Determination of the Distribution of Psorosis in Commercial Plantings

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ABSTRACT. The objective of the present work was to determine the distribution of trees with symptoms of psorosis A in commercial citrus plantings. Approximately 10,000 trees of Valencia Late on rough lemon in the groves of Pindapoy S.A. in Saladas, Corrientes, Argentina, were surveyed. The distribution of trees with scaly bark symptoms was evaluated by the method of Bitancourt and Fawcett. Grouping of diseased trees was not detected and distribution appeared to be random, suggesting that there was not tree to tree spread. The high proportion of infected trees suggested some type of transmission, perhaps by buds or insects. Plant age was correlated to number of symptomatic plants and the proportion of trees with symptoms was greater in orchard 27 and 31 years old than in an orchard 17 years old.

The economic significance of the damage that psorosis virus causes has been known since the last century (14).

Fawcett (5) established the viral nature of the disease and in collaboration with others studied transmission and control as well as the different types or strains of this virus (6, 7, 8, 9, 11). Later, it was established that psorosis could be transmitted through the seed of some rootstocks, but only in low percentage (2, 12) and by natural root grafting in the field (1).

The knowledge obtained of this disease made it possible to produce psorosis free citrus plantations by seedling selection and use of psorosis-free buds since no insect vector was known. It was considered that the psorosis epidemics could take more than half century to develop with a natural spread so low that it was impossible to demonstrate in the field.

In a commercial grove in Bella Vista, Corrientes, 20% of the trees were affected by bark-scaling at 14 years of age and random distribution of affected trees was observed (4). Subsequently the percentage of diseased trees has increased.

The objective of the current work was to determine the distribution of psorosis-affected trees (bark-scaling) in three commercial groves of different ages and to test the relationship of age and number of trees to the psorosis symptoms.

MATERIALS AND METHODS

The citrus trees surveyed were Valencia Late grafted on rough lemon rootstocks in three groves of Pindapoy, S.A. in Saladas, Corrientes, Argentina. All trees were spaced 7 m x 7 m. The mother trees of these groves were selected in Concordia, Entre Ríos, as virus-free. The number and age of trees and groves surveyed are as follows: 1) "La Florida" grove; 3,568 trees 17 years old, 70 trees 3 to 7 years old, and 96 trees 1 year old for a total of 3,734 trees; 2) "La Armonía" grove; 2,890 trees 27 years old, 394 trees 3 to 7 years old, and 503 trees 1 year old for a total of 3,787 trees; and 3) "Mabel y Pico" grove; 2,701 trees 31 years old, 242 trees 3 to 7 years old and 321 trees 1 year old for a total of 3,264 trees.

The soil type for these orchards is Yataytí Calle series with a sandy, very deep A horizon (10).

All trees were surveyed in October, 1982 and those with bark-scaling (psorosis symptoms) were mapped.

The method of Bitancourt and Fawcett (1) was used to determine the distribution of trees with

symptoms. In this method, the 8 adjacent trees around the central tree, should be evaluated. Four trees will be located at a distance L and 4 at distance 1.4L of central tree where L equals the 7m planting distance. The adjoining 16 trees should also be evaluated, and 4 will be located at 2L and 4 at 2.8L from the central tree.

Because of a previous report (4), only the 7 m (L) and 10.5 m (1.4L) distance from central tree were considered in this work.

This method also suggests calculating (for each distance) the average of trees with symptoms around central trees with and without symptom and to evaluate the significance of the difference among those averages by the "t" test.

To measure the spread of the plants with symptoms (randomly distributed), the I_D (index of spread) (13) was calculated for each grove.

$$I_D = \frac{S^2 (n-1)}{\bar{x}}$$

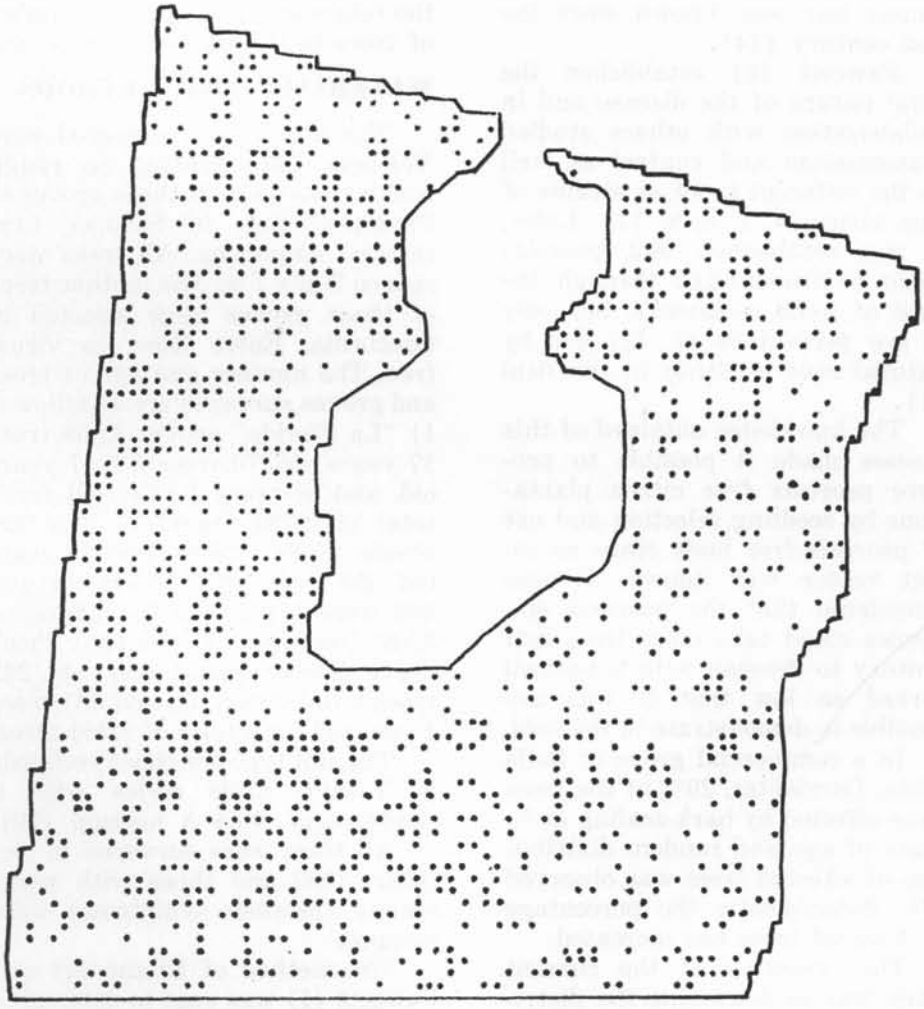

Fig. 1. Distribution of plants with psorosis symptoms in the grove "La Florida" near Saladas, Corrientes, Argentina. The groves had 3,734 trees of Valencia orange on rough lemon of 17 years of age.

TABLE 1
COMPARISON OF THE MEAN NUMBER OF TREES WITH AND WITHOUT PSOROSIS SYMPTOMS, SURROUNDING INFECTED OR SYMPTOMLESS TREES AT DISTANCES OF 7 AND 10.5 METERS FROM THE CENTRAL TREE.

Orchards and tree age	Distance from the central tree	Total number of trees	% without symptoms	Mean number of trees with symptoms surrounding		df	"t" $\alpha = 0.05$
				Central tree without symptoms	Central tree with symptoms		
La Florida (17 years)	7 m	3,474	20.15	1.42	1.57	384	0.1478 N.S.*
	10.5 m	3,267	19.13	1.31	1.41	361	0.0964 N.S.
La Armonía (27 years)	7 m	3,456	30.50	1.93	2.35	382	0.4386 N.S.
	10.5 m	3,249	30.78	2.11	2.08	359	0.0270 N.S.
Mabel y Pico (31 years)	7 m	3,195	34.87	2.29	2.67	352	0.4034 N.S.
	10.5 m	3,195	33.93	2.46	2.44	352	0.0192 N.S.

N.S. = non-significant.

where S^2 = observed variance
$\bar{x}$ = observed average
(n–1) = number of samples

To determine if there is relationship among the number and age of plants with symptoms, the chi-square test of independence was applied (3).

RESULTS AND DISCUSSION

The distribution of trees with bark-scaling symptoms (psorosis), in three Valencia orange groves analyzed was random, which is in agreement with previous results (4).

The distribution of plants with psorosis symptoms in one grove is shown in fig. 1. The other two groves surveyed had similar distributions.

When comparing statistically the means of trees with symptoms around a healthy one or a symptomatic one, in none of the three groves were plants with symptoms at 7 m and 10.5 m distance from the central tree grouped (table 1). These results indicate that there was no plant-to-plant transmission and that the spread by tilling tools was unlikely.

To corroborate the results obtained with the preceding method, the index of spread was calculated. This index did not give significant differences which also demonstrated that the diseased trees in all three groves are randomly distributed.

Considering that these plantations were produced from virus-free mother plants, the high percentage of tree with psorosis symptoms was surprising. The percentage of infection in mature trees ranged from 36% in "La Florida" grove to 68% in the "Mabel y Pico" grove.

Replants exist in each grove surveyed which are now 3 to 7 years old. The infection percentage in these plants ranged from 35% in "La Armonía" grove to 66% in "Mabel y Pico" grove) (table 2, last row).

Due to the high number of infected trees, the relationship between the number and age of symptomatic trees was investigated. Trees of different ages in the three groves were compared. The chi-square test gave $x^2 = 863.2^{**}$. This statistically significant difference indicated that in the surveyed groves the percentage of psorosis infection was correlated with tree age (table 3). Comparison of disease percentages in all three groves confirmed this correlation (table 4).

When 3 to 7-year-old trees were analyzed from all three groves, large numbers of plants with psorosis were found in the oldest

TABLE 2
NUMBER AND PERCENT OF PLANTS WITH AND WITHOUT SYMPTOMS OF PSOROSIS IN 3 GROVES OF VALENCIA ON ROUGH LEMON OF DIFFERENT AGES

Grove	Plant age (years)	Number of plants	Healthy plants (%)	Plants with symptoms (%)
La Florida	17	3,568	63.88	36.12
	3-7	70	61.43	38.57
La Armonía	27	2,890	33.64	66.36
	3-7	394	64.47	35.53
Mabel y Pico	31	2,701	31.51	68.49
	3-7	242	33.06	66.94

TABLE 3
NUMBERS OF PLANTS OBSERVED WITH AND WITHOUT SYMPTOMS OF PSOROSIS. THE HIGHLY SIGNIFICANT X^2 TEST INDICATES NON INDEPENDENCE OF NUMBER OF PLANTS WITH SYMPTOMS AND PLANT AGE

Grove	Plant age years	Number of healthy plants	Number of plants with symptoms
La Florida	17	2,279	1,289
La Armonía	27	972	1,918
Mabel y Pico	31	851	1,850

X^2 = 863.20** chi square test for independence

TABLE 4
PROPORTION OF VALENCIA ORANGE ON ROUGH LEMON TREES OF DIFFERENT AGES WITH SYMPTOMS OF PSOROSIS

Grove	Plant age (years)	Proportion of trees with psorosis symptoms
La Florida	17	0.36
La Armonía	27	0.66 N.S.*
Mabel y Pico	31	0.68

*N.S. = non-significant, $\alpha = 0.05$.

TABLE 5
NUMBER OF PLANTS WITH AND WITHOUT SYMPTOMS OF PSOROSIS. VALENCIA ORANGE ON ROUGH LEMON IN THREE GROVES OF 3-7 YEARS OF AGE

Grove	Plant age (years)	Number of healthy plants	Number of plants with symptoms of psorosis
La Florida	3-7	43	27
La Armonía	3-7	254	140
Mabel y Pico	3-7	80	162

X^2 = 61.46 ** Chi square test for independence

plots (table 5). These results indicate that the probability of infection of young replacement trees increases when the number of affected trees within the plots is higher.

Certainly this situation and the random distribution of affected plants does not elucidate the mechanism of pathogen transmission, but suggests consideration of some kind of efficient flying vector.

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