidence ($y = 0.4$) would be expected within the year.

The progress of citrus canker in our plots was followed by measuring disease incidence. The measurement of disease severity (total amount of host tissue involved in disease) would be more difficult, but perhaps, would provide a more accurate determination of *host* and environmental influences on disease progress. An incidence vs.

severity relationship for citrus canker could be determined as has been done for numerous other diseases. A citrus type that may have only one lesion per tree might be unfairly ranked by incidence with another variety that had thousands of lesions per tree. However, these incidence-severity relationships vary with season (8), pesticide application (13), location (8), and crop variety (12).

The calculation of epidemic rates for the increase in incidence of citrus canker among scions, rootstocks, and sanitation practices may provide growers with criteria upon which to base management decisions. In Florida, for example, 'Valencia Late' and Navel oranges comprise $>35\%$ of the citrus acreag. Rough lemon is the rootstock for $\sim$ 60% of the trees. If canker should be reintroduced into Florida, rather rapid spread of the disease can be anticipated since susceptible scion types are present and most of the trees are on a rootstock that increases the likelihood of infection.

The removal of infected shoots or entire trees would be expected to slow the disease spread as has occurred with other diseases (1). Such sanitation procedures should be combined with other rate reducing practices to be most effective (1).

We gained much insight into the spread of canker in groves with our epidemiological approach. We encourage future workers to obtain histories of disease progress so that critical analyses of location, cultivar, climatic, and other differences can be performed.

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SUMMER PRUNING OF ORANGE TREES[1]

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Abstract. **Based on experience in West China, physiological responses to pruning of orange trees are quite different from apples. While winter pruning in suitable but not excessive amounts stimulates the vegetative processes of apples, it enhances the reproductive processes of citrus and summer pruning does the opposite.**

As a supplementary practice to winter pruning, summer pruning of oranges at the right time with specific techniques will invigorate neglected and old trees and modify the alternate bearing habit of healthy trees. During the on-year, trees respond to moderate summer pruning by producing moderate amounts of summer flushes which increases the shedding of young fruits. Thus, the on-year crop will be reduced and the next year crop increased. This is "physiological thinning," as compared to chemical or hand thinning. Excessive summer pruning before the time of "June drop" can result in considerable fruit drop.

Growth patterns and endogenous processes of fruit trees differ during the season and from season to season. Therefore, the responses to pruning practices in different seasons also may differ distinctly. These phenomena have been found in apple orchards, for example, in Germany, Lange (ca. 60's reported that "Summer pruning (of apples) promotes reproductive development and winter pruning promotes vegetative growth" (Der Sommerschnitt fordert . . . der Fruchtbarkeit; der Winterschnitt fordert . . . die Triebkraft). However, for citrus fruits little work has been done on the relation of pruning to fruiting habit.

According to research in the humid Chungking area of West China it was found that winter pruning of orange trees in moderate amount of cuts can enhance vegetative growth and also improved fruit setting, probably through the improvement of sunlight penetration into the canopy. Whereas, summer pruning just before the appearance of an early summer flush vigorously stimulated vegetative growth and enhanced "June drop." These findings suggest that physiological responses between apples and oranges to pruning, especially summer pruning, appear to be opposite. In other words, summer pruning of mature orange trees promotes vegetative growth while summer prunning of mature apple trees promotes reproductive development.

Materials and Methods

The material and methods for this report are common

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