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Salt-Tolerance and Cold-Hardiness Tests on Avocado Trees

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Salt and cold injury are the major problems in the commercial production of avocados in the Rio Grande Valley of Texas. Both kinds of injury are characterized by leaf burning, twig dieback, and in extreme cases by death of the tree. Salt injury is associated with high soil salinity and a high chloride content of the leaves, just as in citrus (Cooper and Gorton, 1950), while cold injury results from freezing temperatures. Frequently after freezes a tree may show both salt-excess and cold-injury symptoms, and these symptoms may be visually indistinguishable. However, analysis of the tissue for chlorides will distinguish them.

Observations in citrus and avocado orchards on saline soils in the Rio Grande Valley showed that all varieties of avocados under cultivation, including Waldin (West Indian race), Itzamna (Guatemalan race), Lula (West Indian-Guatemalan hybrid), Fuerte (Guatemalan-Mexican hybrid) and Jalna (Mexican race), showed considerably more leaf burning than adjacent trees of grapefruit and orange (Cooper and Gorton, 1950). There was, however, a wide range in extent of salt injury of the various avocado varieties on the same rootstock; Waldin, Lula, and Itzamna showed less salt injury than the Fuerte and Jalna.

Most of the information on cold hardiness in avocados in the Rio Grande Valley is based on observations of cold injury subsequent to the freezes of 1949 and 1951 (Cooper et al, 1949; Cintron et al, 1952). Most varieties and selections of the Mexican race showed much less cold injury than varieties of other races and their hybrids, including such varieties as Fuerte, Lula, Itzamna and Waldin. In general, trees of West Indian, Guatemalan, and West Indian-Guatemalan hybrid varieties showed severe wood injury, some being killed outright, while trees of the Mexican race showed only leaf and twig injury. The selections of Mexican hybrids showed damage to the wood, ranging from none to severe.

Since soil salinity under field conditions is generally variable and uncontrolled, field observations on the relative tolerance of various scion varieties have their limitations. Likewise, testing cold hardiness of avocados by field survival is basically a waiting process since winters severe enough to separate the partially hardy varieties from the fully hardy ones have not occurred since 1951. The objectives of the present studies

were (1) to determine whether field-survival observations for cold hardiness and salt tolerance can be replaced by artificial freezing and salt-tolerance tests under controlled conditions and (2) to classify varieties and selections of avocados as to cold and salt tolerances.

METHODS

The procedures used for the salt-tolerance tests were those described elsewhere for citrus (Cooper et al, 1951). The salt solutions used to irrigate the salinized plots consisted of a 50-50 mixture of NaCl and $CaCl_2$ to give a concentration of 3000 ppm of total salts, 88 per cent of which was chloride ion. While approximately 50 per cent of the total cations in this solution were sodium, enough calcium was present in the mixture to prevent puddling the soil.

The avocado varieties or selections tested included Lula, Castro, Pancho, and Arsola selections 29-9, 1-8, and 5-6. The Pancho and Castro are selections of the Mexican race, while the Arsola selections are considered to be Mexican-West Indian hybrids. One tree of each variety was included in each of 4 plots. The trees in each plot were planted in a randomized manner 3 feet apart in 2 rows 3 feet apart.

Grafted trees, with a trunk circumference of approximately 25 mm, were planted on March 15, 1955. The trees were irrigated with 3 inches of salt solution or of river water at approximately 2-week intervals. River water was used from March 15 until June 20, 1955; the salt solution from June 20 until August 9, 1955; river water from August 9, 1955, to May 3, 1956; salt solution from May 3 to August 10, 1956; and river water thereafter.

The tree-freezing unit and method of operation are the same as those described elsewhere for citrus (Cooper et al, 1954). The numbers of trees and the selections or varieties tested are as follows: Two of Lulu, 3 of Castro, 1 of Pancho, 4 of Arsola 1-18. The trees were grafted on West Indian rootstock and were of the same age and size as the trees tested for salt tolerance. The freezing tests were conducted during December 1956 and January 1957.

RESULTS AND DISCUSSION

The effects of the salt and freezing treatments on the trees of the various kinds of avocados are described in tables 1 and 2 and figures 1 and 2. A tentative classification of 6 kinds of avocado as to salt tolerance and of 4 kinds as to cold hardiness is given in table 3. Additional work is needed to give a more accurate and comprehensive picture of the salt tolerance and cold hardiness of these kinds of avocado. The variety and selections were given numerical ratings for salt tolerance and cold hardiness. The values increase with increase in salt tolerance and cold hardiness A value of 1 was given to completely killed trees (killed by 3 hours of 23°F in case of cold hardiness), and a value of 5 to those showing no injury under the same conditions of freezing or salt treatment. Intermediate values reflect intermediate degrees of injury. Salt-tolerance and cold-hardiness ratings for grapefruit on sour orange (Cooper et al, 1951 and 1954) are also given for comparison with those of the avocado.

Figure 1. Complete defoliation and twig dieback on trees of the Pancho selection on West Indian rootstock grown in plots irrigated with salt solution containing 3000 ppm. of a mixture of NA Cl and CA Cl_2. Picture taken September 10, 1956.

Table 1. Salt injury, chloride content of leaves and increase in trunk circumference of 6 kinds of avocados grown in artificially salinized plots.[a]

Selection or variety and date of observation	*Extent of salt injury*	*Con. of chloride in leaves (% dry weight)*	*Circumference of trunk (mm.)*
Arsola 29-9			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.66	–
July 26, 1956	Slight defoliation	.81	–
September 10, 1956	Complete defoliation	–	76
December 10, 1956	3 out of 4 dead	–	69
Pancho			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.40	–
July 25, 1956	Slight defoliation	.42	–
September 10, 1956	Complete defoliation; twig die-back	–	76
December 10, 1956	3 out of 4 dead	–	73
Castro			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.38	–
July 26, 1956	Slight defoliation	.54	–
September 10, 1956	Complete defoliation, twig die-back	–	68
December 10, 1956	All dead	–	67
Arsola 5-6			
June 20, 1955	None	–	30
August 9, 1955	Severe leaf-burn	.43	–
July 26, 1956	Complete defoliation	.78	–
September 10, 1956	Severe twig dieback	–	74
December 10, 1956	3 out of 4 dead	–	68
Lula			
June 20, 1955	None	–	30
August 9, 1955	Moderate leaf burn	.29	–
July 26, 1956	Moderate leaf burn	.60	–
September 10, 1956	Severe leaf-burn; Slight defoliation	–	86
December 10, 1956	All old leaves defoliated	–	97
Arsola 1-18			
June 20, 1955	None	–	30
August 9, 1955	Moderate leaf-burn	.53	–
July 26, 1956	Moderate leaf-burn	.70	–
September 10, 1956	Severe leaf-burn; slight defoliation	–	97
December 10, 1956	All old leaves defoliated	–	97

[a] Salt treatment applied June 20 to August 9, 1955, and from May 3 to August 10, 1956. River water applied at other times.

Table 2. Condition of trees at time of freezing, freezing temperature and extent of freeze injury of 2-year-old Avocado trees of varieties or selections, grown in the field at Rio Farms, Inc., Monte Alto, Texas, 1956 and 1957.

Selection or Variety	*Date of freezing treatment*	*Tree condition before freezing treatment*	*Freezing temp.*[a] *(° F.)*	*Extent of freezing injury*[b]
Pancho	December 31	Buds dormant	23	A few leaves and twigs in top of tree killed
Castro	January 2	Full bloom	23	Bloom and a few leaves and terminal twigs killed
Castro	January 29	Full bloom	26	No injury to bloom
Castro	January 30	New flush growth	26	No injury to new flush
Lula	January 3	New flush growth	24	Entire top of tree killed
Lula	January 29	New flush growth	26	No apparent injury
Arsola 1-18	December 31	Buds just breaking	23	All leaves and all wood ½" in diameter killed
Arsola 1-18	January 2	Buds just breaking	22	Upper half of top of tree killed
Arsola 1-18	January 3	Buds just breaking	23	All leaves and all wood ¼" in diameter killed
Arsola 1-18	January 28	Buds just breaking	23	All leaves and all wood ¼" in diameter killed

[a] All trees were held at the indicated temperature three hours.
[b] Estimated 2 weeks after freezing treatment.

Table 3. Classification of avocados as to salt tolerance and cold hardiness.

Selection or Variety[a]	*Race*	*Units of*[b] *salt tolerance*	*Units of*[b] *cold hardiness*
Castro	Mexican	1	4
Pancho	Mexican	1	4
Arsola 29-9	Mexican-West Indian	1	[d]
Arsola 1-18	Mexican-West Indian	3	3
Arsola 5-6	Mexican-West Indian	1	[d]
Lula	Guatemalan-West Indian	3	1
Grapefruit on sour orange[c]		5	4

[a] All were propagated on West Indian rootstock.
[b] Values increase with tolerance and hardiness.
[c] Values based on other work (Cooper et al, 1952) included here for comparison only.
[d] No determination.

The salt-tolerance and cold-hardiness ratings derived from tests under controlled conditions agree with those obtained by field-survival observations, and such tests are recommended for screening varieties and selections of avocados for salt-tolerance and cold-hardiness. The results of the freezing tests at 23 °F, however, do not indicate the actual extent of freezing injury to be expected from a natural freeze at 23°F. The rate of cooling, wind velocity, relative humidity and possibly other factors affecting freezing injury during the artificial freezing period are not necessarily comparable with conditions

during a natural freeze in the Rio Grande Valley. The test conditions, however artificial, were identical for the various kinds of avocado and comparisons of cold hardiness are valid.

Figure 2. Severe leaf burn on old leaves, but no injury on new leaves on trees of the Lula variety on West Indian rootstock grown in plots irrigated with salt solution containing 3000 ppm. of a mixture of NA Cl and Ca Cl_2. Picture taken at the same time as that of the Pancho selection shown in Figure 1.

The ratings of these kinds of avocado as to salt tolerance and cold hardiness illustrate the basic problem in selecting suitable avocado varieties for the Rio Grande Valley. A suitable selection should have both salt tolerance and cold hardiness. Yet one of the selections with the greatest salt tolerance, the Lulu, showed the least cold hardiness. The Mexican selections, one the other hand, showed poor salt tolerance but good cold hardiness. The selection which showed the highest combined ratings of cold hardiness and salt tolerance was Arsola 1-18, which showed a high value for salt tolerance and an intermediate value for cold hardiness. Field observations on the Arsola planting of Mexican-West Indian hybrid seedlings at Llera, Tamps., Mexico, indicate a range in cold hardiness for these trees (Cintron et al, 1952). More of these selections should be tested for both cold-hardiness and salt-tolerance. Among these selections may be one that is superior to Arsola 1-18.

The relatively high rating given the Arsola 29-9 selection in the classification of subtropical fruit plants for salt-tolerance by Cooper et al (1952) is not consistent with the poor performance of this selection in the present series of tests. The earlier rating was based on a comparison of the Fuerte variety and the Arsola 29-9 selection. Presumably Arsola 29-9 has salt tolerance superior to that of Fuerte variety but not equal to that of the Lula variety.

SUMMARY

The Lula variety, 2 selections of the Mexican race, and 3 selections of Mexican-West Indian hybrids were tested for salt tolerance and cold hardiness by artificial tests under controlled conditions. The salt-tolerance and cold-hardiness ratings obtained agree with those obtained by field-survival observations. The Lula variety showed a high salt tolerance rating but a low cold hardiness rating. The Mexican selections, on the other hand, showed a low salt tolerance rating and a high cold hardiness rating. A Mexican-West Indian hybrid, Arsola 1-18, had the best combined salt-tolerance-cold-hardiness ratings.

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