tion varied from 4% to 100% in over 60 nurseries inspected. Only one nursery, propagating only one variety, was 100% free of psorosis. Many psorosis-free trees, adjacent to registered parent trees, are also a source of clean budwood for straight-run stock. Sixth, through the careful practices encouraged by this program, dangers from mix-up of varieties are reduced.

The big question in the nurseryman's mind is "will the grower pay the additional cost of certified stock?". The answer is "yes." This has already been proven in both California and Texas.

The advantages to the grower are more obvious. For a higher initial cost per tree he obtains assurance that psorosis will not weaken or kill his trees at an age when the tree should be most productive. This means maximum production per acre, since there are fewer skips or weak trees. It means economies in fertilizer and replacements costs. Therefore, a higher initial cost of trees is repaid by higher returns. It is more economical to pay a little more for a disease-free tree at the nursery, rather than pay many times that amount nursing an unproductive sick tree.

The grower who hopes to derive benefits from the registration program must create the demand for such trees, and the progressive nurseryman will be ready and able to supply that demand. Both California and Texas have learned through experience that the nurseryman cannot do the job alone. In both states a demand has been created for these disease-free trees by an educational program sponsored by those concerned with the welfare of the citrus industry. Without such an educational program this program can fail.

Today no one is to blame for the number of infested trees in a grove because at the time these trees were propagated no one knew about the virus nature of psorosis or its transmission through infested buds. Tomorrow ignorance will be no excuse as a method of prevention is well known. Present Florida laws are designed to protect the people of Florida from misrepresentation and plant material infested with dangerous insect pests, and diseases. At present the sale of plants with some minor insects or scale may be stopped, but citrus nursery trees with psorosis, a deadly virus disease, may be sold. The sale of such psorosis infected trees should be stopped. Only you, the nurseryman, the foundation of the largest citrus industry in the world, and you, the grower, the backbone of this great citrus industry, can change this by starting a citrus registration program today.

VARIATIONS IN STEM PITTING ON TRISTEZA-INOCULATED PLANTS OF DIFFERENT CITRUS GROUPS

THEODORE J. GRANT[1], A. S. COSTA[2], AND SILVIO MOREIRA[3]

INTRODUCTION

The reported association of stem pitting symptoms with tristeza disease in Brazil, decline of grapefruit in South Africa and quick decline of sweet oranges in California affords additional evidence of the great similarity of these diseases (2, 5, 6, 8). The studies in Brazil of reactions of the grapefruits, limes, lemons and trifoliate hybrids to tristeza and the occurrence of stem pitting indicated the importance of hybrid plant reactions (5). To obtain further information it seemed desirable to record systematically the degree of pitting on the large number of tristeza-inoculated seedling and grafted plants at Campinas, Brazil (3). This paper describes the methods employed and discusses pitting in relation to the citrus groups studied.

METHODS

General field observations of trees naturally infected with the tristeza virus indicated that pits frequently occurred on stems at or below

1—Pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, Orlando, Florida.
2—Pathologist, Instituto Agronomico do Estado de Sao Paulo, Campinas, Brazil; and collaborator, United States Department of Agriculture.
3—Head of Division of Horticulture, Instituto Agronomico do Estado de Sao Paulo, Campinas, Brazil.

the point where the second or third from the last terminal flush of growth ended. Thus, on the young inoculated nursery plants, branches having three flushes of growth were selected and cut off, the bark was removed and the degree of pitting was rated numerically as follows: 0, no pits; 1, very few scattered pits; and 2, 3, 4, and 5, increases in the frequency of pits from few to many. Field observations also indicated that on older trees, pits might be found on some branches and not on others. Thus, in making the detailed observations on the younger field plants when no pits or only questionable ones were found, additional branches were cut off and examined before a final rating was given.

Detailed data on the degree of pitting were obtained from examination of more than 2,000 citrus scions on a large number of different rootstocks, of tops of some 465 seedlings of many citrus varieties, and of the roots on 400 grafted plants and 170 seedlings. Study was also made of the roots and tops of approximately 200 potted plants that had been employed in various tristeza disease tests under screenhouse conditions. For convenience the data obtained have been combined (table 1) and the results are discussed by citrus groups.

TABLE 1.

RESULTS OF EXAMINATION OF TRISTEZA-INOCULATED PLANTS IN NURSERY AND SCREENHOUSE TESTS AT CAMPINAS, BRAZIL, FOR DEGREES OF PITTING, BY CITRUS GROUPS

Citrus group[1]	No. of tops	No. of roots	Percent frequency distribution of degrees of pitting[2]					
			0	1	2	3	4	5
Mandarin	300	167	98	2	0	0	0	0
Sweet orange	1252	57	75	17	5	2	1	0
Grapefruit	588	110	21	28	22	21	7	1
Pummelo	40	127	57	11	13	11	4	4
Tangelo	122	146	95	4	0.7	0.3	0	0
Trifoliate orange	20	----	100	0	0	0	0	0
Citrumelo	15	28	100	0	0	0	0	0
Citrangequat	13	----	84	8	0	8	0	0
Citrange	24	14	55	8	3	18	11	5
Eureka lemon	163	-----	98	2	0	0	0	0
Seedling lemon (7 varieties)	34	-----	91	6	0	0	3	0
Kulu lemon (seedlings)	20[3]	-----	0	10	25	30	20	15
West Indian lime (4 varieties)	93[3]	-----	9	5	3	21	37	25
Sour orange	65	145	99	0.5	0	0	0	0.5
	2749	794						

1—Material includes stem and roots pieces from seedlings, rootstocks with various tops, and tops on various rootstocks.
2—Degree of pitting: 0, no pits; 1, very few scattered pits; 2, 3, 4, 5, increases in frequency of pits from few to many.
3—Observations made on roots as well as tops.

Observed Reactions By Citrus Groups

Mandarin Group

Examination of 196 Dancy tangerine tops on 52 different rootstocks showed that 98 percent of the tops had no pitting and 2 percent had a small amount. As the rootstocks represented a wide range in citrus types it would seem that rootstocks had not influenced the remarkably uniform reaction of the Dancy tangerine tops. Similar results were obtained from 104 seedling tops of 20 mandarin varieties; 99 percent had no pits, and 1 percent had a small number.

When 111 root pieces representing 16 mandarin varieties employed as rootstocks for 4 different sweet orange and 2 grapefruit varieties were examined, it was found that 99 percent of the mandarin rootstocks had no pits and only 1 percent had a few. This lack of pits on the mandarin roots was obtained in spite of the fact that pitting was observed in many of the grapefruit tops. Of 56 seedling roots representing 10 mandarin varieties, 96 percent had no pits and 4 percent had a few.

The combined results from 300 tops and 167 roots of the mandarin group studied at Campinas show 98 percent with no pits and 2 percent with few (table 1). Thus, it would seem that the mandarins studied can be classified as having tissues tolerant to tristeza and no or little tendency to pit.

Sweet Orange Group

Observations on 777 Barao sweet orange tops on 120 different rootstocks, 265 Valencia orange (seedling origin) tops on 82 rootstocks, 108 Bahianinha navel orange tops on 22 rootstocks, 50 Florida Sweet Seedling orange tops on 11 rootstocks, and 52 tops of seedling plants

of 12 sweet orange varieties showed that there were some differences among sweet orange varieties in the degree of pitting. For example, the most severe pitting occurred on the Florida Sweet Seedling tops; 2 percent of these had no pits and the percentages in classes 1 to 4 were 34, 18, 38 and 8. In contrast, 92 percent of the Valencia orange tops had no pits, 7 percent had degree 1 pitting, and 1 percent had degree 2.

A study of the data showed that in sweet orange scions on non-tolerant rootstocks the degree of pitting was lower than in similar scions on tolerant rootstock. This may be due to the poor growth and difficulties in removal of bark from scions on non-tolerant rootstocks.

By study of the roots of 38 plants of 5 sweet orange varieties employed as rootstocks for 3 sweet orange and 2 grapefruit varieties, it was found that 87 percent of the rootstocks had no pits and 13 percent had few. Pitting in the grapefruit scions did not extend into the sweet orange rootstocks. Of 19 seedling roots of 4 sweet orange varieties 85 percent had no pits, 10 percent had degree 1 pitting, and 5 percent had degree 2.

This study of 1252 sweet orange tops and of the roots of 57 plants shows that sweet oranges, although tolerant to tristeza, have tissues which sometimes react to form pits (table 1). This is of special interest, for in general sweet oranges on tolerant rootstocks do not show any recognized leaf symptoms of tristeza but the presence of the causal virus might be indicated by the occurrence of stem pits. In sweet oranges, this pitting cannot be seen until the bark is removed from the young branches. The observations suggest also that some varieties of sweet orange may be affected more than others. How much effect pitting may have on growth or production is not known. It is evident that the tristeza virus does have some detrimental effects, and it would be of interest to learn, as was previously pointed out (4), whether sweet orange tops infected with a mild tristeza virus strain when on tolerant rootstocks would grow and produce more or better fruit than comparable plants infected with the severe tristeza virus. From the currently observed differences in expression of pitting symptoms by sweet orange varieties, it seems possible that the effect of a mild virus strain might be less harmful on some varieties than on others. It also follows that, although all sweet orange varieties may be considered relatively tolerant to the tristeza virus, over a period of years some varieties may prove to be more satisfactory as rootstocks than others.

Grapefruit Group

The examinations of plants in the grapefruit group may be summarized as follows: of 312 Duncan grapefruit tops on 82 different rootstocks 18 percent showed no pits, 54 percent had few pits (degrees 1 and 2), and 28 percent had many pits (degrees 3 to 5). Of 235 Leonardy grapefruit tops on 66 rootstocks 18 percent had no pits, 52 percent had few and 30 percent had many. Of 41 seedling grapefruit tops of 9 varieties, 27 percent had no pits, 25 percent had few, and 48 percent had many. Of 95 grapefruit plants of 5 varieties used as rootstocks for 3 sweet orange and 2 grapefruit varieties, 33 percent had no pits, 48 percent had few and 19 percent had many. Of 15 seedling grapefruit roots, of 5 varieties, 7 percent had no pits, 53 percent had few, and 40 percent had many.

The combined results from 588 tops and 110 roots of grapefruit show that, in comparison with sweet orange and mandarin, grapefruit plants have relatively very sensitive tissues (table 1). This fact not only reconfirms the knowledge that grapefruit plants are non-tolerant to tristeza; but it may also help in understanding why, in tristeza-infested areas, a gradual decline in grapefruit production may occur, as is the case in South Africa (7) and Argentina (9), even when the grapefruit trees are on tolerant rootstocks. The greater sensitivity of the grapefruit tissues is illustrated also by the fact that grapefruit scions may show distinct pitting symptoms even when their mandarin or sweet orange rootstocks have no or few pits. These observations emphasize the importance of differences in plant tissue reaction to the tristeza virus or its by-products.

Pummelo Group

Of 40 seedling pummelo tops of 9 varieties 45 percent had no pits, 38 percent had few, and 17 percent had many. Of the roots of 30 seedling pummelo plants of 7 varieties 60 percent had no pits, 23 percent had few, and 17 percent had many. Of 97 pummelos of 12 varieties being used as rootstocks for 3

sweet oranges and 2 grapefruits 61 percent had no pits, 19 percent had a few, and 20 percent had many.

In most of the work at Campinas the unit number in any given test was 5 plants whether as a rootstock, a scion or a seedling. It was frequently noted that 1 or 2 pummelo plants in a group of 5 might be badly pitted and the others might have few or no pits. Possibly this reaction may be related to the fact that the pummelos as a whole are considered to be monoembryonic. Thus, the seedling plants are gametic in origin and the differences in reactions may be related to their hetrozygous nature.

By combining the 40 observations on pummelo tops and those on 127 pummelo plant roots, it can be seen that the degree or frequency of pitting on the pummelo plants was not as great as on the grapefruit plants but was much greater on the pummelo than on the sweet orange and mandarin plants studied. (table 1).

Tangelo Group

The combined results for 122 tangelo tops of 27 varieties and for the root growth from 146 tangelo plants of 13 varieties show that pitting was somewhat more than in the mandarin group but very much less than in the grapefruit group (table 1). Inasmuch as tangelos are hybrids it is of interest that the observed reactions were closer to those of the mandarin parent than to those of the grapefruit parent.

Trifoliate Orange and Hybrid Group

The material in the trifoliate orange and hybrid group was somewhat limited (table 1). It is of interest, however, that none of the 20 trifoliate orange tops, the 15 citrumelo tops, or the 28 citrumelos used as rootstocks showed any definite pits. In contrast definite pitting was found on some of the 24 citrange seedling tops, on some of the citranges used as rootstocks for sweet orange and grapefruit, and on some of the 13 seedling citrangequat plants. The data limitations do not permit adequate comparison of varieties but that there are distinct differences in reactions of different hybrids is certainly clear.

Lemon Group

Of the 163 Eureka lemon tops, 98 percent had no pits and 2 percent had a few (table 1). In contrast, Kulu lemon seedlings were badly pitted. Limited observations on the seedlings of 7 different varieties indicated that in a seedling population of lemons one might find some plants with few or no pits and others that are badly pitted. These observations also indicate that important differences may occur between varieties of a single group and also between plants in a seedling population, especially when such plants may be of gametic rather than nucellar origin.

Lime Group

Observations on 93 plants of 4 West Indian lime varieties showed that pitting occurred on both tops and roots. The combined data show that only 9 percent of the plants had no pits and that the majority had many (table 1). The positive reactions of the West Indian limes to tristeza makes them particularly valuable as test plants, as has previously been noted (2, 5, 6, 8).

Sour Orange Group (Including Bittersweet varieties)

Of 65 seedling sour orange tops representing 14 varieties 99 percent had no pitting and 1 plant was badly pitted. None of the roots of 62 sour orange plants representing 14 varieties were pitted. Of the roots of 83 plants of 6 sour orange varieties being used as rootstocks for 3 sweet orange and 2 grapefruit varieties, 99 percent had no pits and 1 percent had a very few small pits.

Summary of the 210 observations shows that 99 percent of the sour orange plants had no pits, 0.5 percent had few pits, and 0.5 percent had many (table 1). The two plants which appear to be exceptional in respect to pitting could very well be of gametic rather than nucellar origin.

Additional observation on sprouts from 20 sour orange rootstocks which had tristeza-diseased sweet orange tops showed that none of these sprouts had any pitting.

The lack of pits in the sour orange group would appear to be related to the reactions of sour orange previously described (1), namely that sour orange is difficult to infect by means of aphid inoculations and it appears to have a physiological resistance to tristeza that tends to limit virus multiplication and distribution.

Discussion

When Oberholzer et al. (7) first reported stem pitting on grapefruit varieties, they also noted the occurrence of similar pitting on a few trees of Valencia and Bailidge Early

orange and on shaddock trees. Since that time, similar symptoms have been reported on certain varieties of limes, lemons, grapefruits, and sweet oranges (2, 5, 6). Also some differences have been noted with respect to size of the pits and the coloration associated with the pits. McClean (6) reported, "they differ in colour from the normal surrounding wood: in young branches they may have a greenish, glassy appearance or may be a light orange or brown colour in the larger branches or trunk." In Brazil, the authors have noted that in one lot of five seedlings of the hybrid Poormans Orange one plant had large definite pits such as frequently are found on grapefruit while another plant had a very large number of pinpoint pits. They also observed at Limeira Citrus Experiment Station a red coloration in the pits occurring on a seedling tree resulting from a cross between a grapefruit and a pummelo. A cross section of the stems of this tree showed scattered red lines in the wood, indicating that the stem had been repeatedly pitted but that it had been able to maintain a more or less normal outer appearance. There were also indications that the pits when first formed did not always have the associated red coloration. These instances are given in order to point out the need for further work and the limitations of our present knowledge.

The data presented in this paper, although they indicate certain trends such as the general lack of pitting in the mandarin group, do not necessarily mean that some mandarins or tangerines will not be found that will show pitting. The data, however, do indicate that when a pitted mandarin is found it would be well to consider the possibility that it is of hybrid origin.

The association of pitting symptoms with tristeza in Brazil, grapefruit decline in South Africa, and quick decline in California is helpful and provides opportunities for comparison of studies in different places. At the same time the recognition of mild tristeza virus strains (4) and the indicated variations in hybrid plant responses make comparisons difficult and point to the need for some limited exchange of comparable citrus seed lots in cases where distinct differences in reactions are reported.[1]

Summary

Careful examination of 3,543 citrus seedlings, scions, and rootstocks (parts or all of tristeza-inoculated plants) has been made in the field nursery and screenhouse tests at Campinas, Brazil. The presence and degree of pitting were recorded on a numerical basis. The data obtained are summarized briefly in table 1, which gives the percentage frequency distribution according to the degree of pitting observed by citrus groups.

Among the citrus groups considered to be tolerant and desirable as rootstocks for sweet orange, the mandarin varieties observed had no pits or very few. In the sweet orange group there appeared to be distinct differences in varietal reactions. Florida Sweet Seedling orange had appreciably more pitting than the Valencia or the Bahianinha navel orange. Pitting of the sweet orange varieties as tops was most noticeable when they were grown on tolerant rootstocks and when no other tristeza symptoms were evident.

Although there may be some varietal differences the grapefruit appears to have tissues which tend to show pitting whether employed as a top, a rootstock or a seedling. Tangelos had less pitting than the grapefruit

1—Footnote by T. J. Grant

Since the preparation of this manuscript, L. C. Knorr, E. P. Ducharme, and H. Banfi published (Citrus Magazine October, 1951) an article, "The occurrence and effects of 'stem pitting' in Argentine grapefruit groves." Their observation of extensive occurrence of stem pitting on a mandarin, the so-called Improved mandarin, and on Rough lemon do not coincide with the observed reactions of plants inoculated with tristeza by means of viruliferous aphids in the tests at Campinas, Brazil. These differences in observations suggest that pitting of the so-called Improved mandarin might be a hybrid reaction to tristeza or that they may be dealing with a specific virus strain or an additional disease such as concave gum, blind pocket psorosis, xyloporosis or cachexia. Their report is based on field observations as they state, "In the absence of transmission tests we are not in a position to comment on the casual nature of Argentina's stem pitting."

It is of some interest also, that field observations in the Citrus Experiment Station plantings at Limeria in Brazil indicated (2) that the Foster grapefruit was more severely pitted than was the Marsh seedless grapefruit in adjoining plantings. This does not agree with the greater severity of pitting on Marsh grapefruit observed in South Africa and Argentina. The investigations in Brazil have pointed out the existence of tristeza virus strains. It is to be expected that virus strain differences may be related to differences in the presence and degree of stem pitting symptoms. The current report emphasizes the important differences in tissue reactions that may be related to minor differences in hybrid plant response to the tristeza virus. The terms Rough lemon, sweet lime are indeed extremely general and within each there may eventually be found appreciable differences in tissue reactions.

The exchange of virus material within disease infested areas may not be advisable but exchange of citrus seed from controlled sources for use in controlled comparative tests would seem to be highly desirable to eliminate as far as possible one of the variable factors in comparison of plant variety reactions to a specific source of virus.

group but slightly more than the mandarin group.

The results of examination of the pummelo, trifoliate hybrid, lemon, and lime groups strongly suggest that minor differences in hybrid plant reactions can have an important effect on the presence and degree of pitting.

Tristeza-inoculated plants of the sour orange group would seem to have no or very little tendency to show pitting.

LITERATURE CITED

1. Costa, A. S., Grant, T. J., and Moreira, S. Investigacoes sobre a tristeza dos citrus. II. Conceitos e dados sobre a reacao das plantas citricas a tristeza. Bragantia 9: 59-80. 1949.
2. Costa, A. S., Grant, T. J., and Moreira, S. A possible relationship between tristeza and the stem pitting disease of grapefruit in Africa. Calif. Citrog. 35 (12): 504, 526-528. 1950.
3. Grant, T. J., Costa, A. S., and Moreira, S. Studies of tristeza disease of citrus in Brazil. III. Further results on the behavior of citrus varieties as rootstocks, scions and seedlings when inoculated with tristeza virus. Proc. Fla. State Hort. Soc. (1949). 62: 72-79. 1950.
4. Grant, T. J., and Costa, A. S. A mild strain of the tristeza virus of citrus. Phytopath. 41: 114-122. 1951.
5. Grant, T. J., Costa, A. S., and Moreira, S. Studies of tristeza disease of citrus in Brazil. V. Further information on the reactions of grapefruits, limes, lemons, and trifoliate hybrids to tristeza. Calif. Citrog. 36 (8) 310, 311, 324-326, 328, 329. 1951
6. McClean, A. P. D. Virus infections of citrus in South Africa. Farming in South Africa. 25: (293) 262, 25: (294) 289. 1950.
7. Oberholzer, P. C. J., Mathews, I., and Stimie, S. F. The decline of grapefruit trees in South Africa. A preliminary report on the so-called stem pitting. Union of South Africa Sci. Bull. 297. (1949).
8. Wallace, J. M., and Drake, R. J. Newly discovered symptoms of quick-decline and related diseases. Citrus Leaves. 31: (2) 8, 9, 30. 1951.
9. Knorr, L. C., E. P. Ducharme and A. Banfi. The occurrence and effects of "stem pitting" in Argentina grapefruit groves. Citrus Magazine 13: (14), 32-36, 1951.

CACHEXIA, A BUD-TRANSMITTED DISEASE AND THE MANIFESTATION OF PHLOEM SYMPTOMS IN CERTAIN VARIETIES OF CITRUS, CITRUS RELATIVES AND HYBRIDS

J. F. L. CHILDS

Bureau of Plant Industry, Soils and Agricultural Engineering
United States Department of Agriculture

Orlando

INTRODUCTION

Cachexia, derived from two Greek words, kakos (bad) and hexis (condition), refers to the symptoms of malnutrition and wasting characteristic of affected citrus trees of those varieties that are highly susceptible to, or that readily express symptoms of, the disease of that name. The trouble was first brought to our attention in 1945 when affected Orlando tangelo trees were found near Clearwater, Florida (2). A few plantings of this variety are free of the disease, but in others (sometimes on the same property) 1 to 60 percent of the trees may be diseased. That certain trees are diseased may become noticeable within two years from planting, because of their lack of vigor, chlorotic foliage, and other symptoms. If no symptoms have appeared by the time a tree is five years of age (from planting date) it seems to remain free of cachexia indefinitely, indicating that the disease is seldom spread from tree to tree in a grove.

SYMPTOMS OF THE DISEASE

The symptoms described here refer specifically to the Orlando tangelo. On other varieties and species of citrus the symptoms may or may not be as sharply defined.

Phloem discoloration:—Discoloration of the inner bark, or phloem, through gum impregnation is a characteristic and diagnostic symptom of cachexia. In order to observe gum impregnated phloem tissues, it is necessary to cut away the outer bark at the bud union boundary. Discoloration commences just above the bud union and in the early stages may consist of no more than a series of small brown spots along the scion-rootstock boundary, but in five or six year old trees the phloem may be discolored 18 inches or more above the union. Discoloration has not been observed below the union when the rootstock is Rough lemon, Cleopatro mandarin, Rusk Citrange, grapefruit, or sweet orange, but when the rootstock is Orlando tangelo phloem discoloration also appears below the union.

Wood-pitting:—When the bark of a diseased Orlando tangelo is peeled off at the bud union the exposed wood is found to be indented or pitted in a very characteristic manner. The inner (cambial) surface of the removed bark is marked by lumps and projections that coincide with and fit into the depressions in the