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Yield and Mineral Content of Scaly-Bark-Affected Sweet Orange Trees

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THE DEVELOPMENT of psorosis bark lesions reduces the yield of sweet orange trees in comparison with that of infected trees without conspicuous trunk symptoms. Salibe and Moreira (8) quoted other authors to the effect that successive stages of psorosis reduce yields from 0.5 per cent to 72 per cent in comparison with control plants; the control plants may or may not have been infected.

A first step in attempting to minimize losses due to psorosis is an actual evaluation of such losses. A major difficulty in designing experiments for this purpose is to find adequate plots of adult trees, since the occurrence of psorosis lesions is irregular.

It seems possible that the relation between mineral content of leaves and the yield of trees is different in affected and nonaffected trees. We therefore made a direct comparison of these relations to establish "Standard Values" for the mineral content of both classes of trees.

Experimental Procedures

Washington Navel sweet orange trees, 32 years old, on sour orange stock were used. All the trees had the same origin and had been for 7 years in a nitrogen fertilization experiment in which a randomized block design of 4 blocks and 11 treatments was employed. Each plot consisted of 2

rows of 4 trees separated from the surrounding plots by single rows of nonrecord trees.

A basic amount of 200 g of N was applied 0, 1, 2, 4, 6, or 9 times per year to individual trees. It was applied in either of two ways: in the spring in the form of ammonium sulfate or half in the spring as ammonium sulfate and the other half in the summer in the form of calcium nitrate. All trees received equal amounts of super phosphate and of potassium sulfate.

Psorosis leaf symptoms present in the spring were used as criteria for diagnosing infection. In July 1966, the trees were rated for bark lesions by 4 independent observers according to a scale in which the zero value (Ps-0) was given to trees without lesions and a value of 5 (Ps-5) to severely affected trees; ratings were averaged to obtain mean tree values (11). The lesion index of a plot is described as the mean of the values for the trees that compose it.

From each of the 4 replicates in treatments N-2, N-4, and N-6, 3 trees were selected at random with mean values of Ps-0, Ps-2, and Ps-4. In October, spring flush leaves were picked from these trees in accord with the criteria of Chapman (1), and their mineral content was determined by previously described methods (3). In May 1968, nitrogen determina-

tions were made of leaves from the same trees since the N content of leaves at this time is better related to the nutritional status of the tree than in October (4). Leaves from the N-0 treated trees were also included in the spring analyses. Spring flush leaves were picked at random from fruit-bearing and non-fruit-bearing terminals and analyzed jointly.

the mean yields of all the trees in the same plots. The data permit the conclusion that the Ps-0 tree yields were significantly greater than those with lesions, but that trees with a lesion index less than 1.5 (very mild incidence of lesions) yielded about as well as those without bark lesions. Plots with a lesion index greater than 2.0 (severely lesioned trees) seemed

TABLE 1. COMPARISON OF THE YIELDS OF TREES HAVING VARIOUS INCIDENCES OF BARK LESIONS WITH THOSE OF TREES WITHOUT LESIONS

Lesion index (mean of plot)	Yield (kg per tree)			Distribution of plots in treatments					
	Ps-0	Mean	Difference						
	trees	of plot		N-0	N-1	N-2	N-4	N-6	N-9
Less than 1.5	93.2	97.7	-2.5			2	1	2	2
1.5-2.0	111.0	97.2	14.8 ^a		2	3	6	3	2
More than 2.0	105.7	86.6	19.1 ^a	4	4	3		2	4
Mean	105.6	92.4	13.2 ^b	4	6	8	7	7	8

a. Significant at 0.05 level.

b. Significant at 0.01 level.

In October 1966, 1 Ps-0 tree in each plot was selected at random and the N content of its leaves determined. The yields of these trees were recorded separately the following spring when the mean yields were then related to the lesion index of the plots.

Statistical analyses were made as described by Vessereau (10). Yield comparisons were obtained by means of the pairing method, mineral content of the leaves by randomized blocks, and variability of variances was estimated by Bartlett's Chi square test.

Results

EFFECT OF BARK LESIONS ON YIELD.—In Table 1 the mean yields of the Ps-0 trees are compared with

to yield about as well as those with an index between 1.5 and 2.0 (indicating medium-sized lesions at the trunk level). Overall, bark lesions appear to induce a loss of about 12.5 per cent in the yield.

In Table 2 the data are summarized according to the various levels of N, a comparison being made between the Ps-0 trees at each N level with all trees in the plot at the same level. Although arithmetical differences are large, statistically significant differences in yield between the Ps-0 trees and the mean of the plot are found only at the N-6 level. Nevertheless, some interesting conclusions can be made. As the lesion index in the treatments N-2, N-4, and N-6 is similar, a direct comparison can be made between the yield of the Ps-0 trees and

the mean yield of the plots in all 3 treatments. The yield increased as the rate of N fertilization increased until a rate of 6 basic units per tree (1.2 kg of N) was reached; this rate appeared to be optimal in this experiment (unpublished data). The increase in rate was more effective in the Ps-0 trees than in those with bark

ENCE OF BARK LESIONS AND THE MINERAL CONTENT OF LEAVES.—In the October sampling, the iron content was lower in leaves from the Ps-4 trees than in those from the Ps-0 trees, but no relationship could be found between psorosis bark lesions and the content of the other minerals in the leaves (Table 3).

TABLE 2. COMPARISON OF THE YIELDS OF TREES HAVING PSOROSIS BARK LESIONS WITH THOSE WITHOUT LESIONS WHEN BOTH GROUPS WERE FERTILIZED WITH VARIOUS LEVELS OF NITROGEN

Nitrogen level	Yield (kg per tree)			No. of plots	Lesion index
	Ps-0 trees	Mean of plot	Difference		
N-0	84.5	56.4	28.1	4	2.58
N-1	96.1	80.9	15.2	6	2.44
N-2	88.9	94.6	-5.7	8	1.95
N-4	103.2	92.5	10.7	7	1.77
N-6	138.1	113.4	24.7 ^a	7	1.80
N-9	114.4	97.3	17.0	8	2.01
Mean	105.6	92.4	13.2 ^b	40	2.04

a. Significant at the 0.05 level.

b. Significant at the 0.01 level.

lesions. The depressive effect on yield associated with bark lesions was maximal in treatment N-6 (17 per cent).

A different conclusion can be made when treatments N-0 and N-1 are considered; here the application of N seemed to increase the yield of lesioned trees more than it did the yield of nonlesioned trees. However, the differences may merely reflect annual fluctuations in individual trees that are very noticeable in these treatments (4) and are not statistically significant.

RELATIONSHIP BETWEEN THE PRES-

From the results it is deduced that the N content of leaves of the Ps-0 trees gives a valid estimate of the N content in all classes of trees for October. It was thus of interest to calculate the regression of yield (Y, expressed as kg per tree) on the percentage of N (on a dry weight basis), taking the N content of the Ps-0 leaves as the standard.

$$Y = -729.0 + 796.3 N - 185.7 N^2$$

with a correlation coefficient, $r = 0.529$, that is highly significant.

For the mean yields of the trees of the plots

$$Y = -387.0 + 423.5 N - 94.2 N^2$$

with a correlation coefficient, $r = 0.571$, that is again highly significant. The two regression curves are similar, indicating that the maximum yield is at the same N level. This maximum yield is higher for the Ps-0 trees than for those with bark lesions.

The data from the sampling carried out in May 1968 showed that there was a higher N content in the leaves of the Ps-4 trees than in the Ps-0 trees at all N fertilization levels. The results indicate that the regression of the mean yield of the plots on the N content of leaves in May is shifted toward higher N values when the re-

gression for Ps-0 trees is taken as a reference. The correction is, however, small and without practical value in most cases (Table 4).

The variance of the distribution of the content of mineral elements in leaves was shown by Bartlett's test to be the same for all classes of trees.

Discussion and Conclusions

The loss in yield in infected trees being greater in the N-6 trees (17 per cent) than in the mean of all levels

TABLE 4. INFLUENCE OF FERTILIZATION WITH NITROGEN AND OF BARK LESIONS OF PSOROSIS ON THE NITROGEN CONTENT OF SWEET ORANGE TREES

Treatment	Fertilizer effect		Bark lesion effect	
	N content on dry weight basis (%)		Lesion index	N content on dry weight basis (%)
N-0	1.82		Ps-0	2.14
N-2	2.19		Ps-2	2.19
N-6	2.46		Ps-4	2.26
N-9	2.32			
LSD	0.11		LSD	0.10

TABLE 3. INFLUENCE OF BARK LESIONS OF PSOROSIS ON THE MINERAL CONTENT OF LEAVES AND BARK OF SWEET ORANGE TREES

Lesion index	Mineral content on dry weight basis									
	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Cu (ppm)	B (ppm)	Mn (ppm)
Ps-0	2.03	0.079	0.70	6.9	0.18	0.45	62	13	37	7.0
Ps-2	2.02	0.084	0.69	6.7	0.17	0.42	65	13	35	7.2
Ps-4	2.04	0.081	0.67	7.1	0.16	0.40	59	14	39	7.5
	NS ^a	NS	NS	NS	NS	NS	b	NS	NS	NS

a. Not significant.

b. Significant at the 0.05 level.

(12.5 per cent, Table 2) cannot be related to a higher lesion incidence in treatment N-6 than in the trees as a whole because the respective lesion indexes were 1.80 and 2.04. It is probably due to a different behavior of affected and nonaffected trees. Similar results have been reported by Valmayor and Bugante (9).

Since the N content of leaves from the Ps-2 and Ps-4 trees was the same as that for the Ps-0 trees, any evaluation of the effects of N fertilization drawn from leaf analyses of Ps-0 trees can be applied to all types of Navel orange trees infected with psorosis virus. This principle cannot, however, be extended to the other

mineral elements tested since comparable data on fertilization with these elements are not available. Some of the trees with bark lesions display chlorotic patterns similar to those induced by iron deficiency, which may be reflected in the fact that leaf analyses revealed a significant difference between Ps-0 and Ps-4 trees in content of this element.

Differences in yields and in mineral content of the leaves cannot be attributed merely to the presence of bark lesions. Although trees with lesions of mechanical origin develop chlorotic leaf patterns similar to those found in some of the trees in the experimental plots, several workers (2, 5, 6, 7) have

reported that several viruses affect the mineral content of leaves while having little effect on the anatomy of the vascular system.

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