JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 10, 1956

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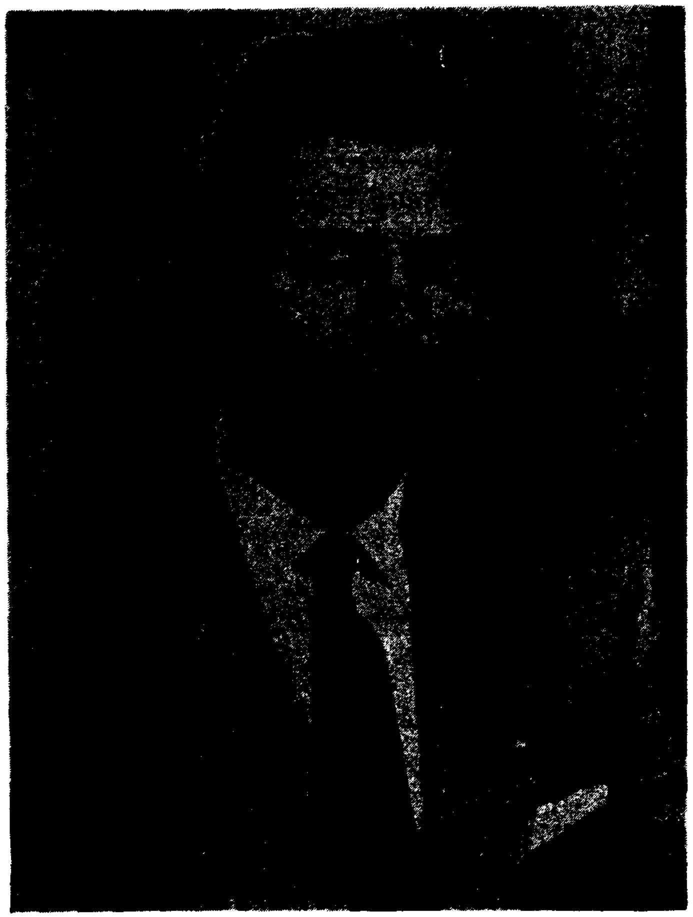

Stanley Crockett, President

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1955 - 1956

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Report of
The Editorial Committee

The Journal of the Rio Grande Valley Horticultural Society is the official publication of the Society which resulted from the amalgamation of the Rio Grande Valley Horticultural Club, The Texas Avocado Society and the Texas Grape Society.

For the purpose of continuity with the oldest publication, The Proceedings of the Rio Grande Valley Institute, the 1956 Journal is designed as volume 10.

The Avocado Yearbook is now being published in the avocado section of the Journal.

The Committee

Bailey Sleeth
Norman Maxwell
Edward Olson
George P. Wene

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History and Objectives of the Rio Grande Valley Horticultural Society

STANLEY B. CROCKETT, *President,*
Rio Grande Valley Horticultural Society

The Rio Grande Valley Horticultural Society was formed on June 1, 1955, by the merger of the Rio Grande Valley Horticultural Club, the Texas Avocado Society and the Texas Grape Society. This new Society takes over the functions of the other three groups and also directs the annual Rio Grande Valley Horticultural Institute. It is fitting at this time that we briefly review the history and accomplishments of these groups which are the parent organizations of our Society and outline the objectives of this new Society.

The Rio Grande Valley Horticultural Club was formed in 1945 at a meeting held at Rio Farms, Monte Alto. The membership was limited to 45 persons who were actively engaged in some branch of horticultural work and were qualified to participate in programs of the Club. The group included citriculturists, olericulturists, ornamental horticulturists, entomologists, plant pathologists, soil scientists, and irrigation engneers, all of whom were active in Valley horticulture. About half of the members were personnel of state and federal agricultural institutions in the Valley, while the rest were technical men in the horticultural industries of the Valley.

The Club met once a month for a discussion of technical papers on current problems in Valley horticulture. When a problem required further study a committee was formed to pursue the matter further. In 1947 the citrus psorosis committee of the Club brought Dr. H. S. Fawcett, world authority on citrus diseases, to the Valley and worked with him in making a psorosis survey. Dr. Fawcett and the committee recommendd a citrus budwood certification program for the ultimate solution of the problem. A Valley nurserymen's association was formed as an action group to carry out this recommendation.

Similarly a Horticultural Club committee was responsible for the formation of the Texas Avocado Society in 1948. The Club also conducted freeze-damage surveys following the 1949 and 1951 freezes and made recommendations to citrus growers on the pruning of freeze-damaged trees.

The annual Rio Grande Valley Horticultural Institute was the Club's greatest endeavor. These Institutes arranged for a discussion of the Valley's horticultural problems with the growers. The first Institute was held in 1946 and was limited to a discussion of citrus problems. In 1947 and 1948 the scope of the Institute was enlarged to include both citrus and vegetables. In 1949 ornamental horticulture was added to the agenda.

The 1946 Institute was a joint endeavor of the Texas A. and M. Colleg and the Rio Grande Valley Horticultural Club. Dr. Guy Adriance, head of the College's Horticultural Department asked the Club to assist in conducting a short course, or institute, on citrus culture in the Valley, and the Club did so. Since then the Club has taken the lead in directing the Institute, with the College contributing agricultural workers from the staff at the Weslaco substation as well as from the main campus at College Station. The staff of Texas A. and I. College and the staffs of several units of the U. S. Department of Agriculture have also contributed to the program. These Institutes have been held at the auditorium of the Citrus and Vegetáble Training Center of Texas A. and I. at Weslaco since 1949.

The past-presidents of the Rio Grande Valley Horticultural Club are as follows:

1945	W. H. Friend, Weslaco
1946	Lloyd Ryall, Harlingen
1947	W. H. Hughes, Elsa
1948	Don McAlexander, Elsa
1949	William C. Cooper, Weslaco
1950	E. D. Kornegay, Harlingen
1951	E. B. Dubuisson, Elsa
1952	N. P. Maxwell, Weslaco
1953	R. H. Cintron, Mercedes
1954	E. O. Olson, Weslaco
1955	George P. Wene, Weslaco

Dr. George P. Wene presided over the last meeting of the Horticultural Club in June 1955 when it joined with the Texas Avocado and Grape Societies to form the Rio Grande Valley Horticultural Society.

The Texas Avocado Society was organized in April 1948 in order to encourage the study of subtropical fruits, including the avocado. A wide range of these subtropical fruits can be grown in the Rio Grande Valley but problems uncommon in many other subtropical regions have slowed the development of these fruits. During the first year test plots were established to study the adaptability of many named varieties from California and Florida and seedling selections found in the Valley. In 1947 th Society began to actively explore Mexico for superior selections of avocados and these selections were brought to the Valley for trial in the test plots.

Ther were 125 members in the Avocado Society and these included anyon who was interested in the Avocado and was not limited to technical people. The programs of meetings always included a "qustion and answer" period that was freely participated in by the members. The past presidents of the Avocado Society are as follows:

1948-49	E. B. Ballard, Weslaco
1950	R. H. Cintron, Mercedes
1951	J. B. Chambers, Harlingen
1952	William C. Cooper, Weslaco
1953	Norman Maxwell, Weslaco
1954	Henry Link, Weslaco

The Texas Grape Society was formed in 1953 to study the feasibility of growing Vinifera grapes commercially in the Rio Grande Valley. There were 20 members of the Society and its president was Dr. P. W. Rohrbaugh.

By merging the three organizations into one Society, it is hoped that a stronger Society will result. By adopting unrestricted memberships and encouraging grower participation in both the government and programs of the Society good attendance has been achieved at all meetings during this first year. The present membership includes active members, sustaining members, and patron members. A horticultural industry as large as ours should boast five times this membership. More grower participation is still urgently needed.

The purpose of the Society is to:

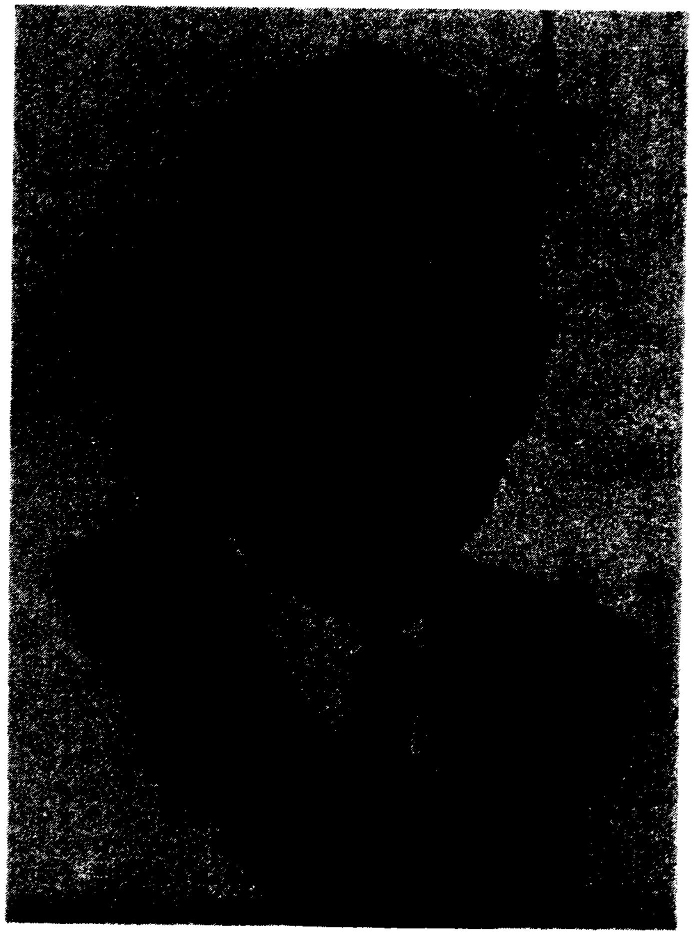
(1) Encourage horticultural research and experimentation both by governmental agencies and by the individual growers, shippers, and canners.

(2) Disseminate horticultural information to the public.

(3) Arouse interested in crop diversification, new crops, and new varities.

(4) Give the public an honest and practical approach to horticultural ventures by blending scientific and practical information.

The work of the Society is divided into five sections: namely, Citrus, Vegetables, Avocados, Grapes, and Ornamental Plants. Horticultural programs are given at monthly meetings and at the Annual Horticultural Institute. Each year more and more scientific and semi-scientific papers on local horticultural research projects are printed in the journal of this Society, giving up-to-the-minute and yearby-year reports on these worthwhile projects. As years go by this journal should constitute a compendium on horticultural research in the Valley and thus become an invaluable repository of knowledge and experience concerning Valley horticulture. It is a Valley endeavor of which we should all be proud, and special commendation should be given to our perennial editors, Dr. George P. Wene and Dr. Edward Olson for their excellent work in editing this journal.



Arthur T. Potts

The Arthur T. Potts Award

When the Rio Grande Valley Horticultural Society decided to recognize outstanding horticultural work in this area from year to year there was little doubt as to whom the award should be named after.

The Society chose Arthur T. Potts of Harlingen because of his many and early horticultural accomplishments in this area. He also was chosen to be the first recipient of this award.

Potts worked in the field of citriculture in Texas long before the establishment of a commercial citrus industry in the Lower Rio Grande Valley where he finally settled.

The recipient of this award is a native Texan, having been born at Weatherford, Texas.

He graduated from Texas A. and M. College with a Bachelor of Science degree in horticulture and went to the Beeville Experiment Station as superintendent.

He returned to A. and M. and joined the Extension Service, traveling over the state locating experiment substations, including Substation No. 15 of the Texas Agricultural Experiment Station at Weslaco.

It was while he was at the Beeville station that he determined satsumas and kumquats could be grown in South Texas. That was during the period of 1909 to 1912. Citrus in that area was grown on trifoliata rootstock which was susceptible to citrus canker. Citrus canker and freezes finally eliminated most of the citrus trees along the Gulf Coast.

The citrus industry then moved southward and by 1921 most of the citrus trees in the state were located in the Lower Rio Grande Valley where Potts moved in 1924 to become a partner with Sam Baker in the Baker-Potts Nursery Co. He had in the meantime received a master's degree from the University of California and another from A. and M.

He bought out his partner's share in the business and has been closely identified with the development of the citrus industry in the Valley ever since. He also helped in the development of several large citrus tracts including those at Bayview, Progreso and Adams Gardens. Mr. Potts was instrumental in formation of the Texsun Citrus Exchange and has served in many civic capacities.

Every other year the Rio Grande Valley Horticultural Society will give the Arthur T. Potts award to a Texas horticulturist for his contributions towards the advancement of Horticulture in the Rio Grande Valley. Since many out-of-state horticulturists have made contributions indirectly affecting Valley horticulture, the award will be given on alternate years to an outstanding out-of-state horticulturist.

Arthur T. Potts Award Recipient For 1956

★ ★ ★

ARTHUR T. POTTS, Harlingen, Texas
For his outstanding work in the early development of the citrus industry in Texas.

DR. WILSON POPENOE, Tequcigalpa, Honduras
For his interest in developing an avocado industry in the United States.

Program of the Tenth Annual Institute of the Rio Grande Valley Horticultural Society

Tuesday Morning, January 24, 1956
Texas A&I College, Weslaco, Texas

Joint Session—Dr. E. H. Poteet, Chairman
Texas A&I College, Kingsville, Texas

Report of the President: Stanley Crockett

Soil Problems in the Valley: Dr. George Schulz, Texas Soil Laboratory, McAllen, Texas

Some Physical and Chemical Factors involved in Soil Management: Dr. J. B. Page, Head of Agronomy Department, Texas A&M College, College Station, Texas

Fruit Frost Protection Service: Harry Swift, Special Service Officer, U. S. Weather Bureau, Washington, D. C.

SPLIT SESSION

Vegetable Session—Dr. R. D. Lewis, Chairman
Texas A&M College, College Station, Texas

Virus Diseases of Vegetables: Dr. David Rossberg, Texas A&M College, College Station, Texas

Soil Fumigation of Vegetable Crop Land: Dr. R. A. Biron, Dow Chemical Company, Midland, Michigan

Vegetable Insect Problems: Dr. George Wene, Texas A&M College, Weslaco, Texas

Vegetable Processing Studies: Tom Stevens, USDA, Weslaco, Texas

Citrus Session—Dr. Guy Adriance, Chairman
Texas A&M College, College Station, Texas

Spreading Decline and Citrus Nematodes: Ed Ayers, Chief Florida State Plant Board, Gainesville, Florida

Stubborn Diseases of Citrus: Dr. John Carpenter, U. S. Date Field Station, Indio, California

Nitrogen Fertilization of Citrus: Dr. William L. Sims, Texas A&I College, Weslaco, Texas

Tuesday Afternoon, January 24, 1956
TEXAS A&I COLLEGE, Weslaco, Texas

Joint Session—DR. R. H. CINTRON, Chairman
Hoblitzelle Ranch, Mercedes, Texas

Research on Avocado and Subtropical Fruits in Florida: Dr. George Ruehle, Vice Director, Subtropical Experiment Station, University of Florida, Homestead, Florida

Avocado Varieties for the Valley: J. B. Chambers, Jr., Harlingen, Texas

SPLIT SESSION

Grape Session—ELMER LINNARD, Chairman,
McAllen, Texas

Problems of Grape Culture: H. B. Richardson, Extension Marketing Specialist, University of California Extension Service, Davis, California

Nematodes of Grapes: John Machmer, USDA and Texas A&M College, Weslaco, Texas

Ornamental Plant Session—RAY D. GOODWIN, Chairman
Mission, Texas

Landscape Design and Planting: H. Durwood Thompson, President of Texas Nurserymen's Association, Corpus Christi, Texas

Observations on Ornamental Horticulture in the Valley since the Freeze of 1951: Ed Kornegay, Harlingen, Texas

CITRUS SECTION

DR. R. H. CINTRON, *Section Chairman*

A Summary Covering the Development of Horticulture In South Texas

By Arthur T. Potts

To record events and observations covering a span of fifty years through the use of statistics and by detailed accounting would be unnecessary for the purpose of this review. In this instance, the succession of general events will be used to augment the span of history that is adequately covered in the wealth of information that has always been available to technicians and laymen who were in pursuit of information of this nature. Information is available through our fine school systems, through federal and state agencies, and through published reports that have faithfully recorded the history of horticulture as it began its development through the South Texas area.

Political, social and economical influences have shared important roles, and sometimes have taken priorities to geographical influences in this development. As a technician, it has been my pleasure to have served in testing, exploring, and evaluating the realm of horticulture for this fine geographical area.

Instruction and dissemination of information covering the development of horticultural pursuits while associated with the Texas A. & M. College is a pleasure that has remained with me even after entering my own business as a nurseryman and practicing horticulturist.

At the turn of this current century, geographical manifestations of temperate climate and favorable disposition to the growth of vegetables and sub-tropical fruits were stirring inquisitive minds toward the exploration and development of the Texas Gulf Coast area for the purpose of producing similar crops to those beginning to be exploited in Florida and California.

Railroads were seeking new sources of freight revenue; therefore the development of those facilities created little, if any problem. Transportation agencies had a strong influence in the propagandizing and encouragement of the pioneer to join in the development of the gulf-coast section. The need for additional food producing areas for an expanding nation; incidents involving the activities of our armed forces along the Mexican border, and a liberal amount of inquisitive minds all combined with other events, called more attention to the Coast and the Rio Grande Valley.

Interest in and the demand for citrus fruit has been a major factor in the present location of sub-tropical vegetable and fruit production in Texas. The similarity of climatic requirements governing the production of both truck crops and fruit, linked with similar demands for adequate water, labor, processing and transportation may all be noted as factors responsible for causing the discussion of citrus to cover a major portion of this review. The evolution of the citrus industry in South Texas was, to a great extent, the pattern for the formation of vegetable and other pursuits of horticultural produce for South Texas.

By the beginning of this twentieth century, winter truck gardening was being attempted on a commercial basis from Beaumont to Brownsville, on the coast, through Beeville and to Eagle Pass to the North and West portion of the Texas gulf area. Commercial citrus plantings, comprised mostly of Satsuma oranges and Kumquats, were the basis of the new Texas industry that in 1910, boasted a citrus population of over 833,000 trees. These plantings were mostly in the Houston-Beaumont, Galveston-Alvin, and Beeville areas. After killing freezes in 1916 and 1917, and the devastation the imported citrus canker caused to the predominantly trifoliate orange understock, the Texas census of 1921 showed its citrus tree count reduced to around 123,000. A major portion of the trees shown in the 1921 census were those in the newly beginning development of the Rio Grande Valley.

From about 1910 on, attempts to develop citrus production on a commercial basis were in evidence from Brownsville through Mission. The first Valley groves were mostly the round orange commonly called the Louisiana Sweet. From about 1918 on, Valley citrus planting was conducted with considerable zest and vigor; so, that by the middle 1920's the process of selection and elimination of varieties, root-stocks and the acceptance of standard orchard practices had well evolved. By 1923 citrus fruit production was acclaimed with a sixty per cent increase over the previous year's Valley out-put. Land development for future citrus plantings was extensive from Bayview to Mission, and by 1924 our survey of citrus plants counted sixty-eight per cent grapefruit, twenty-eight per cent orange trees, and four per cent of miscellaneous citrus plants in a total count of over 2,000,000 citrus trees in the Valley. Production figures for that same period were about 75,000 boxes, but purported to be over 100,000. From that time on the production and marketing of citrus fruit and winter vegetables served to form major industries for this section of Texas. Production figures for both citrus and vegetables increased annually, and this newly developed horticultural area responded in every way to the advent of, and the depression following the "roaring' twenties."

To be remembered along with the stock market difficulties of 1929, was a mutation or bud-sport that occurred in many instances, and in various parts of the Valley on Pink Marsh Grapefruit trees. The Redblush or Ruby Red Grapefruit trees that make up a large part of currently planted citrus orchards, are all progeny from propagation that was developed from those original and numerous sports.

Citrus fruit production had reached such proportions by 1933 that the hurricane of that year exhibited fruit volume by stripping the trees, and literally covering the ground as far as one could see. The problems covering the production of tomatoes, cabbage, carrots, onions and other vegetables have reflected themselves, in some instances, quite acutely

on the development of our Valley; but the failures or rewards of citrus fruit production have been of greater economic importance, in general.

Events encompassed within the past few years as they pertain to this subject, are well known to everyone and will not be mentioned here. Even so, current events have had their influence on fruit and vegetable production in the Valley. Speculation is at a comparative minimum, and development and production are based on intelligent methods of operation, as compared to the irresponsible procedures that were in evidence when development was the cause, rather than the result of the horticultural activity that has enriched our Valley.

To briefly touch upon the events covering the development of other horticultural pursuits, Fig production should not be overlooked. The Alvin-Angleton area enjoyed development for that purpose in the early part of the century, and still provides the production of figs utilized in Texas fig processing. Fig varieties were investigated, tested and proven for adaptability and production. An industry based on the production of certain varieties of that fruit would not be an impractical addition to the development of portions of the Valley.

Grape production was the basis of study and interest during the early 1900's. It is gratifying to note the revival of interest in grape production. Encouragement is extended to those whose efforts might easily create another industry for our section, based on that produce.

Interest concerning the production of avocadoes has been aroused off and on, since citrus was first considered for Valley commerce. The exploitation of citrus proved to be easier, and the full exploitation of avocado possibilities remains as a challenge to those fine men now engaged in the careful selection of proper varieties and the establishment of proper cultural practices for the development of that crop.

A prognosis of the future, generally serves as a basis of concluding such a review as this; therefore no exceptions will be made in this instance.

The pursuit of new industries, based on products of sub-tropical horticulture have only achieved their initiation during the past fifty year period of development in the Rio Grande Valley. Unlimited horizons remain to be exploited. The development of the culture and production on a commercial basis of many fruits and vegetables such as the mango, papaya, cherimoya and many others, falls within those horizons. The evolution of the past half-century has served to select the geographical area for this development. Predicted on past history, the expansion and development of many new horticultural enterprises may be expected to locate within this same area.

Review of Studies on Adaptability of Citrus Varieties As Rootstocks for Grapefruit in Texas[1]

WILLIAM C. COOPER *and* EDWARD O. OLSON, *U.S. Dept. of Agriculture;*
NORMAN MAXWELL, *Texas Agricultural Experiment Station, and*
GEORGE OTEY, *Rio Farms, Inc.*

INTRODUCTION

Investigations were initiated in 1946 to study adaptability of citrus rootstocks to conditions in the Lower Rio Grande Valley of Texas. The first approach to the problem was to establish replicated orchard plantings where grapefruit scion tops were grown on more than 100 citrus varieties (Cooper, 1948). Observations since 1947 indicated that tolerance to salt, boron, lime, low temperatures and diseases may be important independent and interrelated factors that affect the adaptability of citrus varieties for use as rootstocks in Texas. Previous publications have emphasized the importance of single factors. The present paper reviews these reports and gives a current appraisal of the tolerances of the various rootstocks.

METHODS

Orchard Plantings

Scion-rootstock orchards were established at 5 locations in the Valley (table1). Shary Red or Webb Red Blush grapefruit tops were used in each orchard. A total of 135 different citrus varieties was used as rootstocks; however, all of these are not present in each orchard but each contained many of the more promising types. The trees in each orchard were planted in 4 replications of 3-tree blocks, comprising 12 trees on each rootstock. The planting distance was 25 x 25 feet in the Experiment Station, Rio Farms and Engelman orchards, while that in the Bryan and in the Randle planting was 25 x 20 feet.

Orchard care was provided by each cooperator. A weed cover was maintained during the summer and clean cultivation was practiced during the winter. The Engelman planting was occasionally irrigated with drain ditch water, and the other plantings were irrigated with river water except for the Rio Farms planting which was irrigated with salty water during 1952. All trees were fertilized with 1 to 2 pounds of nitrogen per year in the form of ammonium nitrate.

Each year, every tree was carefully inspected for visible symptoms of salt excess, boron excess, iron chlorosis, foot rot, cotton root rot, Rio Grande gummosis, tristeza and other disorders. In determining the salt and boron tolerances of the various rootstocks, the field observations were supplemented by leaf analysis for chloride and boron. A strip of bark approximately 1 inch long (½ inch on both sides of the bud union) and ¼ inch wide was peeled off to supplement the general disease observations on each tree. The inner face of the bark and the exposed wood were examined for discoloration, gumming, pitting, pegging and creasing.

The 1949 and 1951 freezes killed the tops of all trees down to the banks of soil protecting the bud unions of the trees. Observations on tree recovery were made on all plantings during 1951 (Cooper, 1952). The milder freezes of 1950, 1953 and 1955 caused some leaf and twig injury on many trees and the extent of injury was estimated.

Supplementary Tests for Salt, Boron, Lime, Cold and Disease Tolerance

Other experimental plantings were made to obtain specific information that might be useful in analyzing results from the rootstock orchard plantings. Salt-tolerance tests, for example, were conducted on 2- and 3-year-old trees of various scion-rootstock combinations planted in soil plots that were uniformly salinized with water containing known amounts of sodium, calcium, chloride and sulfate ions. The techniques

[1] These investigations are a part of the Cooperative Citrus Rootstocks Investigations conducted by the Texas Agricultural Experiment Station and the U.S. Department of Agriculture, certain phases of which were carried on under the Agricultural Marketing Act (RMA Title II). The cooperation of Rio Farms, Inc., Monte Alto; Engelman Products Co., Elsa; Harold Randle, Mission, and W. J. Bryan, Bayview, is greatly appreciated.

Table 1. Description of the five grapefruit-rootstock orchards, Texas.

Cooperator	*Place*	*Year planted*	*Soil classification*	*Rootstock varieties in test, number*	*Variety of grapefruit scion*
Experiment Station	Weslaco	1947	Hidalgo fine sandy loam	39	Webb Red Blush
Rio Farms, Inc.	Monte Alto	1950	Brennen fine sandy loam	83	Shary Red
Engelman Products Co.	Elsa	1950	Hidalgo loam	24	Shary Red
Harold Randle	Mission	1952	Rio Grande fine sandy loam	25	Webb Red Blush
W. J. Bryan	Bayview	1953	Rio Grande silty clay loam	14	Webb Red Blush

used in salting the plots and the methods of chemical analysis of water, soil and leaves were described by Cooper and Edwards (1950) and Cooper and Gorton (1952).

Boron-tolerance tests were conducted in trees which were irrigated with water containing known amounts of boron (Cooper and Edwards, 1950). Symptoms of boron toxicity were observed and the leaves on the trees were analyzed for boron content.

The lime tolerance of grapefruit trees on various rootstocks was studied in a closely spaced planting in a calcareous soil at Floyd Everhard's at Mission. The severity of iron chlorosis in the grapefruit foliage was estimated and recorded.

The freezing points of grapefruit trees on sour orange, Cleopatra mandarin, Savage citrange and Rough lemon rootstocks were determined by tests at controlled low temperatures with the aid of a portable tree-freezing unit (Cooper, Gorton, and Tayloe, 1954). These determinations supplemented the orchard-freeze-damage data in assaying the cold tolerance of grapefruit tops on those rootstock varieties.

The susceptibility of citrus rootstocks to cotton root rot was also studied. One- and two-year-old citrus seedlings were grown at close spacing in a soil infested with sufficient cotton root rot fungus to kill alfalfa and cotton interplanted between the citrus (Olson, 1952).

RESULTS

Tolerance to Diseases

No tristeza was found in any experimental rootstock orchards, and consequently no information was obtained on the tolerance of rootstocks to the Texas strains of the virus. Tolerance of many of the stocks to other strains of the virus has been tested in other areas (Grant and Costa, 1949).

Five other bud-transmitted disorders which stunt or kill trees on susceptible rootstocks were found in the field plantings (Olson, 1952, 1954). They are cachexia, xyloporosis, exocortis, Rangpur lime disorder and a bud-union-crease disorder common to kumquat-hybrid rootstocks. Trees of many commercial strains of Texas citrus carried the casual agent of one or more of the five disorders (Olson and Shull, 1955). In the rootstock orchards susceptible rootstocks grafted with Shary Red or Webb Red Blush grapefruit developed symptoms of these disorders, but grafted sour orange and Cleopatra mandarin rootstock did not.

Cachexia symptoms such as phloem discoloration, gum deposits and pegs and xylem pits were found on many mandarin, mandarin-lime, tangor and tangelo rootstocks and on the Leonardy grapefruit rootstock (Table 2). Of the mandarin and mandarin-hybrid rootstocks observed during a 5-year period, those showing no visible cachexia symptoms were Cleopatra, Sunki, Ponkan, Lau Chang, Changsha, King, Kara,

Table 2. Classification as to disease, salt, boron, lime and cold tolerance of citrus varieties used as rootstock for Webb Red Blush and Shary Red grapefruit.

Group and Variety	*Tolerant to tristeza in Brazil*[1]	*Symptoms of indicated disease visible*	*Tolerance to*[2]			
			Salt	*Boron*	*Lime*	*Cold*
Mandarin:						
Cleopatra	yes	None	ttt	[3]	tt	tt
Sunki	yes	Bark shelling, unidentified cause	ttt	–[4]	tt	tt
Timkat	–	–	ttt	–	t	–
Suenkat	yes	Cachexia (many)	tt	–	t	tt
Ponkan	yes	None	tt	tt	t	tt
Betangas	–	–	tt	–	t	t
Dancy	yes	Cachexia (few)	tt	–	tt	tt
Kunembo	–	–	ttt	–	tt	–
Oneco	yes	Cachexia (few)	tt	–	t	tt
Clementine	yes	Cachexia (few)	tt	t	t	t
Lau Chang	–	None	tt	t	t	tt
Changsha	–	None	tt	–	t	tt
Pong Koa PI 14054	yes	Cachexia (few)	tt	–	t	tt
Chu Koa PI 10032	yes	Cachexia (few)	tt	–	t	tt
Sanguinea	–	Cachexia (few)	ttt	–	–	t
Choo Chou Tien Chieh	yes	Cachexia (many)	t	–	–	t
Willow leaf	–	Cachexia	tt	–	tt	t
Miray	–	–	t	–	t	t
C. Noblis PI 10642	yes	–	t	–	t	t
Silverhill satsuma	–	Cachexia	t	–	t	t
False hybrid satsuma	–	Cachexia	t	–	t	t
Shekwasha[5]	–	–	tt	–	ttt	tt
Calashu[6]	–	–	tt	ttt	–	tt
Tangor:						
Umatilla	yes	Cachexia (few)	–	–	t	tt
Altoona	–	Cachexia (few)	t	–	–	tt
Tangor CPB653	yes	–	tt	–	–	t
King	yes	None	t	–	tt	t
Kara	yes	None	t	–	t	t
Kinnow	yes	None	tt	–	t	tt
Temple	yes	Cachexia (few)	–	–	t	tt

[1] Based on work in Brazil (Grant and Costa, 1949; Grant, Costa and Moreira, 1950). No tristeza was found in any of the experimental orchards in Texas.
[2] ttt indicates good tolerance, tt moderate and t poor as described in the text.
[3] The boron tolerance of the Cleopatra is slightly less than the moderate rating but greater than the poor rating.
[4] - indicates no determination.
[5] Shekwasha is considered to be a natural hybrid (*Citrus tachebana* x mandarin.)
[6] Calashu is a hybrid of calamondin and satsuma.

Table 2. Continued

Group and Variety	Tolerant to tristeza in Brazil[1]	Symptoms of indicated disease visible	Tolerance to[2]			
			Salt	Boron	Lime	Cold
Tangelo:						
San Jacinto	yes	None	tt	—[4]	—	tt
Webber	yes	None	tt	tt	—	tt
Williams	yes	Bark shelling, unidentified cause	tt	t	tt	tt
Orlando	yes	Cachexia (many)	tt	—	t	t
Sunshine	yes	Cachexia (many)	tt	tt	t	tt
Suwannee	yes	Cachexia (many)	tt	—	t	tt
Watt	no	None	tt	t	t	tt
Thornton	no	Cachexia (many)	tt	t	t	tt
Minneola	yes	Cachexia (many)	tt	t	tt	tt
Pina	no	Cachexia (many)	tt	t	t	tt
Yalaha	yes	Cachexia (many)	tt	—	t	tt
Seminole	yes	Cachexia (many)	tt	—	tt	t
Sampson	yes	None	tt	t	t	tt
Pearl	—	—	t	—	—	t
Sour lime:						
Mexican	no	—	tt	tt	tt	t
Egyptian sour	—	—	tt	—	tt	t
Kalpi	no	None	tt	—	t	t
Sweet lime:						
Palestine	yes	Xyloporosis	t	t	tt	tt
Columbian	yes	Xyloporosis	tt	t	tt	tt
Butnal	—	Xyloporosis	tt	t	tt	tt
Mandarin-lime:						
Rangur	yes	RLD[7]; Cachexia (few)	ttt	tt	ttt	ttt
Kusaie	—	RLD; Cachexia (few)	ttt	—	—	—
Poak Ling Ming	—	RLD; Cachexia (few)	ttt	—	—	—
Ling Ming	yes	RLD; Cachexia (few)	ttt	—	—	—
Lemon:						
Rough lemon	yes	None	tt	tt	ttt	tt
Kumquat hybrid:						
Winter Haven Lemonquat	—	Bud-union crease	t	t	—	tt
Tavares limequat	—	Bud-union crease	—	—	—	t
Lakeland limequat	—	—	—	—	—	t
Calamondin	—	Bud-union crease	tt	t	tt	tt

[7] RLD indicates Rangur lime disease.

Table 2. Continued

Group and Variety	Tolerant to tristeza in Brazil[1]	Symptoms of indicated disease visible	Tolerance to[2]			
			Salt	Boron	Lime	Cold
Trifoliate orange:						
Trifoliate orange	yes	Exocortis	t	tt	t	t
Citrange:						
Rusk	yes	None	t	tt	t	t
Troyer	yes	None	t	ttt	t	t
Savage	yes	None	tt	tt	tt	tt
Carrizo	—	—	tt	—[4]	tt	—
Morton	yes	Exocortis	—	ttt	tt	—
Cunningham	yes	Exocortis	t	—	t	—
Saunders	—	None	t	ttt	t	tt
Uvalde	no	None	t	ttt	t	t
Norton	—	—	t	ttt	t	t
Rustic	—	None	t	ttt	—	t
Citrumelo:						
Sacaton	yes	None	tt	tt	t	tt
Citrumelo CPB4475	yes	None	tt	tt	t	tt
Other trifoliate-orange hybrids:						
Highgrove citremon	no	None	tt	—	—	tt
Brownell citradia	—	Exocortis	t	—	—	tt
Thomasville citrangequat	—	None	t	—	t	t
Glen citrangedin	—	Bud-union crease	t	—	—	tt
Citrangeor, CPB 44301-A_2	—	None	t	tt	—	t
Citraldin, CPB50130	—	None	tt	—	—	tt
Citranguma, CPB 48060	—	None	tt	—	—	tt
Sweet orange:						
Pineapple	yes	Foot rot	tt	ttt	t	tt
Hamlin	yes	Foot rot	tt	—	t	tt
Florida	yes	—	t	—	t	tt
Louisiana	—	Foot rot	tt	—	t	tt
Torregrossa	yes	Foot rot	tt	—	t	tt
Gzel Gzel	—	Foot rot	tt	—	t	tt
Lambs summer	yes	Foot rot	tt	—	t	tt
Weldon	—	Foot rot	tt	—	t	tt
Valencia	yes	Foot rot	tt	—	t	tt
Precoce	—	None	tt	—	t	tt
Maltese Oval	—	—	—	—	t	tt
Avena Blood	—	Foot rot	tt	—	t	tt
Caderna	—	Foot rot	tt	—	t	tt
Indio	—	Foot rot	tt	—	—	tt

Table 2. Continued

Group and Variety	Tolerant to tristeza in Brazil[1]	Symptoms of indicated disease visible	Tolerance to[2] Salt	Boron	Lime	Cold
Sweet orange (continued)						
Sanguinea Grosse Ronde	—[4]	—	—	—	t	—
Harvard No. 2	—	—	—	—	t	—
Drake Star	—	—	—	—	t	—
Enterprise	yes	—	—	—	t	—
Homosassa	yes	—	tt	ttt	t	tt
Sour orange:						
Texas	no	None	tt	tt	ttt	tt
Florida	no	None	tt	tt	ttt	tt
Bergamot	no	None	tt	—	ttt	tt
Sauvage	no	None	tt	—	ttt	tt
Bittersweet	no	None	tt	—	ttt	tt
Oklawaha	no	None	tt	—	ttt	tt
Grapefruit:						
Duncan	no	None	tt	tt	t	tt
Webb Red Blush	no	None	—	tt	t	tt
Leonardy	no	Cachexia (many)	—	—	tt	tt
Shaddock:						
Siamese	no	None	tt	—	t	tt
Thong Dee	no	None	tt	—	t	tt
Cuban	no	None	tt	t	tt	tt
African	—	None	tt	t	—	tt
Other species:						
Severinia buxifolia	no	None	ttt	ttt	t	ttt
Citron, PI 11292	—	Weak root system, unidentified cause	t	t	—	t
Yuzu ichandarin[8]	—	Bud-union crease	—	—	—	—
Natsu Mikan[9]	no	None	t	—	t	t

Kinnow, San Jacinto, Webber, Williams, Watt and Sampson; some of these may develop symptoms when the trees are older. The sweet and sour oranges, shaddocks, most grapefruit, trifoliate-orange hybrids and rough lemon employed as rootstocks for grapefruit were also apparently free of symptoms of cachexia. Childs et al (1955) report that in Florida the rough lemon rootstock exhibited cachexia-like symptoms when budded with sweet orange carrying cachexia virus but did not do so when budded with grapefruit scions carrying the virus. The Texas results for grapefruit thus confirm those for grapefruit in Florida.

[8] Considered to be a natural hybrid (*Citrus ichangensis* x sour mandarin).
[9] A sour orange type.

Xyloporosis symptoms, similar to those of cachexia, occurred in the sweet lime rootstocks; the gumming and bark-shelling symptoms of Rangpur lime disease were common in the mandarin limes; exocortis was identified by scaling of the outer bark of trifoliate-orange rootstock and some trifoliate-orange hybrid rootstocks; and bud-union crease occurred in some kumquat hybrids, Glen citrangedin and Yuzu ichandarin. Bark shelling of unidentified cause also occurred on the Williams tangelo and Sunki mandarin rootstocks.

Some of these bud-transmitted disorders may have a common cause. Xyloporosis and cachexia are considered identical in Florida (Childs, 1952) on the basis of similarity of symptoms. Recent work in Brazil (Moreira, 1955) suggests that the Rangpur lime disease and exocortis are associated. Tests are now under way in Texas to study the relationships of these disorders.

Fungus-caused diseases also may limit the choice of rootstocks. Symptoms of foot rot, caused by *Phytophthora* species, were found commonly on sweet orange rootstocks in the experimental orchards. Rio Grande gummosis, a disease of grapefruit trees associated with infection by *Diplodia natalensis* (Olson, 1952), has not been found in the rootstock orchards. Since it commonly affects trees older than those in the rootstock orchards, it may develop at a later date. Cotton root rot, caused by *Phymatotrichum omnivorum*, also was not found on trees in the rootstock orchards. The incidence of cotton root rot in commercial citrus orchards is slight and, when the disease is found, it is associated with 1- and 2-year-old trees, wet seasons and highly susceptible cover crops. The weed cover crops used in the experimental orchards were not susceptible to this disease. Also the period of these observations was generally dry. Special tests of young seedlings of many varieties as rootstock grown for 2 years in root-rot-infested plots resulted in infection of a wide range of varieties, but comparatively few trees died and the differences between varieties were not great (Olson, 1952).

Salt, Boron and Lime Tolerance

The rootstocks listed in table 2 were classified for 3 degrees of salt tolerance; good (ttt), moderate (tt) and poor (t). The ranges for the 3 classes were approximately equal to those for the moderate, poor and very poor classes used by Cooper, Cowley and Shull (1952). Grapefruit trees on rootstocks with good salt tolerance showed no evidence of toxicity when grown in plots irrigated with 4000-ppm salt solution. Grapefruit on rootstocks with moderate salt tolerance showed severe leaf burn, defoliation and growth retardation when irrigated with the 4000-ppm salt solution but no evidence of toxicity when irrigated with a 2500-ppm salt solution. Poor salt tolerance was indicated by development of toxicity symptoms on trees irrigated with 2500-ppm salt solution.

Rootstocks with good salt tolerance were not necessarily tolerant to excess boron in the irrigation water. Boron toxicity on grapefruit trees was evidenced largely by leaf abnormalities: yellowish dots; irregular areas of yellowish color between the veins, particularly along the margins and at the tip; presence of pustules on the underside of the leaf; and tip burn. The degree of boron toxicity symptoms in the foliage was closely related to the boron content of the leaves, and differences in specific selectivity of rootstocks to boron accumulation were measured by the boron content of the leaves (Cooper, Peynado and Shull, 1955). Accordingly, the boron tolerances of the rootstocks listed in table 2 were based on the relative accumulation of boron in grapefruit leaves of trees on various rootstocks grown in soil irrigated with water containing standard amounts of added boron.

The lime tolerances of the rootstocks listed in table 2 were based on the incidence of iron chlorosis in the leaves of the grapefruit trees grown in calcareous soil (Cooper and Olson, 1951; Cooper and Peynado, 1956). When grapefruit foliage of trees on certain rootstocks showed no iron chlorosis, the rootstocks were classed as having good (ttt) lime tolerance; those which occasionally showed iron chlorosis but usually recovered without treatment were classed as having moderate (tt) tolerance; and those which showed severe iron chlorosis and made poor recovery without special treatment were classed as having poor (t) tolerance.

None of the citrus varieties under test as rootstocks showed good tolerance to all three soil factors: salt, boron, and lime. The Rangpur lime came the closest with good salt and lime tolerances and moderate boron tolerance. *Severinia buxifolia* had good salt and boron tolerances but poor lime tolerance. The sour orange and Rough lemon had good lime tolerance but only moderate salt and boron tolerances. The Cleopatra mandarin had good salt tolerance, moderate lime tolerance, and nearly moderate boron tolerance.

Cold Tolerance

Cold tolerance, as used in this paper, was based on the degree of recovery of young trees frozen to the banks by the 1949 and 1951 freezes and on the extent of twig and leaf injury from the milder freezes of 1950, 1953 and 1955. The rootstocks listed in table 2 were classified according to 3 general levels of cold tolerance: good (ttt), moderate (tt) and poor (t). Rootstocks with cold tolerance approximately equal to that of the sour orange were classed as having moderate cold tolerance; temperatures below 23°F for 3 or more hours caused considerable wood injury to the tops of grapefruit on these rootstocks (Cooper, Gorton and Tayloe, 1954). Rootstocks showing less cold tolerance than the sour orange were listed as poor, while those with tolerance greater than the sour orange were listed as good.

Rangpur lime and *Severinia buxifolia* rootstocks are classed as having good cold tolerance. The temperature at which injury might be expected on these rootstocks has not been established, but grapefruit on both rootstocks showed no leaf injury from the December 7, 1950-freeze (25°F for 4 hours) while up to 50 percent defoliation occurred on grapefruit on sour orange rootstock. Rangpur lime rootstock, however, has

not shown consistently good cold tolerance. The February 17, 1955-freeze (24° for 3 hours) caused as much wood damage to trees on Rangpur lime rootstocks as to those on other rootstocks. In this instance, however, the trees on Rangpur lime rootstock were declining from the Rangpur lime disease, which may influence cold tolerance.

DISCUSSION

The relative importance of disease, salt, boron, lime and cold tolerance in the choice of rootstocks varies with the circumstances in the individual orchards in the Rio Grande Valley.

Tolerance of rootstocks to tristeza is important to a grower who believes that the tristeza hazard will increase in the future. The rootstock experiments were initiated in 1946, after Texas growers had heard reports that tristeza, an aphid-transmitted virus disease, had decimated groves on sour orange rootstock in South America. The growers were concerned because in Texas trees were grown on the tristeza-susceptible sour orange rootstock. The growers' fear of tristeza disease lessened when they learned that a mild form of tristeza virus has been present in Meyer lemons in Texas for 30 years without apparent spread to adjacent susceptible trees (Olson and Sleeth, 1954). To date, no experimental evidence has been obtained to prove field spread of the disease, and aphids present in Texas are recognized as relatively inefficient vectors (Olson, 1955). The relative tolerance of rootstocks to a severe strain of tristeza virus (Table 2) must of necessity be based on work in Brazil (Grant and Costa, 1949; Grant, Costa and Moreira, 1950). At present the tristeza hazard in Texas is of minor importance although this situation could change with the introduction of an efficient vector of the virus.

Rootstocks susceptible to the other bud-transmitted virus diseases discussed herein are not suitable for use with commercial red grapefruit varieties which carry several such viruses; however, some of these rootstocks probably could be used successfully with virus-free tops. Such virus-free tops may either be found or produced through use of nucellar material.

Rootstocks susceptible to foot rot, such as the sweet orange, are not well adapted to present practices of citrus culture in Texas, where irrigation by sprinklers or flooded basins favors development of this disease. Furrow irrigation, as practiced in California on sweet orange stocks to avoid foot rot, increases soil salinity and the practice is not generally feasible in Texas.

Salt tolerance is an important factor in the choice of rootstocks. In 1953 saline water from wells and drainage ditches was the only water available for irrigation of many citrus orchards of the Valley. In 1954 and 1955 the recently-completed Falcon Dam supplied an abundance of low-salinity water and thus reduced the salinity hazard. However, saline water is still the only water available in some areas at some times, and saline soils are still being planted to citrus. The salinity factor in choice of rootstocks will probably decline in importance, but a successful rootstock for Texas should possess moderate to good salt tolerance.

Saline water from wells and drainage ditches frequently carry 1 to 6 ppm of boron. Boron tolerance, as well as salt tolerance, is therefore important where this kind of water is used for irrigation. Groves consistently watered with water high in salt and boron are probably destined to become marginal.

Lime-tolerant rootstocks are required for successful citriculture in some calcareous soils of the Lower Rio Grande Valley, but are not required in the non-calcareous soils. Final evaluation of the importance of this factor in the choice of rootstocks awaits observations on the performance of trees over a longer period than that reported in these investigations. The data presented represent lime tolerance of young trees only.

The major citrus problem in the Lower Rio Grande Valley is cold tolerance. The freezes of 1949 and 1951 decimated the Texas groves, killed millions of trees, and almost wiped out the Texas citrus industry. Increased tolerance of trees to disease, salt, boron, and lime can make profitable groves even more profitable; increased tolerance to cold can mean the difference between success and failure of an industry in a few hours.

Citrus in the Rio Grande Valley is generally more tender to cold than the same varieties in most other citrus areas. This lack of cold tolerance is associated with a lack of dormancy of the trees during the winter. In December and January of 1953-54 and 1954-55 there was no cessation of cambial activity in citrus trees on any variety of rootstock under test even though the trees showed no visible bud growth (Cooper, Tayloe and Maxwell, 1955). Rootstocks can influence the extent of freeze injury and modify the rate of recovery of freeze-damaged trees. The commercial use of rootstocks showing poor cold tolerance could be disastrous. However, there is little prospect that any new rootstock selections will show a great improvement in cold tolerance as compared with sour orange. Nevertheless, the apparently cold-tolerant Rangpur lime and *Severinia-buxifolia* rootstocks are being tested further.

Salt accumulation, affected by the rootstock, also increased the severity of freeze damage (Cooper, 1952). The apparent lack of cold tolerance of trifoliate-orange rootstocks as compared with general observations to the contrary in other citrus areas was probably related to a large salt accumulation by this rootstock.

Since adaptability of citrus rootstocks is influenced by many soil, water, climate, and disease factors, the cumulative yields of trees on various rootstocks and the quality of the fruit produced are the best measures of the adaptability of a rootstock variety. Work in Florida (Cook, Horanic and Gardner, 1952) and in California (Webber, 1948) indicates that rootstock influenced the yield, size and quality of the

Table 3. Summary of general reactions of citrus rootstocks budded with Webb Red Blush and Shary Red grapefruit to disease, salt, boron, lime and cold.

Group	*Disease Symptoms visible*	*Tolerance to*			
		Salt	*Boron*	*Lime*	*Cold*
Mandarin	Some varieties show cachexia, others do not	Good to poor	Moderate to poor	Moderate to poor	Moderate to poor
Tangor	Ditto	Poor	—[1]	Moderate to poor	Moderate to poor
Tangelo	Ditto	Moderate	Moderate to poor	Moderate to poor	Moderate to poor
Sour lime	None	Moderate	Moderate	Moderate to poor	Poor
Sweet lime	Xyloporosis	Moderate to poor	Poor	Moderate	Moderate
Mandarin-lime	Rangpur lime disease	Good	Moderate	Good	Good
Rough lemon	None	Moderate	Moderate	Good	Moderate
Kumquat hybrids	Bud-union crease	Moderate to poor	Poor	—	Moderate to poor
Trifoliate orange	Exocortis	Poor	Moderate	Poor	Poor
Citrange	Some varieties show exocortis, others do not	Moderate to poor	Good to moderate	Moderate to poor	Moderate to poor
Citrumelo	None	Moderate	Moderate	Poor	Moderate
Sweet orange	Foot rot	Moderate	Good	Poor	Moderate
Sour orange	None	Moderate	Moderate	Good	Moderate
Grapefruit	Leonardy showed cachexia, others do not	Moderate	Moderate	Moderate to poor	Moderate
Shaddock	None	Moderate	Poor	Moderate to poor	Moderate

[1] Indicates no determination.

fruit produced. Limited fruit data from the rootstock orchards in Texas indicate a similar influence of rootstock on fruit production and quality. The rootstock orchards in Texas, however, are not yet in full production and data on these critical tests of a rootstock are not yet available.

This progress report, based mostly on the behavior of relatively young trees, is a preliminary assay of rootstock adaptability. As the trees grow older, other disorders and diseases may express symptoms not apparent in young trees. A summary of the data presented in this paper is given in table 3.

Literature Cited

Childs, J. F. L. 1952. Cachexia disease, its bud transmission and relation to xyloporosis and to tristeza. Phytopathology 42:265-268.

____________, G. R. Grimm, T. J. Grant, L. C. Knorr and G. Norman. 1955. The incidence of xyloporosis (cachexia) in certain Florida Citrus varieties. Proc. Fla. Sta. Hort. Soc. In Press.

Cook, James A., G. E. Horanic, and F. E. Gardner. 1952. Citrus rootstock trials. Proc. Fla. State Hort. Soc. 65:69-77.

Cooper, William C. 1948. A progress report for 1948 on the Texas citrus rootstock investigation. Proc. Rio Grande Valley Citrus and Veg. Inst. 3:128-54.

____________, 1952. Influence of rootstock on injury and recovery of young citrus trees exposed to the freezes of 1950-51 in the Rio Grande Valley. Proc. Rio Grande Valley Hort. Inst. 6:16-24.

____________, W. R. Cowley and A. V. Shull. 1952. Selection for salt tolerance of some subtropical fruit plants. Texas Avocado Soc. Yearbook for 1952:24-36.

____________, and C. Edwards. 1950. Salt and boron tolerance of citrus. Proc. Rio Grande Valley Hort. Inst. 4:58-79.

____________, and B. S. Gorton. 1952. Toxicity and accumulation of chloride salts in citrus on various rootstocks. Proc. Am. Soc. Hort. Sci. 59:143-146.

____________, B. S. Gorton and S. D. Tayloe. 1954. Freezing tests with small trees and detached leaves of grapefruit. Proc. Am. Soc. Hort. Sci. 63:167-172.

____________, and E. O. Olson. 1951. Influence of rootstock on chlorosis of young Red Blush grapefruit trees. Proc. Am. Soc. Hort. Sci. 57:125-132.

____________, A. Peynado and A. V. Shull. 1955. Boron accumulation in citrus as influenced by rootstock. Prac. Rio Grande Valley Hort. Inst. 9:86-94.

____________, and A. Peynado. 1956. Iron chlorosis of grapefruit in calcareous soil as influenced by rootstock and iron-chelate treatment. In preparation.

____________, and A. V. Shull. 1953. Salt tolerance of and accumulation of sodium and chloride ions in grapefruit on various rootstocks grown in a naturally saline soil. Proc. Rio Grande Valley Hort. Inst. 7:107-117.

____________, Sam Tayloe and N. Maxwell. 1955. Preliminary studies on cold hardiness in citrus as related to cambial activity and bud growth. Proc. Rio Grande Valley Hort. Inst. 9:1-15.

Grant, T. J. and A. S. Costa. 1949. A progress report on studies of tristeza disease of citrus in Brazil. I. Behavior of a number of citrus varieties as stocks for sweet orange and grapefruit, and as scions over sour orange rootstocks when inoculated with tristeza virus. Fla. State Hort. Soc. Proc. 61:20-33.

____________, ____________, and S. Moreira. 1950. Studies of tristeza disease of citrus in Brazil. 3. Further results on the behavior of citrus varieties as rootstocks, scions, and seedlings when inoculated with tristeza virus. Fla. State Hort. Soc. Proc. 62:72-79.

Moreira, Silvio. 1955. Sintomas de exocortis en limoeira cravo. Bragantia 14:19-21.

Olson, E. O. 1952. Investigations of citrus rootstock diseases in Texas. Proc. Rio Grande Valley Hort. Inst. 6:28-34.

____________. 1954. Some bark and bud union disorders of mandarin and mandarin-hybrid rootstocks in Texas citrus plantings. Proc. Am. Soc. Hort. Sci. 63:131-136.

____________. 1955. A survey for tristeza virus in Texas citrus. Proc. Rio Grande Valley Hort. Inst. 9:51-60.

____________ and Bailey Sleeth. 1954. Tristeza virus carried by some Meyer lemon trees in South Texas. Proc. Rio Grande Valley Hort. Inst. 8:84-88.

____________, and A. V. Shull. 1955. Red grapefruit strains as symptomless carriers of the causal agent of cachexia, a bud transmitted disease. Proc. Rio Grande Valley Hort. Inst. 9:46-50.

Webber, H. J. 1948. Rootstocks: their character and reactions. In Citrus Industry Vol. II, Chapter II, pages 69-1068.

Nitrogen Fertilization of Citrus

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Introduction

More information is needed here in the Lower Rio Grande Valley of Texas concerning the proper fertilization of citrus trees. Little is known of the fertility levels necessary for the production of highest yields and the best quality and size of fruit in this area.

Since nitrogen is the most expensive item in the citrus grower's fertilizer bill, it is only natural that he would be interested in an efficient nitrogen fertilization program. Certainly, if only from a cost standpoint, a grower would not want to add nitrogen fertilizer in greater amounts than would be necessary to maintain his trees in a healthy growing and productive condition.

We are just as interested in knowing the effect of the addition of too much nitrogen to our trees as we are the effect of the addition of too little nitrogen. Nitrogen is known to be one of the most important nutritive elements required in the diet of a citrus tree. It has a great influence on growth and yield. The symptoms of nitrogen deficiency are fairly common to most growers. Research workers in California (Chapman and Brown, 1950) and in Florida (Smith and Reuther, 1951) have shown in work with oranges that when the percentage of nitrogen in the leaves on a dry matter basis falls below 2.0 percent nitrogen that the nitrogen is deficient in the trees. The normal range was found to be 2.0 to 3.2 percent and was considered excessive when the percent nitrogen was more than 3.5 percent in the leaves.

It has been postulated (Chapman, 1946) that under favorable conditions of temperature and otherwise satisfactory nutrient conditions, excessive nitrogen, in favoring vegetative growth, would prevent the accumulation of carbohydrate within the plant and hence tend to reduce reproductive differentiation. In studies conducted in California (Chapman, Brown and Liebig, 1943) it was found that high nitrogen had no appreciable effect on rind thickness or external fruit texture if the phosphorus supply was also high. In Arizona, workers (Finch, 1944) have shown that a reduction in nitrogen to the point of nitrogen starvation during the summer and fall improved the quality of grapefruit. It is probable that the ratio of nitrogen to phosphorus in the tree is the important factor in fruit quality.

The soil and climatic conditions in our Valley are different from other citrus producing areas in the United States and therefore the answers to our problems are different. In order to answer as many of these problems as possible, a long term nitrogen fertilizer experiment was initiated at the Weslaco campus.

Materials and Methods

In the winter of 1953 a four acre block at the Texas A. & I. Citrus and Vegetable Training Center was planted to Webb red grapefruit on sour orange and cleopatra mandarin rootstock in alternating rows. This block was set out for the purpose of conducting nitrogen fertilizer experiments. Three different levels of nitrogen and a control were to be used. The treatments were randomized and replicated three times giving a total of 12 plots. Each plot had 16 trees.

The treatments which were considered to be low, medium and high applications of nitrogen are given in table 1. Phosphorus was applied in equal amounts to all plots. A five-year fertilizer program was outlined and at the end of this time the various rates of applications are to be re-evaluated and adjusted as chemical tests of the soil, leaf tissue and fruit indicate.

Potassium was not added to these plots as chemical tests indicated the amount of available potassium in the soil was high. A mechanical analysis of the soil classified it as a sandy loam with 59 percent sand, 15 percent clay and 26 percent silt. The percent organic matter was 2.2

Since the trees were set out in 1953 and the root systems had not become well established, the rates of nitrogen applications were low during that year. The fertilizer material was added to approximately nine sq. ft. around each tree during 1953 and 1954. In 1955 the fertilizer was broadcast over the entire area of each plot and this method of application was to be continued for the duration of the experiment. The source of nitrogen was ammonium nitrate (32%) and that of phosphorus was superphosphate (45%).

In order to maintain an equal amount of nitrogen in the leaves throughout the year, the applications were applied three times—Feb., May and Sept.—with one-third of the total annual amount being applied with each application.

A cultural practice of non-cultivation was followed in the plots and the grass and weeds were kept down by cutting with a rotary stalk cutter.

Soil and leaf tissue samples were collected to analyze chemically

Table 1. Fertilizer treatments to be applied over a 5-year period to a newly planted citrus orchard of Webb red grapefruit trees.

Fertilizer treatment	Crop Year 1953	1954	1955	1956	1957
Low N	0.1	0.3	0.75	0.75	0.75
Med N	0.3	0.6	1.50	1.50	1.50
High N	0.6	1.2	3.00	3.00	3.00
P_2O_5	0.25	0.25	0.25	0.25	0.25

for the level of nitrogen and its availability in the soil as well as in the leaves. As soon as the trees bear fruit, other data will be taken to determine the effect of nitrogen on fruit quality, size and yield.

Results

Soil samples were collected from each of the nitrogen plots in October of 1954 just one year after the initiation of the fertilizer experiments and again in September of 1955. Chemical analysis of the total nitrogen present were run on these samples and the results are given in Table 2.

An analysis of variance of the data in table 2 indicated the individual treatment variances were not significantly different from the variance which was ascribed to error. There were no differences between the treatments in the amount of total nitrogen found in the soil during 1954 or again in 1955. However, it was readily illustrated in all treatments in 1955 that there was a decrease in the total percentage of nitrogen found in the soil from the previous year.

Leaf samples were also collected from the nitrogen plots in October of 1954 and again in September of 1955. The samples were washed and dried and the percentage of total nitrogen present was determined. The results are given in table 3.

Table 2. The effect of nitrogen fertilizer treatments on the percent of total nitrogen present in the soil during the years 1954 and 1955.*

Fertilizer treatment	*Percent total nitrogen in soil* 1954	1955
Control	0.162	0.147
Low N	0.160	0.142
Med N	0.161	0.143
High N	0.171	0.154

Table 3. The effect of nitrogen fertilizer treatments on the percent of total nitrogen present in the leaves of 2 and 3 year old Webb red grapefruit trees in Texas in 1954 and 1955.*

Fertilizer treatment	*Percent total nitrogen in leaves* 1954	1955
Control	2.44	1.88
Low N	2.51	1.89
Med N	2.69	2.16
High N	2.89	2.31
LSD–5% level	0.300	0.193
–1% level	0.456	0.292

* All data average of 3 replications

A statistical analysis of the data in table 3 showed there was a significant difference between the high fertilizer treatment and the control in 1954. There were no significant differences between the other treatments in 1954. In 1955 the analysis of variance indicated there were significant differences between the medium and high nitrogen fertilizer treatments over the control.

Again it was indicated that there was a decrease in all treatments in the percentage of total nitrogen in the leaves over the previous year.

Discussion

After two years of observations, it was evident that leaf analysis could greatly facilitate the interpretation of field fertilizer experiments. The chemical analyses of the percentage of total nitrogen found in the leaf tissue of the grapefruit trees indicate a direct response to the 1954 nitrogen fertilizer in proportion to the rate of application. During this time, all fertilizer plots including the control showed the percentage of nitrogen in the leaves was well within the normal range—2.0 to 3.2 percent as indicated by California and Florida workers.

However, the leaf samples collected in 1955 showed the control and low treatment plots had fallen below the 2.0 percent total nitrogen mark. These trees also showed a small amount of yellowing at different times of the year and a decrease in growth as measured by height of the tree and diameter of the trunk (data unpublished). The medium and high nitrogen applications indicated a normal amount of nitrogen in the leaves but a drop from the level of the previous year. With a greater demand for nitrogen being brought about by the trees being one year older and by a heavier growth of grass and weeds in the orchard, it was probable that the control and low application plots were not supplying sufficient nitrogen to the trees. This general trend in the experiment can be watched in the years to follow. If the decomposing material of the grass and weeds in the orchard fails to return to the soil the amount of nitrogen necessary to replenish the demands of the cover crop, then it will be necessary to re-evaluate the lower application of nitrogen. It is hoped that after the experiment has been in progress for several years, an equilibrium will be reached in the amount of nitrogen consumed by the cover crop and that returned by the crop, and still further that the cover crop will aid in adding organic matter and nitrogen to the soil.

The data in table 2 indicates there was no significant differences between fertilizer treatments as to the percent of total nitrogen in the soil. There was a decrease in the amount of nitrogen found in the soil in 1955 from the previous year. This also indicated that the fertilizer nitrogen did not remain in the soil to increase the total amount to be found in the soil, but rather that the fertilizer was utilized by the trees and cover crop or was leached from the soil. Nitrates are soluble and are easily leached from the soil.

Summary

In order to obtain more information concerning the proper nitrogen fertilization and fertility levels which are necessary for the production of highest yields and the best quality and size of citrus fruit in the Rio Grande Valley of Texas, a long-term nitrogen fertilizer experiment was started in the winter of 1953 at the Texas A. & I. Training Center in Weslaco, Texas.

Four acres were planted to Webb red grapefruit on cleopatra mandarin and sour orange rootstock. Three different application rates or treatments of nitrogen and a control were used.

A chemical analysis of the soil both in 1954 and 1955 showed no significant differences between fertilizer treatments as to the percent of total nitrogen in the soil. There was a decrease in the amount of nitrogen found in the soil in 1955 from the previous year.

Leaf samples showed a direct response to nitrogen fertilizer in proportion to the rate of application in 1954. The leaf samples in 1955 indicated the soil fertility level of nitrogen was an important factor in the uptake of nitrogen fertilizer. This was pointed out as there was a decrease in percent of soil nitrogen during 1955 and a corresponding decrease in the percent of total nitrogen found in the leaves despite the fact that nitrogen application rates were even higher in 1955.

The grass and weeds in the fertilizer plots under a cultural practice of non-cultivation were found to be in competition with the citrus trees during this early part of the experiment. It is believed that this competition will be nullified when an equilibrium is reached in the amount of ntrogen used by the cover crop and the amount returned by the crop.

Literature Cited

Chapman, H. D. and S. M. Brown. 1950. Analysis of orange leaves for diagnosing nutrient status with reference to potassium. Hilgardia 19:501-540.

Chapman, H. D., S. M. Brown, and G. F. Liebig, Jr. 1943. Some effects on citrus fruit quality of nitrogen, phosphorus and potassium. Calif. Citrog. 28 (8, 9): 198, 211, 230, 246.

Chapman, H. D. and W. P. Kelley. 1946. The mineral nutrition of citrus. Chap. VII, The Citrus Industry, Vol. I, Edited by H. J. Webber and L. D. Batchelor, Univ. of Calif. Press, Berkeley and Los Angeles.

Finch, A. H. 1944. Fertilizing desert grapefruit. Calif. Citrog. 30-34-35.

Reuther, W. and P. F. Smith. 1951. Tissue analysis as an aid in evaluating the nutritional status of citrus trees. Proc. 5th Ann. Rio Grande Valley Hort. Inst. 34-35.

Preliminary Studies to Determine Possibility of Insect Transmission of Tristeza Virus in Texas[1]

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Grapefruit and orange trees on sour orange rootstock can be seriously affected by tristeza, a disease caused by a virus. The severe tristeza virus complex has killed millions of trees in South America and South Africa. The mild tristeza virus complex has caused some losses in Florida and Louisiana. Considerable losses have also occurred in California, where the disease caused by tristeza virus is known as Quick Decline. Knowledge as to the presence of the causal virus and testing of possible insect vectors are of special interest to Texas citrus growers because more than 95% of their trees are on sour orange rootstock.

The discovery of mild tristeza virus in some Meyer lemon trees in Texas pointed out the need to determine its distribution and possible spread by insects to other citrus varieties (Olson and Sleeth, 1954). Infected trees of some citrus varieties other than Meyer lemon have already been reported (Olson and McDonald, 1954; Olson, 1955). In an initial study of 53 trees adjacent to Meyer lemon trees infected with mild strain of tristeza virus, only one was found infected; this indicated that transfer of tristeza virus was not common in Texas though it might occur to a limited extent. At present the mild tristeza virus complex is not considered to be a common cause of tree decline in commercial plantings in Texas, but it is a potential threat to millions of trees on sour orange rootstock.

This article describes studies to determine whether there has been spread of the virus from infected Meyer lemon trees to other citrus trees in field plantings. It reports screenhouse studies with leaf grafts to determine tristeza virus presence in young foliage of infected plants used in insect studies, and it gives the results of screenhouse tests to determine whether aphids of Texas origin are vectors of the existing tristeza virus complex.

Field Studies

Methods: Buds of Meyer lemon trees from scattered citrus plantings in the Rio Grande Valley were grafted to Mexican (Key) lime seedlings grown in gallon cans of soil. Mexican lime plants are the conventional test plants that indicate presence of tristeza virus. Those bud sources causing vein clearing and stem pitting of the grafted lime seedlings were

[1] These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the U.S. Department of Agriculture, certain phases of which were carried on under the Agricultural Marketing Act (RMA Title II). Acknowledgment is due Miss Louise M. Russell, U.S. Department of Agriculture, Insect Identification and Parasite Introduction Section, Beltsville, Md., for aphid identification.

considered as having been potential field sources of tristeza virus for 5 to 30 years, i.e. from the time they were planted.

To determine whether citrus trees in the vicinity of the known tristeza virus sources had become infected under field conditions, twigs were collected from these and buds were grafted on Mexican lime test plants. Special attention was given to all citrus trees on sour orange rootstock that showed any decline symptoms.

While many different groves were sampled in this manner, the results obtained from one grove are representative of those obtained from other scattered plantings. Every third row of 15-year-old trees in a 20-acre grove consisted of tristeza-infected Meyer lemon trees. The trees in the rows adjacent to the infected Meyer lemon trees were red grapefruit and navel orange, except for a few Temple orange trees in one row. The Meyer lemon trees were all on their own roots; the other varieties were on sour orange rootstock.

Results: Tristeza virus was determined as present in each of the 26 samples of Meyer lemon trees selected and tested from the 20-acre grove. The virus was probably present in the Meyer lemon trees not tested, since every Meyer lemon tree in the grove was propagated from a single infected tree. In spite of this, the tests failed to show the presence of tristeza virus in any of the citrus field trees that were tested. These had grown for 15 years immediately adjacent to known sources of virus and consisted of 12 Temple orange, 20 navel orange and 30 red grapefruit trees. These studies on a 20-acre grove were duplicated on a smaller scale in other scattered plantings. No instance of virus transfer was detected.

Up to the present, only one instance indicating natural spread of tristeza from Meyer lemon has been detected. A single Mexican lime in a budling row grown adjacent to a row of infected Meyer lemon showed typical vein clearing and stem pitting symptoms (Olson, 1955). The results in Texas are in agreement with those reported from numerous California counties where diseased Meyer lemon trees have been found but no other citrus types have shown evidence of being infected (Wallace and Drake, 1955). Possible insect transfer of the virus from varieties other than Meyer lemon may have caused tristeza disease in a few trees located during a tristeza survey (Olson, 1955).

Leaf-Graft Studies

Methods: Mature twigs were used in previous studies to determine whether suspect trees carried tristeza virus. Aphids feed only upon young citrus growth and all the tests in Brazil and elsewhere showed that the virus if present is in young citrus growth. To be sure that this was the case with the tristeza virus complex in Texas, young leaf pieces of known infected plants were leaf-grafted to Mexican lime plants by the technique described by Wallace (1947).

Results: Those seedlings with living pieces of leaf-graft developed the characteristic symptoms of tristeza within a 3-month period. Thus

young leaves from infected trees carried tristeza virus, indicating that the virus was present in the leaves of plants used as a virus source in the insect vector studies.

Insect Vector Studies

Literature Review: Aphids are the principal carrier, or vector, in other areas where tristeza has become a serious hazard to citrus on sour orange rootstock. Menghini (1946) was first to prove that the citrus brown aphid, *Aphis citricidus* (Kirk.), was a vector of the virus in Brazil. Since that time, this aphid has been proved to be an efficient carrier of the virus by Valiels (1948) in Argentina, McClean (1950) in South Africa and Costa and Grant (1951) in Brazil. Bennett and Costa (1949) reported that a single *A. citricidus* transmitted the virus in a small percentage of tests, but high percentages of transmission were obtained only with large numbers of the aphid. This aphid has not been reported from the United States.

Dickson, et al. (1951), in California, reported the cotton or melon aphid, *Aphis gossypii* Glover, to transmit the virus in only 13 instances in a large number of tests. Wallace (1951) in one test found 9 infected plants in a group of 30 lime seedlings exposed to 80 melon aphids. Norman and Grant (1954) working in Florida, reported that the spirea aphid, *Aphis spiraecola* Patch, did not transmit the virus in 160 tests from infected Valencia orange, but where Temple orange was used as the virus source, this aphid successfully transmitted the disease in 9 of 128 tests; successful transmission with the melon aphid from infected Temple orange to Key lime test plants occurred once in 26 tests. These workers thus concluded that *A. spiraecola* and *A. gossypii* are inefficient vectors of mild tristeza virus. Hughes and Lister (1954) reported the mealybug, *Ferrisia virgata* (Cockerell), to successfully transmit the virus on the Gold Coast of Africa.

Dean (1953) reported the common aphids on Texas citrus. The spirea aphid, *A. spiraecola*, was most abundant; the cotton or melon aphid, *A. gossypii*, occurred frequently; the black citrus aphid, *Toxoptera aurantii* (Fonsc.), was found in large numbers only during certain years; the cowpea aphid, *A. medicaginis* Koch, sometimes occurred on a few young citrus trees. The citrus mealybug, *Pseudococcus citri* (Risso), was found on citrus in the area many times, but seldom has caused much damage during the past five years.

Methods: Young citrus leaves infested with aphids were placed on young leaves of virus-infected plants or cuttings. Aphids were allowed to crawl onto the virus-infected plant and feed during a 2-day period. With a camel's-hair brush, varying numbers of insects were then transferred from the infected plant to the healthy Mexican lime, Cleopatra mandarin or Temple orange test plant and allowed to feed for 24 hours: In other tests, aphids from virus-infested field trees were transferred immediately to the test plant. During the feeding period, plants were kept in 2x2x3-foot cages screened with 52x52 plastic-mesh screen. Leaf curling was considered evidence that the aphids had fed on the plant.

Under natural light conditions, aphids did little feeding on the Mexican lime foliage. When a fluorescent lamp was placed next to the screened cages, the aphids settled down and more of them fed on the lime leaves. Subsequently, fluorescent lamps were placed over the cages and kept lighted throughout the period when aphids were feeding.

Test plants were sprayed twice with nicotine sulphate to assure control of insects overlooked in the process of removing them to vials of alcohol. Two parathion sprays were applied to plants where mealybugs were the test insects. The plants were placed on benches in a screenhouse for observation for at least a 6-month period. Plants in the screenhouse were sprayed as necessary to keep the screenhouse insect-free. Each plant was considered a separate test.

In tests where the aphids had fed on healthy Temple orange or Cleopatra mandarin on Mexican lime rootstock, the Mexican lime shoots from the rootstock were later periodically checked for tristeza symptoms. When aphids were fed on unbudded Cleopatra mandarin seedlings, twigs from the mandarin plants were budded to Mexican lime after several months; these Mexican lime plants indicated whether the Cleopatra mandarins were infected.

During 1954, the spirea aphid was used in 310 tests; the cotton or melon aphid was used in 24 tests; and the mealybug, *Pseudococcus* sp., probably *citri* (Risso), was used in 10 tests. Tests conducted in 1955 involved the spirea aphid and the cotton or melon aphid and mixed colonies of the two. These aphids preferred feeding on Temple orange and Cleopatra mandarin leaves to feeding on the Mexican lime leaves. In 706 attempts to transfer tristeza by aphids, several different kinds of virus-infected citrus were used. In tests involving the mild virus strain, Meyer lemon was the virus source in 146 tests; Mexican lime, 76 tests; grapefruit, 109 tests; Cleopatra mandarin, 99 tests; Temple orange, 199 tests; and sweet orange, 28 tests. In 49 tests involving a severe strain of virus, the virus source plants were Mexican lime, Cleopatra mandarin and Temple orange. The number of aphids varied from 8 to 185 and the number of mealybugs from 40 to 170.

Results: No positive transmission of tristeza virus by insects has been found in controlled tests up to the present (December, 1955). Aphids did not feed well on lime plants infected with a severe strain of virus (Olson, 1956), apparently similar to the "corky vein" strain of tristeza reported from the Gold Coast of Africa (Hughes and Lister, 1953). The young leaves of Mexican lime plants used for source of the severe virus strain frequently seemed brittle and would drop off after the aphids had fed. Aphids usually fed a short time and only a few aphids were found on the "corky vein" virus source plant at the end of 40 to 48 hours. When Cleopatra mandarin plants infected with this virus were used, more aphids remained on the plant after 48 hours of feeding.

Discussion

Under controlled conditions, 706 attempts to transmit tristeza virus

by *A. spiraecola* and *A. gossypii* were unsuccessful. In field studies, only a few instances of possible tristeza virus transfer by insects has been found. Present indications are that the principal method of tristeza virus distribution in Texas would be through the use of buds from virus-infected plants.

The results of insect vector tests should not be interpreted to mean that tristeza virus can never be transferred by aphids or other insects in Texas. Further testing may disclose circumstances under which virus transfer may take place. It is known that tristeza has been present for over 30 years in some Meyer lemon trees in Texas and that infected Meyer lemon trees are common throughout south Texas. In spite of this, spread of tristeza into commercial plantings of grapefruit and orange trees on sour orange rootstock has not been detected except in one instance.

Summary

Insect transmission of tristeza virus from infected Meyer lemons to other citrus varieties in mixed field plantings was not demonstrated in these studies. The virus was shown to be present in the immature leaves of infected plants used in insect transmission studies. Aphids, fed on foliage of infected plants for 48 hours and transferred to virus-free seedlings, were used in 706 transmission tests of the virus. The spirea aphid, A. *spiraecola*, was the principal test insect while the cotton or melon aphid, A. *gossypii*, was used to a less extent; the mealybug, *Pseudoccoccus* sp. probably *citri* (Risso), was used in 10 tests. In the 716 tests no transmission of the virus occurred.

Literature Cited

Bennett, C. W. and A. S. Costa. 1949 Tristeza disease of citrus. Jour. Agr. Res 78(8): 207-237.

Costa, A. S. and T. J. Grant. 1951. Studies on transmission of the tristeza virus by the vector, *Aphid citricidus*. Phytopathology XLI(2): 105-113.

Dean, H. A. 1953. Some beneficial insects of citrus in the Lower Rio Grande Valley of Texas. Proc. Rio Grande Valley Hort. Inst. 7:42-47.

Dickson, R. C., R. A. Flock and M. McDonald Johnson. 1951. Insect transmission of citrus quick decline. Jour. Econ. Ent. 44(2):172.

Hughes, W. A. and C. A. Lister. 1953. Lime dieback in the Gold Coast, a virus disease of the lime, *Citrus aurantifolia* (Christmann) Swingle. Jour. Hort. Sci. 28(2):131-140.

McClean, A. P. D. 1950. Virus infections of citrus in South Africa. Farming in S. Africa, 25(293):262; 26(294):289.

Menghini, M. 1946. Sobre a natureze e transmissibilidade da doenca "tristeza" dos citrus. Biologico 12:285-287.

Norman, Paul A. and T. J. Grant. 1954. Preliminary studies of aphid transmission of tristeza virus in Florida. Proc. Florida State Hort. Soc. 66:89-92.

Olson, Edward O. 1955. A survey for tristeza virus in Texas citrus. Proc. Rio Grande Valley Hort. Inst. 9:51-60.

Olson, Edward O. and Bailey Sleeth. 1954. Tristeza virus carried by some Meyer lemon trees in South Texas. Proc. Rio Grande Hort. Inst. VII:84-88.

Olson, Edward O. and James McDonald. 1954. Tristeza in satsuma varieties in Texas. Plant Disease Reporter 38(7):439-442.

Olson, Edward O. 1956. Evidence for mild and severe strains of tristeza virus complex in Texas citrus. Unpublished manuscript.

Valiels, M. V. Fernandez. 1948. Informe preliminar acerca de la etiologia de "podredumbre de las reacillas" del naranjo agrio injertado. Rev. de Inrest. Agro (Argentina) 2:139-146.

Wallace, James M. 1947. The use of leaf tissue in graft-transmission of psorosis virus. Phytopathology 37:149-152.

Wallace, J. M. 1951. Recent developments in studies of quick decline and related diseases. Phytopathology XLI(9):785-793.

Wallace, J. M. and R. J. Drake. 1955. Tristeza virus in Meyer lemon. Calif. Citrograph 40(3):84.

Occurrence of Tristeza in Two Citrus Variety Plantings

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Citrus growers in South Texas are vitally concerned over the transmissibility of the tristeza virus. Since tristeza was detected in 1953 (Olson and Sleeth 1954) in the Lower Rio Grande Valley, the question of how widely the disease had spread or how rapidly it will spread in a grove became of major importance to the citrus industry. The accumulated evidence to date (Olson and Sleeth 1954, Olson and McDonald 1954, Olson 1955) shows that tristeza-virus infected citrus trees were brought into Texas in 1925 or earlier. Only a relatively small number of infected trees have been found (Olson 1955), which would indicate that the spread of the disease in Texas has been negligible or nil. This report summarizes the results obtained from testing all the trees in two citrus variety blocks at the Weslaco Agricultural Experiment Station for tristeza in which bud-infected trees had been planted.

Ten trees infected with tristeza virus had been detected by May 1954 in two variety blocks on the Station by Olson (1955), which consisted of budded introductions and locally grown nursery stock. The age of the infected trees ranged from 12 to 28 years old and were obviously infected when planted. Even though nearby trees were found free of the tristeza virus, all remaining trees on the two variety blocks, B-4 and B-12, were tested for tristeza by the Mexican lime seedling method. The purpose of the extensive testing was to determine if the remaining trees were free of tristeza and to check on the possible spread of the disease under grove conditions in which a source of infection had been present for many years.

Citrus block B-4 consisted of 145 citrus trees 20 to 30 years old of which 72 were grapefruit, 66 oranges, 6 tangerines and 2 Meyer lemons. All trees were on sour orange rootstock, except 4 grapefruit of which 2 were on mandarin roots and 2 on citrange, and 2 Meyer lemons on their own roots. Also, there were 55 tree vacancies and 14 replants less than 2 years old. The trees were spaced 27 feet apart with 14 trees in a row. A block of some 20 rows on the north side had been removed for replanting. The 2 Meyer lemons planted in 1925 and a Thompson grapefruit on citrange roots, planted in 1930, had been found to be infected with the tristeza virus (Olson and Sleeth 1954, Olson 1955). These 3 infected trees were located in the southwest quarter of the block. A small number of adjacent and nearby trees had been tested to check on transmission with negative results.

In the summer of 1954 buds from each of 127 trees, which had not been previously tested, were placed in 4 or 5 Mexican lime seedlings growing in a test nursery. The budded Mexican lime seedlings were observed for a period of 9 months and none developed tristeza symptoms.

Citrus block B-12 consisted of a number of introduced varieties as well as trees from local sources, which had been planted over a period of years from 1936 to 1948. In the original plan there were 17 rows of 11 trees to a row on approximately 20 foot spacing. By 1954 there were 124 live trees in the planting made up of 8 varieties of grapefruit, 10 lemons, 2 limes, 46 oranges, 10 tangelos, 4 mandarins and 6 others. The various rootstocks used included sour orange, mandarin, grapefruit, rough lemon, sweet orange, citrumelo, shaddock, sweet lime, citrange, calamondin and tangelo. The condition of the grove, B-12, was poor because of damage suffered in the 1951 freeze and drought conditions of the next 3 years. A number of the trees had been killed back to the bud union and had developed rootstock sprouts only. Buds were taken from these sprouts and used in the testing process since they would give the same response as if taken from the scion tops. Of the 124 trees, 86 were tested, each on 3 to 5 Mexican lime seedlings growing in either gallon cans or in nursery rows. The remaining trees making up the block had been tested by Olson (1955), of which 7 had been found to be infected with the tristeza virus.

Results and Discussion

No additional tristeza-infected trees were found in the older block, B-4, in which 3 infected trees had been found earlier by Olson (1955). In the younger block of trees, B-12, two Mediterranean Blood orange trees on Cleopatra mandarin rootstock were found to be carrying the tristeza-virus in addition to the 7 trees that had been detected earlier by Olson (Table 1). Thus in two citrus blocks consisting of 268 trees, in which tristeza-virus infected trees had been growing for 12 to 25 years or longer, only 12 tristeza-infected trees were found and these are believed to have been infected when planted. The source of the tristeza virus has been traced by Olson (1955) to several varietal introductions that have

Table 1. Results of testing all trees in two citrus variety blocks in which tristeza-virus infected trees had been growing for 12 years or longer.[1]

Citrus	Number of varieties represented	Citrus trees tested for tristeza: Non-infected trees	Varieties infected	Trees infected
	Number	*Number*	*Number*	*Number*
Grapefruit	14	82	3	3
Orange	50	147	3	4
Mandarin (Tangerine)	5	9	3	3
Lemon	5	4	1	2
Tangelo	5	6	0	0
Other Citrus	6	8	0	0
TOTALS	75	256	10	12

[1] Included in the table are 52 trees tested earlier by E. O. Olson of which he found 10 to be infected with tristeza virus.

occurred over a period of years. It is of interest to note that these introductions were from China, Australia, New Zealand, Japan and India.

The failure of the tristeza virus to spread under what appears to have some extremely favorable conditions is reassuring to the citrus growers in South Texas. On the other hand, there is no assurance that this condition will continue indefinitely. The growers are still confronted with the probabilities that have existed since they first became aware of the potential destructiveness of the disease several years ago. The present situation seemingly exists because under the conditions prevailing in Texas insects are inefficient or ineffective vectors of the tristeza virus. The introduction, inadvertently or unwittingly, of either a tristeza virus strain readily transmitted by native insects, or of an efficient insect vector would present a serious problem to the citrus growers in South Texas.

Summary

Two blocks of citrus consisting of some 75 varieties and 268 trees 12 to 28 years old, in which 10 tristeza-infected trees had been detected earlier, were tested for tristeza by the Mexican seedling lime method. Only two additional citrus trees were found to be infected with tristeza virus. Thus in a total of 268 citrus trees, in which tristeza-infected trees had grown for many years, only 12 were found to be carriers of the tristeza virus. The 12 diseased trees were apparently infected by budding with buds from parent trees affected with tristeza.

Literature Cited

Olson, Edward O. and Bailey Sleeth. 1954. Tristeza virus carried by some Meyer lemon trees in South Texas. Proc. Rio Grande Valley Hort. Inst. 8:84-88.

Olson, Edward O. and James R. McDonald. 1954. Tristeza in satsuma varieties in Texas. Plant Disease Reporter Vol. 38, (7) 439-442.

Olson, Edward O. 1955. A survey for tristeza virus in Texas citrus. Proc. Rio Grande Valley Hort. Inst. 9:51-60.

Tangerine Declines in the State of Nuevo Leon, Mexico[1]

Edward O. Olson,[2] Mortimer Cohen,[3] and Teodoro Rodriguez[4]

During the past few years many tangerine trees on sour orange rootstock have declined and died in citrus districts near Montemorelos, Nuevo Leon, Mexico. The PATRONATO PARA LA INVESTIGACION, FOMENTO Y DEFENSA AGRICOLA DE NUEVO LEON, with headquarters in Monterrey, requested assistance in determining if the tangerine decline was caused by tristeza disease, which has killed tangerine, orange, and grapefruit trees on sour orange rootstock in other countries. Information on tristeza disease caused by a virus spread by budding or by certain aphids, has been summarized by Grant, Klotz and Wallace (1953). This present article reports the present status of studies on the tangerine decline in Nuevo Leon.

Types of Declines

An inspection of declining tangerine trees in 4 orchards during December, 1954, revealed that at least 3 different types of decline were present.

Cachexia. The first decline type was common in an orchard owned by Ing. Plutarco Calles and located near the town of General Teran. The owner noted that some late tangerine trees needed heavy pruning each year to remove dead or weak branches, while other trees of the same variety were apparently healthy and needed no pruning. No dead trees were noted in this orchard. In the weaker-growing trees, the inner surface of the bark of the sour orange rootstock appeared normal; gum-impregnated inner bark and stem pitting symptoms characteristic of cachexia disease occurred in the tangerine top above the bud union. A few trees with the same characteristics also occurred in the other 3 locations. In Texas cachexia disease can be reproduced in susceptible mandarin and mandarin-hybrid trees by budding them with red grapefruit scions which are symptomless carriers of the causal agent of the disease (Olson, 1954; Olson and Shull, 1955). The declining tangerine trees in the Calles orchard showed symptoms identical with those observed in Texas, where cachexia is a disease separate and distinct from either tristeza or psorosis.

[1] These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the U.S. Department of Agriculture, certain phases of which were carried on under the Agricultural Marketing Act (R.M.A. Title II). Mr. W. K. Clore, U.S. Department of Agriculture, Plant Pest Control Branch, Citrus Blackfly Surveys, Monterrey, N. L., Mexico, assisted in locating the diseased trees.

[2] U.S. Department of Agriculture.

[3] State Plant Board, Florida.

[4] Asesor. Tecnico, PATRONATO PARA LA INVESTIGACION, FOMENTO Y DEFENSA AGRICOLA DE NUEVO LEON, Montemorelos, Mexico.

Psorosis. The second decline type was scaly bark, caused by psorosis virus and transmitted by propagation from infected trees (Fawcett, 1936). This disease is characterized by the appearance on trunk and limbs of hard, rough, irregular scales of dead bark which gradually curl up, leaving a layer of live bark underneath. Affected trees show thin foliage and later become unproductive. Tangerine trees with scaly bark symptoms were common in 3 of the 4 orchards. The psorosis status of the Calles planting was not determined.

A decline of unidentified cause. The third decline type caused the most concern to the growers. It occurred in 18-year-old trees on irrigated land 10 miles east of Montemorelos owned by Senor Garcia Leal, in non-irrigated 13-year-old trees 3 miles north of Montemorelos owned by Senor Jose Cantu, and in irrigated 15-year-old trees 3 miles north of Linares at the El Retiro Ranch. Affected trees showed thin foliage and dieback of the branch tips. Some trees had died suddenly with leaves and fruit hanging on the trees. An estimated 25 percent of the trees in the 3 plantings were declining, dead or replaced with young trees. The inner bark of the sour orange rootstock on many declining trees showed minute holes in the inner surface, just below the bud union; this symptom, called honeycombing in Florida, has been associated with tristeza virus infections of trees on sour orange rootstock in Florida (Cohen and Knorr, 1955). Where the tangerine top of declining trees was killed or cut off, sour orange sprouts grew vigorously from the rootstock. Valencia orange and tangerine replants on sour orange rootstock were growing vigorously in soil where declining tangerine trees had been removed several years previously.

This decline type had many characteristics expected from tristeza infection; these included death of trees on sour orange rootstock, honeycombing of the sour orange rootstock bark, and good growth of sour orange from the rootstock when the declining tangerine top was removed. In order to determine if tristeza virus was present in tangerine trees affected with this decline, two tests were used: these were the bark patch test and the lime seedling test.

Results

Bark Patch test. Sections of bark from across the bud union of normal and affected tangerine trees with honeycombed bark were collected from each of 3 locations. The bark samples were sent to the Florida State Plant Board where thin slices of the bark sections were examined for anatomical evidence of the presence of tristeza.[1]

Bark samples from trees in decline which showed the honeycombing symptom of the inner bark below the bud union also showed a definitely reduced layer of active phloem as compared with normal trees. However, these samples did not show the abrupt reduction of functioning phloem

[1] The slides were prepared by Mrs. Jean Smith, technician at the histological laboratory at Gainesville, Florida.

below the bud union which usually characterizes tristeza. Even more significantly the bark samples did not show the mass of small, relatively rapidly dividing phloem cells (hyperplasia) at the bud union which produces a bulge in the bark in trees with tristeza. Also unlike the usual tristeza condition was the sparse amount of callus on the sieve plates of the deteriorating phloem cells. These features lead to the conclusion that these trees probably do not have tristeza disease as it is known elsewhere, despite the presence of a number of histological features which are often found in tristeza-affected bark, namely: the honeycombing symptom, reduction in amount of stored fat below the bud union and appearance of hypertrophied phloem parenchyma cells below the bud union.

Mexican lime test. As a further test for the presence of tristeza virus, buds from 28 different declining trees, most of them with honeycombing symptoms, were grafted on Mexican lime seedlings grown in gallon cans of soil. The plants were kept in a screenhouse built by the PATRONATO in Montemorelos. Leaves on new growth on the lime plants were observed for 5 months by Ing. Rodriguez. Two trips were also made from Texas by the senior writer to observe the budded lime plants. During the 5-month period vein-clearing and stem-pitting symptoms of tristeza were not apparent on the test plants. However, symptoms of psorosis virus did occur in some budded lime plants.

Discussion

Up to the present time, tristeza virus has not been shown to be present in declining tangerine trees in Nuevo Leon. However, two other causes of tangerine decline have been identified as psorosis and cachexia.

As in Texas, psorosis virus is present in most if not all tangerine trees in Nuevo Leon. The only Texas tangerine trees known to be psorosis-free are progeny of a Clementine tangerine type at the Valley Experiment Station, Weslaco. Texas tangerines with psorosis are generally short-lived, show thin foliage, and decline after the appearance of scaly bark symptoms. Psorosis virus, in the absence of tristeza virus, could account for the short life of many tangerine trees in Nuevo Leon.

Cachexia disease, apparently in late tangerines of the Dancy variety at the Calles planting, seems to weaken trees rather than kill them. The combination of cachexia and psorosis may be more destructive than either disease alone.

The occurrence of the honeycombing symptom in Nuevo Leon, and its apparent absence in tangerine-growing sections of the United States where psorosis is also common, suggests that an unidentified factor is involved which is separate from psorosis.

Mexican growers with declining tangerine trees have at least 2 courses of action. They can replace declining tangerines with Valencia orange trees, as is now being done in some instances, or replace them with new tangerine trees propagated from psorosis- and cachexia-free budwood sources.

Literature Cited

Cohen, M. and L. C. Knorr. 1954. Honeycombing – a macroscopic symptom of tristeza in Florida. Phytopathology 44 (9):485 (abst.)

Fawcett, Howard S. 1936. Citrus diseases and their control. McGraw-Hill Book Co. N. Y. 656 pp.

Grant, T. J., L. J. Klotz and J. M. Wallace. 1953. The tristeza disease of citrus. In Plant Diseases, the Yearbook of Agriculture 1953. pp. 730-734.

Olson, Edward O. 1954. Some bark and bud union disorders of mandarin and mandarin-hybrid rootstocks in Texas citrus plantings. ASHS Proc. 63:131-36.

____________ and Art Shull. 1955. Red grapefruit strains as symptomless carriers of the causal agent of cachexia, a bud-transmitted disease. Rio Grande Valley Hort. Inst. Proc. 9:46-50.

Iron Chlorosis of Young Webb Red Blush Grapefruit Trees Grown in Calcareous Soil as Influenced by Rootstock and Iron Chelate Treatment

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Introduction

In the Rio Grande Valley citrus is grown on both calcareous and non-calcareous soils, and rootstocks for citrus which might replace tristeza-intolerant sour orange should be adapted to both types. Earlier reports (Cooper and Olson, 1951; Cooper and Peynado, 1953; and Cooper, Peynado and Shull, 1954) showed that the sour orange rootstock has good tolerance to both soil conditions while tristeza-tolerant Cleopatra mandarin rootstock has good tolerance to non-calcareous soils, but only moderate tolerance to calcareous soils. Young grapefruit trees on Cleopatra rootstock growing in calcareous soils frequently develop iron chlorosis in the summer; it may last only a month or so or may persist until the following spring. In most instances the trees recover without treatment, but growth may be stunted during the period of iron chlorosis.

Grapefruit tops on Hamlin and Florida sweet orange rootstocks showed very poor tolerance to calcareous soils and many trees died from severe iron chlorosis (Cooper and Olson, 1951). Since trees on mandarin and sweet orange rootstocks are tolerant to tristeza (Grant and Costa, 1948) it seemed desirable to screen a large number of such varieties for tolerance to calcareous soils. Results from screening unbudded seedlings (Cooper, Peynado and Shull, 1954) indicated that 19 sweet orange varieties and 16 mandarin varieties were intolerant to calcareous soils while 3 mandarins (Suenkat, Kunembo and Shekwasha) had good tolerance. Since the scion variety also may influence the tolerance of the tree to calcareous soils it seemed desirable to test the tolerance of budded grapefruit trees on the various rootstock varieties. Results of these tested are reported in this paper.

Concomitant with these rootstock trails were experiments on the use of iron chelates for correction of lime-induced iron chlorosis on intolerant rootstocks. The effectiveness of 2 iron chelates, hydroxethylenediaminetriacetic acid (FE-EDTA-OH) and diethylenetriamine pentaacetic acid (DTPA), in correcting iron chlorosis on grapefruit on Cleopatra mandarin rootstock was demonstrated (Cooper and Peynado, 1954, 1955). Recent experiments by Wallace (1955) with a new compound, an amino-

[1] These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the U.S. Department of Agriculture, certain phases of which were carried on under the Agricultural Marketing Act (RMA Title II). The cooperation of Rio Farms, Inc., Monte Alto, and Floyd Everhard, Mission, is greatly appreciated.

polycarboxcylic acid (APCA),[2] indicated that this material is highly stable in calcareous soil and is more effective than some other materials in correction of lime-induced iron chlorosis on citrus. The effectiveness of this new compound on correction of lime-induced iron chlorosis on grapefruit on sweet orange rootstocks grown in the calcareous Rio Grande Valley soil is reported in this paper.

Methods

Seedlings of 20 varieties of sweet oranges and of 4 varieties of mandarin were grown in a seedbed of non-calcareous soil at Rio Farms, Inc., Monte Alto, during 1952; were transplanted to a nursery of non-calcareous soil at the same location; and were budded with psorosis-free buds of the grapefruit variety during 1953. These trees were dug and transplanted to a calcareous soil test plot at Floyd Everhard's place at Mission, Texas, on December 17, 1953. The planting consisted of 9 trees on each of the 24 rootstocks arranged in 3 randomized replications of 3-tree plots. The soil in the test plot area contained numerous small snail shells. The calcium carbonate content of the soil ranged from 2.0 to 3.0% for four soil samples in the first foot of soil, from 5.2 to 10.1% in the second foot, and from 10.4 to 15.9% in the third foot. The pH of the soil averaged 7.9 for the first foot, 7.9 for the second and 7.8 for the third. The trees were irrigated with water from the Rio Grande River and given normal orchard care during 1954 and 1955. The severity of iron chlorosis was recorded for each tree at intervals during 1954 and 1955.

On August 17, 1955, two iron chelates, Fe-DTPA and FE-APCA, were applied to the soil of certain trees on sweet orange rootstock showing iron chlorosis in tests to determine their effectiveness in correcting lime-induced chlorosis of trees on intolerant rootstocks. The materials contained 10.8 percent metallic iron and were applied at the rates of 10 and 50 grams of the materials, or 1.08 and 5.4 grams of iron. They were sprinkled on the surface of the soil over a 4-square-foot area around the trunk of the tree and were chopped into the soil with a hoe.

Results and Discussion

Influence of Rootstock on Iron Chlorosis

Iron chlorosis on the trees on the various rootstocks is rated in table 1. Trees on Shekwasha mandarin were practically free of iron chlorosis; those on Cleopatra and Suenkat mandarins showed less iron chlorosis than trees on the Kunembo mandarin and the 20 varieties of sweet orange. Except for the trees on Lue Gim Gong iron chlorosis was less in 1955 than in 1954. No differences in iron chlorosis occurred during 1954 among the 20 sweet orange rootstock varieties but during 1955 iron chlorosis was less on trees on Drake Star sweet orange than on 6 of the remaining 19 sweet orange varieties, less on Florida sweet orange than 5 of the other 19 sweet orange varieties, and less on Bessie sweet orange than on 2 of the other 19 sweet orange varieties.

[2] Manufactured by Geigy Agricultural Chemicals and called Chel 138HFe.

These experiments with different rootstocks are preliminary and apply only to young Webb Red Blush grapefruit trees. They, however, confirm results obtained with grapefruit on sweet orange rootstocks grown in calcareous soil in the Experiment Station Planting (Cooper and Olson, 1951). The trees in the Experiment Station planting are now seven years old. Twenty-one of the 24 trees on sweet orange rootstock died from severe iron chlorosis. Other trees on susceptible rootstocks continued to show iron chlorosis while still others showed it intermittently or not at all. In general, it appears that lime-induced iron chlorosis on trees on some susceptible rootstocks could be an important factor in citrus production but in many instances it may be only a small-tree disorder. Ob-

Table 1. Severity of iron chlorosis on Webb Red Blush Grapefruit on various rootstocks on two dates, 1954 and 1955.

Rootstock variety	*Severity of iron chlorosis on indicated date*		
	Nov. 23, 1954	Aug. 17, 1955	Mean
Cleopatra mandarin	0.56	0.11	0.33
Suenkat mandarin	0.78	0.00	0.39
Kunembo mandarin	1.56	0.44	1.00
Shekwasha mandarin	0.11	0.00	0.06
Norris orange	2.11	1.00	1.56
Florida sweet orange	1.78	0.56	1.17
Lue Gim Gong orange	2.00	2.00	2.00
Valencia orange	1.78	1.22	1.50
Drake Star orange	1.78	0.44	1.11
Enterprise orange	2.11	1.32	1.72
Homosassa orange	1.78	0.78	1.28
Harvard No. 2 orange	2.11	1.67	1.89
Cuba sweet orange	1.89	1.33	1.61
Bessie orange	1.78	0.67	1.22
Orange de Nice	2.11	1.00	1.56
Gzel Gzel orange	1.78	1.11	1.44
Torregrossa orange	1.67	0.78	1.22
Magnum bonum orange	2.33	1.33	1.83
Maltese Oval orange	2.33	1.56	1.94
Pineapple orange	1.89	1.00	1.44
Del Rio orange	2.44	1.78	2.11
Mediterranean Blood orange	1.67	1.00	1.33
Ruby orange	1.89	1.44	1.67
Sanguinea grosse ronde orange	2.00	1.67	1.83
L.S.D. at .05 level	0.96	0.96	0.68
L.S.D. at .01 level	1.26	1.26	0.89

[1] The key to rating for severity of iron chlorosis: O indicates no chlorosis; 1, less than half of leaves are chlorotic; 2, practically all leaves chlorotic, slight defoliation; 3, all leaves chlorotic, considerable defoliation.

servations should be made on mature trees before a final evaluation is made of a rootstock.

The incidence of iron chlorosis on young grapefruit trees on rootstocks of various citrus varieties except the Kunembo mandarin was similar to that on young unbudded seedlings of the same varieties (Cooper, Peynado and Shull, 1954). Thus in these tests, with the one exception, the rootstock rather than the top of the tree controlled iron chlorosis.

Influence of Iron Chelate Treatment on Iron Chlorosis

The 2 iron chelates differed in their effectiveness in correcting iron chlorosis on grapefruit on intolerant sweet orange rootstocks (table 2). A regreening of chlorotic foliage occurred on trees on all rootstocks and there were no indications of toxicity to the foliage for either concentration of the materials used. Table 2 summarizes the results without reference to the 14 or more varieties tested since there appeared to be no interaction between rootstock and treatment. Fe-APCA was considerably more effective in correcting iron chlorosis than Fe-DTPA. Only 1.08 grams of Fe-APCA per tree was required for practically complete regreening of all trees in the 35-day test period.

It appears that with the use of Fe-APCA chelate, lime tolerance could become a minor factor in the propagation of young trees. These experiments are only preliminary and further trials with chelates should be made on orchard trees. The cost of the material is not known at this time.

Table 2. Decrease in iron chlorosis on mature leaves of Webb Red Blush grapefruit trees on intolerant sweet orange rootstocks by soil application of two chelated-iron materials.

Chelated-iron material	*Chelated iron per tree (grams)*	*Trees per treatment (number)*	*Severity of iron chlorosis[1] at indicated time*		
			Before treatment on Aug. 17, 1955	*35 days after treatment*	*Decrease in iron chlorosis during 35-day period*
None	0	17	1.2	1.2	0
Fe-APCA	1.08	14	1.8	0.2	1.6
	5.40	17	2.4	0	2.4
Fe-DTPA	1.08	14	1.7	1.0	0.7
	5.40	15	2.0	1.0	1.0

[1] The key to rating for severity of iron chlorosis: 0, no iron chlorosis; 1, less than half of leaves on tree chlorotic; 2, practically all leaves chlorotic but only slight defoliation; 3, all leaves chlorotic and considerable defoliation.

Summary

Young Webb Red Blush grapefruit trees on 20 varieties of sweet orange and 4 varieties of mandarin rootstock were tested for tolerance to calcareous soil. The incidence of iron-chlorosis in the grapefruit foliage was used as an index of tolerance.

The Drake Star, Bessie and Florida sweet orange and the Kunembo mandarin showed some tolerance in 1955 but none in 1954. Other sweet orange varieties were intolerant during both years. Trees on Shekwasha mandarin were almost free of iron chlorosis during both years.

Both Fe-DTPA and Fe-APCA were effective in decreasing the incidence of iron chlorosis of grapefruit on sweet orange rootstock but Fe-APCA was the more effective. Fe-APCA at the rate of 1.08 grams per tree induced nearly complete regreening of all chlorotic foliage on all young trees on sweet orange rootstock. This finding applies to young trees 2 years after planting in the orchard. No data exist for large producing trees.

Literature Cited

Cooper, W. C. and E. O. Olson. 1951. Influence of rootstock on chlorosis of young Red Blush grapefruit trees. Proc. Am. Soc. Hort. Sci. 57:125-132.

____________, and A. Peynado. 1953. A comparison of sour orange and Cleopatra mandarin seedlings on salty and calcareous nursery soils. Proc. Rio Grande Valley Hort. Inst. 7:95-101.

____________ and ____________. 1954. Correction of iron chlorosis of young grapefruit trees on Cleopatra mandarin rootstock with chelated iron. Proc. Rio Grande Valley Hort. Inst. 8:106-109.

____________ and ____________. 1955. Experimental control of iron chlorosis of citrus in some Rio Grande Valley soils with chelated iron and gypsum. Proc. Rio Grande Valley Hort. Inst. 9:79-85.

____________ and ____________ and A. V. Shull. 1954. Screening citrus rootstock seedlings for tolerance to calcareous soils. Proc. Rio Grande Valley Hort. Inst. 8:100-105.

Grant, T. J. and A. S. Costa. 1948. A progress report on studies of tristeza disease of citrus in Brazil. Proc. Fla. State Hort. Soc. 61:1-14.

Wallace, Arthur. 1955. Some characteristics and response of new iron chelating agents. Abstract of paper presented before 52nd meeting Am. Soc. Hort. Sci. at East Lansing, Mich.

Experiment Control of Lime-Induced Iron Chlorosis In Trifoliate Orange Seedlings by Soil Applications of Some Iron Compounds

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In the past few years much work has been done on the treatment of citrus for iron deficiency chlorosis, especially with iron chelates. Stewart and Leonard (1952 a, b) found that the ferric complex of disodium ethylenediaminetetraacetic acid (FeEDTA) was effective on acid soils, but was only erratically so on high-lime alkaline soils. They demonstrated that when the chelating agent ethylenediaminetetraacetic acid (EDTA) was applied without first complexing it with iron that it chelated the iron already in the soil and was as effective as FeEDTA. Comparable results were obtained by Perkins and Purvis (1954) and Weinstein et al (1954). Leonard and Stewart (1953) found that the ferric complex of N-hydroxyethylethylenediaminetriacetic acid (Fe-EEDTA-OH) was effective on high-lime (10 to 18 percent) Florida soils with a pH of about 8. Wallace et al. (1953) found that citrus growing in high-lime southern California soil responded to Fe-EEDTA-OH, but the results of Wallihan et al. (1954) in the same region showed no benefit from its use. These trials all involved mature trees already afflicted with iron chlorosis.

To determine the effectiveness of several iron compounds in the treatment of citrus in the high-lime soils of the Coachella Valley for lime-induced iron chlorosis an experiment was initiated in June, 1954, on Indio loam using the trifoliate orange *(Poncirus trifoliata)* as the indicator plant. The soil involved in this experiment has a calcium carbonate content of 10 percent or more and when *P. trifoliata* is maintained under high soil moisture conditions in this soil it usually develops severe chlorosis in the leaves, may finally suffer twig die-back, or occasionally the plant may die.

The experimental area was divided into eighty plots, each 2x2 feet in area and separated by walks between the rows of plants. Twenty treatments, listed in table 1, were compared in a replicated, random-block arrangement. Immediately before planting, the weighed materials were broadcast over the surface of the plots and hoed in to a depth of approximately one inch. One *P. trifoliata* seedling of about one-fourth inch caliper was then planted bare-root in the center of each plot. When transplanted, the seedlings had excellent color and vigor since they had been greenhouse-grown in an acid medium, irrigated with nutrient solution.

The five materials used were ground ferrous sulfate; iron-rich fritted glass, a powdered glass containing a large amount of iron; FeEEDTA-OH absorbed in vermiculite; FeEDTA; and technical grade chelating agent ethylenediaminetetraacetic acid, EDTA. Ferrous sulfate and iron-rich fritted glass were applied at rates of 12.5 grams, 25 grams, 50 grams and 100 grams of material per square foot. The rate of application of the iron complexed chelates were 0.5 gram, 1 gram, 2 grams and 4 grams of iron per square foot. The uncomplexed EDTA, which contained no iron, was applied at rates which would complex 0.5 gram, 1 gram and 2 grams of iron per square foot.

The irrigation interval varied from about one week in the summer to about two weeks in the fall and winter and kept the soil at a high severity of chlorosis. Each seedling was given a numerical grade based on color and vigor. Best growth and normal green color were given

Table 1. Severity of iron chlorosis in plants of *Poncirus trifoliata* receiving soil applications of various materials.

Material applied	*Amount of material applied per sq. ft. (grams)*	*Chelated iron per sq. ft. (grams)*	*Chlorosis rating[1] Nov. 24, 1954*	*Chlorosis rating[1] Oct. 19, 1955*
$FeSO_4$	100	0	2.0	1.1
	50	0	3.4	2.1
	25	0	3.3	2.6
	12.5	0	3.6	3.9
Iron fritt	100	0	3.4	3.3
	50	0	3.6	3.6
	25	0	3.5	3.5
	12.5	0	3.4	4.0
FeEDTA	31	4	1.5	1.6
	15	2	3.1	3.6
	8	1	2.9	3.1
	4	0.5	3.5	4.3
EDTA	11	2 [2]	3.3	3.9
	5.7	1 [2]	3.1	3.5
	2.8	0.5[2]	3.0	3.6
FeEEDTA-OH	67	4	3.1	3.0
	33	2	2.8	2.5
	17	1	2.1	2.6
	8	0.5	3.9	4.3
Control	0	0	3.9	4.0

[1] 1, indicates vigorous growth and normal green color; 2, good growth but slight chlorosis; 3, fair growth, most leaves chlorotic; 4, stunted growth, all leaves severely chlorotic, twigs show die-back; 5, trees dead. The values given represent the average for the four trees per treatment.

[2] The amount of iron that the uncomplexed material would chelate. The material contains no iron.

the value 1; good growth and some chlorotic leaves, 2; fair growth, some twigs and many leaves chlorotic, 3; and poor, severely stunted growth and some twig die-back, 4. Color and vigor values of 5 were given to plants that died.

During the first summer and fall, the untreated trees became chlorotic and stunted. A statistical analysis of the ratings made on November 24, 1954, indicate that there were highly significant differences among some of the treatments. When listed in descending order of effectiveness (table 2), it is found that the first nine treatments were significantly effective in reducing the severity of chlorosis. In addition, the first three treatments were significantly more effective than were the next six.

An evaluation was made again on March 30, 1955, when the *trifoliata* seedlings, which are deciduous, began to leaf out. An analysis showed that most of the trees included in the nine most effective treatments (table 2) were significantly earlier in regaining their leaves.

By October 1955, chlorosis was very severe on many of the control trees and those receiving ineffective treatments. An evaluation made on October 19 showed that there were highly significant differences among

Table 2. The amount of materials applied and the chlorosis ratings given to *Poncirus Trifoliata* seedlings in each treatment, November 24, 1954

Adjective rating	*Numerical rating*	*Treatment, per square foot*
Good vigor	1.5**	FeEDTA, 4 grams of iron
slight	2.0**	100 grams of ferrous sulfate
chlorosis	2.1**	FeEEDTA-OH, 1 gram of iron
Fair	2.8**	FeEEDTA-OH, 2 grams of iron
vigor,	2.9**	FeEDTA, 1 gram of iron
moderate	3.0**	EDTA, equivalent to 0.5 gram of iron
chlorosis	3.1**	FeEEDTA-OH, 4 grams of iron
	3.1**	EDTA, equivalent to 1 gram of iron
	3.1**	FeEDTA, 2 grams of iron
Fair	3.3	EDTA, equivalent to 2 grams of iron
to poor	3.3	25 grams of ferrous sulfate
vigor,	3.4	12.5 grams of iron fritt
moderate	3.4	100 grams of iron fritt
to severe	3.4	50 grams of ferrous sulfate
chlorosis	3.5	FeEDTA, 0.5 grams of iron
	3.5	25 grams of iron fritt
	3.6	50 grams of iron fritt
	3.6	12.5 grams of ferrous sulfate
	3.9	FeEEDTA-OH, 0.5 grams of iron
	3.9	Control

** Significant at one per cent level, L.S.D. = .63

certain of the treatments (Table 3, Figure 1). It may be noted that two of the four significantly effective treatments on this date were high rates of ferrous sulfate, whereas in November, 1954, only one of the nine most effective treatments was ferrous sulfate. Locke (1953) has indicated that ferrous sulfate is effective in curing chlorosis for long periods of time.

For the seventeen-month period there is probably little difference among the 4 best treatments (Table 3). The iron-rich fritted glass had no apparent effect. There were no significant differences among the three rates of technical grade EDTA, and this uncomplexed chelating agent was much less effective than the complexed forms, FeEDTA and FeEEDTA-OH. The higher the rate of application of FeEDTA or ferrous sulfate, the more effective was the treatment.

FeEEDTA-OH was the only chemical used that exhibited toxicity. Of the three plants that died in the course of the experiment, one was treated with the 0.5 gram rate, one with the 4 gram rate of FeEEDTA-OH, and one was a control tree which died of chlorosis. The two FeEEDTA-OH treated plants wilted and died in August, 1954, with initial symptoms very similar to those of excess soil salinity. In a current, unfinished, trial with sweet orange *(Citrus sinensis)* the same toxic symp-

Table 3. The amount of materials applied and the chlorosis ratings given to *Poncirus trifoliata* seedlings in each treatment, October 19, 1955

Adjective rating	*Numerical rating*	*Treatment, per square foot*
Good vigor, slight chlorosis	1.1**	100 grams of ferrous sulfate
	1.6**	FeEDTA, 4 grams of iron
	2.1**	50 grams of ferrous sulfate
	2.5**	FeEEDTA-OH, 2 grams of iron
Fair to poor vigor, moderate to severe chlorosis	2.6	FeEEDTA-OH, 1 gram of iron
	2.6	25 grams of ferrous sulfate
	3.0	FeEEDTA-OH, 4 grams of iron
	3.1	FeEDTA, 1 gram of iron
	3.3	100 grams of iron fritt
	3.5	EDTA, equivalent to 1 gram of iron
	3.5	25 grams of iron fritt
	3.6	EDTA, equivalent to 0.5 gram of iron
	3.6	FeEDTA, 2 grams of iron
	3.6	50 grams of iron fritt
	3.9	EDTA, equivalent to 2 grams of iron
	3.9	12.5 grams of ferrous sulfate
	4.0	12.5 grams of iron fritt
	4.0	Control
	4.3	FeEEDTA-OH, 0.5 gram of iron
	4.3	FeEDTA, 0.5 gram of iron

** Significant at one per cent level, L.S.D. = 1.5

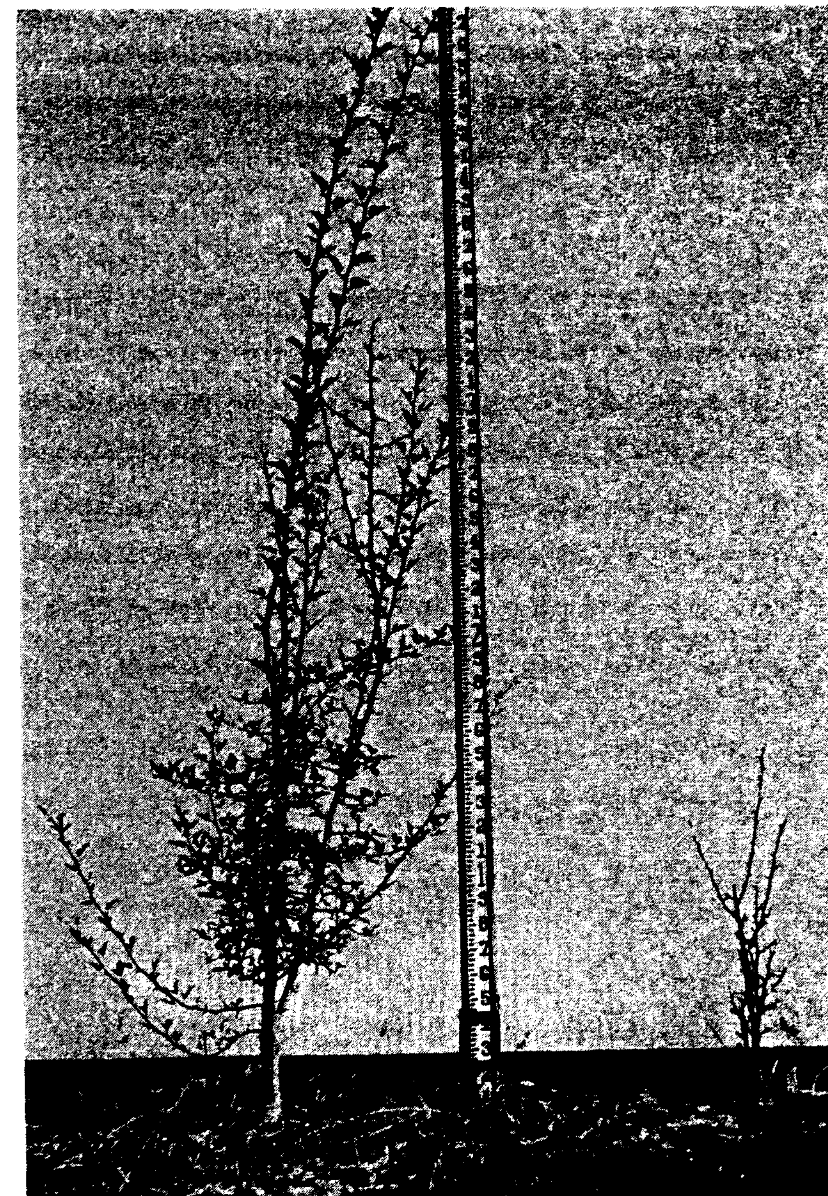

Figure 1. October 19, 1955. Left: Significant response of a *P. trifoliata* seedling to one of the four most effective treatments (Table 3). Right: Control.

toms, leaf burn followed by death, have appeared when FeEEDTA-OH was used at high rates. Cooper and Peynado (1955) found that FeEDTA, when used at high rates in the Rio Grande Valley, was more toxic than FeEEDTA-OH.

When calculated on an acre basis, the high cost of applying the most effective treatments may make their use on mature citrus impractical. It may, however, be advantageous to treat soil where the value of the crop per unit area is high, as in citrus nurseries, or ornamental crops such as roses and gardenias. No recommendation of application rates can be made since the response of citrus nursery stock and ornamental plants is still being studied.

Literature Cited

Cooper, W. C. and A. Peynado. 1955. Experimental control of iron chlorosis of citrus in some Rio Grande Valley soils with chelated iron and with gypsum. Proc. Rio Grande Valley Hort. Inst., 9:79-85.

Leonard, C. D. and I. Stewart. 1953. Chelated iron as a corrective for lime-induced chlorosis in citrus. Proc. Florida State Hort. Soc., 66:49-54.

Locke, L. F. 1953. Chlorosis experiments. Proc. American Soc for Hort. Science, 61:77-83.

Perkins, H. F. and E. R. Purvis. 1954. Soil and plant studies with chelates of ethylenediaminetetraacetic. Soil Science, 78 (4) 325-330.

Stewart, I. and C. D. Leonard. 1952a. Iron chlorosis, its possible causes and control. Citrus Magazine, June 1952.

Stewart, I. and C. D. Leonard. 1952b. Chelates as sources of iron for plants growing in the field. Science, 116:564-566.

Wallace, A., C. P. North, A. M. Krofanek and O. R. Lunt. 1953. Chlorosis in ornamentals. California Agriculture, 7 (10) 13-14.

Wallihan, E. F., T. W. Embleton, G. E. Goodall, R. G. Platt and R. W. Southwick. 1954. Orchard trials with iron chelates. California Citrograph, 40 (1) 28-31.

Weinstein, L. H., E. R. Purvis, A. N. Meiss and R. L. Uhler. 1954. Absorbtion and translocation of ethylenediaminetetraacetic acid by sunflower plants Agriculral and Food Chemistry, 2 (8) 421-424.

The Sodium-Adsorption-Ratio and Its Significance In Irrigation Agriculture[1]

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Owing to the presence of negative electrical charges at their surfaces, soil particles adsorb and retain cations such as calcium, magnesium, and sodium. While the adsorbed cations are combined chemically with the soil particles, they may be replaced by other cations that occur in the soil solution. The process whereby a cation in solution replaces an adsorbed cation is called cation exchange. Each soil has a reasonably definite capacity to adsorb and exchange cations, and the percentages of this capacity which are satisfied by the various cations are referred to as exchangeable-cation-percentages, e.g., exchangeable-sodium-percentage.

Because cations adsorbed on soil particles can interchange freely with adjacent cations in the soil solution, it is to be expected that the proportions of the various adsorbed cations (exchangeable-cation-percentages) will be related to their concentrations in the soil solution. Calcium and magnesium are the principal cations found in the soil solution and on the particles of normal productive soils of arid regions. When normal soils are subjected to irrigation or drainage waters containing a high proportion of sodium, this cation becomes the dominent cation in the soil solution and replaces part of the original adsorbed calcium and magnesium. As a consequence of the adsorption of sodium, normal soils become alkali soils having a poor physical condition and other adverse properties as a medium for plant growth.

Knowledge of the relation between the compositions of the soil solution and the adsorbed cations in soils is of prime importance in irrigation agriculture for at least two reasons: (1) it permits estimation of the exchangeable-sodium-percentage from analysis of soil solutions or extracts, and (2) it is useful for predicting the effects of irrigation waters upon the exchangeable-sodium-percentage. Owing to the fact that calcium and magnesium are more strongly adsorbed than sodium and for other reasons, the proportions of these cations present in the adsorbed form are not the same as the proportions found in the soil solution. It has been shown by the U. S. Salinity Laboratory Staff (1954) that the ratio of the adsorbed sodium to the adsorbed calcium plus magnesium is related in a linear fashion to an adjusted ratio of sodium (Na) to calcium (Ca) plus magnesium (Mg) in the soil solution which is as follows: $Na/\sqrt{(Ca+Mg)/2}$, where the concentrations are expressed in milliequivalents per liter. This ratio has been termed the sodium-adsorption-ratio (SAR). Neglecting the usual low amounts of adsorbed potassium

[1] Contribution from the U. S. Salinity Laboratory, Soil and Water Conservation Research Branch and the Horticultural Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the seventeen Western States and the Territory of Hawaii.

which occur in soils, the ratio can also be related to the exchangeable-sodium-percentage by a simple calculation.

Figure 1 shows a nomogram for determining the sodium-adsorption-ratio of irrigation waters or soil solutions and for estimating the corresponding exchangeable-sodium-percentage of a soil in equilibrium with the irrigation water or soil solution. To use the nomogram, the sodium and calcium plus magnesium concentrations of the water or solution are first located on the two vertical scales and connected by a straight line. The sodium-adsorption-ratio value and corresponding exchangeable-so-

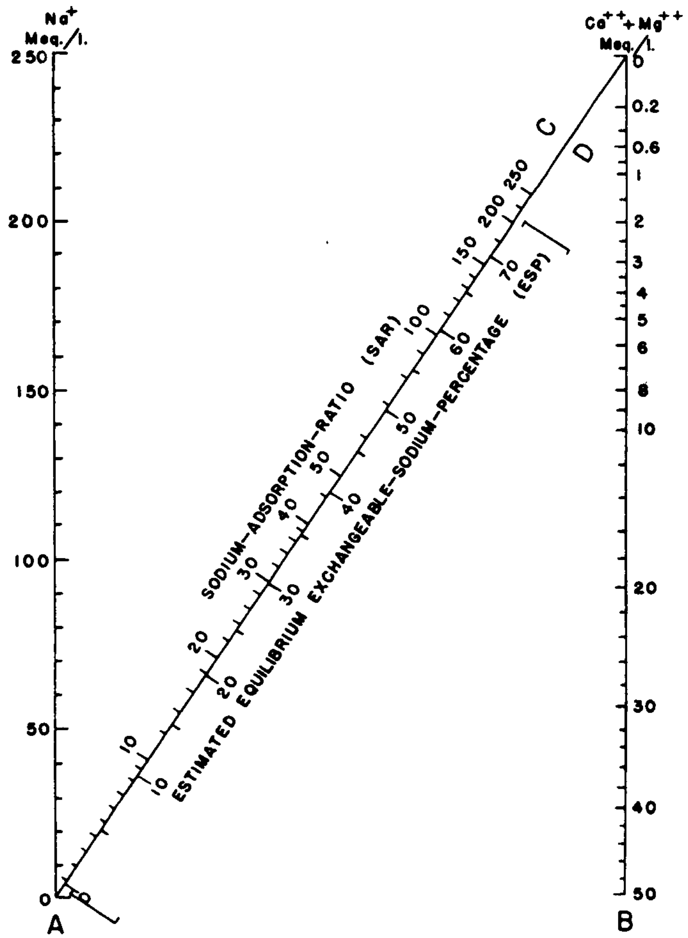

Figure 1. Nomogram for determining the sodium-adsorption-ratio of irrigation waters or soil solutions and for estimating the corresponding exchangeable-sodium-percentage of a soil in equilibrium with the irrigation water or soil solution.

dium-percentage value are then obtained from the point where the straight line intersects the diagonal scales.

The use of the sodium-adsorption ratio in irrigation agriculture is illustrated by the data, shown in table 1, which were obtained from irrigation test plots located on Willacy fine sandy loam at the Rio Farms, Monte Alto, Texas. Three sets of plots were studied. Each set of plots was irrigated for a considerable period of time with a different irrigation water having a sodium-adsorption-ratio as shown, then sampled to a

Table 1. Analyses of the 0-12 inch layer of Rio Farms irrigation test plots showing relations between the SAR* of the irrigation water, the SAR* of the solution from saturated soil, and the ESP* of the soil.

Irrigation Water	*Plot No.*	*pHs**	*Solution from saturated soil*				*ESP* of soil*	
			*EC**	*Na*	*Ca+Mg*	*SAR**	*from SAR*	*by direct determination*
				meq./1	*meq./1*			
Delta Lake (river water)	61	7.2	.94	5.3	3.4	4.1	5	6
SAR* = 2.8 EC* = 1.05;	72	7.3	1.09	5.8	4.8	3.7	4	6
56″ applied over 14 mos.	83	7.4	.97	5.4	).4	4.1	5	6
	94	7.4	.97	4.6	4.6	3.0	3	6
Rio Farms well SAR* = 27	62	7.6	3.49	30.4	3.0	25	26	23
EC* = 5.8; 36″ applied	73	7.7	4.63	40.2	5.2	25	26	22
over 14 mos.	84	7.7	4.44	37.9	5.2	24	25	23
	95	7.6	5.02	43.6	6.2	25	26	23
Delta Lake +	43	7.0	6.67	58.0	14.8	21	23	27
4000 ppm of sodium sulfate	47	7.3	3.41	30.9	3.4	24	25	24
SAR* = 22 EC* = 6.2;	51	7.5	3.36	30.9	2.8	26	27	28
36″ applied over 26 mos.	60	7.3	3.72	33.4	3.8	24	25	29

*Abbreviations: SAR = sodium-adsorption-ratio = $Na/\sqrt{(Ca+Mg)/2}$, where the concentrations are expressed in meq./1;
ESP = exchangeable-sodium-percentage;
pHs = pH reading of saturated soil paste;
EC = electrical conductivity in millimhos/cm.

depth of 12 inches and the samples analyzed. The data show that the sodium-adsorption-ratios of the solutions from saturated soil are quite similar to those of the waters with which the soils were irrigated, indicating that the 0-12-inch layers of the plots are essentially in equilibrium with the irrigation water applied. The data also show that the exchangeable-sodium-percentages of these soils as estimated by the sodium-adsorption-ratios of the solution from saturated soil, agree reasonably well with those found by direct determination. Thus it is seen that sodium-adsorption-ratio values are useful for estimating the exchangeable-sodium-percentage of soils from soil solution analyses, and for predicting the effect of various irrigation waters upon the exchangeable-sodium-percentages of soils to which they are applied.

Literature Cited

U. S. Salinity Laboratory Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils. U. S. Dept. Agr. Handb. 60.

Processing Characteristics of Colored Texas Grapefruit
II. Correlation of Color Measurements and Pigment Analyses of Ruby Red Grapefruit

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Extensive replantings of Ruby Red grapefruit have occurred in the Lower Rio Grande Valley since the freezes of 1949 and 1951. It is estimated (USDA, 1955) that there are now about 1,100,000 producing red and pink trees, and about 350,000 more trees are expected to begin producing annually. As has previously been reported (Lime *et al,* 1954), colored grapefruit presents a problem with respect to marketing or processing because of the color variations which occur. Fruit has maximum color before it reaches a degree of maturity which will permit processing. When the fruit is of optimum maturity for processing (Jan.-Feb.) color has faded sharply and continues to diminish to the end of the harvest.

The U. S. Fruit and Vegetable Products Laboratory is working on visual, spectrophotometric, and chemical methods of measuring grapefruit pigmentation, in cooperation with other State, Federal, and industrial agencies. It is interested in determining seasonal variation in fruit color, extent and causes of variation from grove to grove, tree to tree, and fruit to fruit. The primary objective of this work is to develop better commercial utilization of colored grapefruit. It is believed, however, that better progress in attaining this objective may be made after a better understanding of the fundamental factors affecting grapefruit coloration is obtained.

A previous publication (Lime *et al,* 1954) has reported reflectance measurements on fruit for the 1953-54 season, and results of chemical analyses for carotene and lycopene by a chromatographic separation technic. It was noted that lycopene and carotene values did not correspond very closely with either visual or spetrophotometric measurements of color. Because the chromatographic method was time consuming a shorter chemical method of determining the total carotenoid pigments in terms of lycopene and carotene was developed.

This paper reports the results of two studies undertaken in the 1954-55 season. In one study the precision of the Photovolt Reflectance Meter[2] and the Gardner Automatic Color Difference Meter[2] were compared.

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[2]The mention of equipment and products does not imply that they are endorsed or recommended by the U. S. Dept. of Agriculture over other equipment or products having the same or similar properties.

In the other study a comparison was made of the color, pigment content, and maturity of the Ruby Red grapefruit from four groves. Reflectance measurements of the fruit and of blended pulp samples were made as a measure of visual color. Correlation was established between total pigmentation reported as lycopene and carotene values, and the red to yellow color ratio, *a/b*, obtained with the Gardner instrument.

Experimental Procedure

In the study concerned with a comparison of the precisions of the Gardner Automatic Color Difference Meter[2] and the Photovolt Reflectance Meter[2] three comparisons were made: (1) readings were made on random sections of cut halves from 29 Ruby Red grapefruit; (2) four sections of one fruit were marked, numbered and six readings were made on each section with each instrument; and (3) the precision of instrument readings of a known color was determined by making nine measurements on a standard color plate (LR1) with each instrument.

In the study involving color measurements of grapefruit, fruit was selected from trees in four citrus groves which had survived the freezes of 1949 and 1951, and were approximately 8-12 years old. Two groves were on heavy clay (M,W) and two were on light sandy clay loam (S,B) (Cowley, 1954). One grove, S, had been used for two prior seasons as a source of Ruby Red fruit for color and processing studies. Six trees in each grove were set aside for selection of experimental fruit. In sampling five fruit picked at random were taken at two week intervals from each of the six trees (30 fruit to the sample). All the fruit from each sample was halved and the color of the cut surface of one-half of each fruit was measured at four locations with a Gardner meter. The small ½ inch opening of the instrument was used in order to reduce interferences caused by reflectance from skin, rag, or septums. The fruit could be placed over the ½ inch opening so that only the juice sacs were exposed to measurement. It was impossible to use the large 2¼ inch opening without including reflectance of skin, rag, or septums. In making a reading, a thin polished glass plate was placed between the fruit and the opening, and sufficient pressure was applied to the fruit to remove air bubbles and insure uniform contact between the glass and the pulp. For each 30 fruit sample 120 readings were recorded in terms of reflectance (Rd), redness (a), yellowness (b).

After these readings were obtained, four sections from each half fruit (from 60 halves) were removed with a sharp knife, taking care not to include septum, tissue or rag. The composite sample, usually 600-1000 grams, was blended thoroughly at high speed in a Waring Blender[2], then deaerated by placing in a vacuum dessicator and repeatedly applying high vacuum until foaming ceased. A portion of this deaerated puree was placed in a special cell and the Rd, *a*, and *b* color values obtained, using the 2¼ inch optical opening of the Gardner meter. The cell used for these measurements was made by gluing a 1 mm. thick glass plate to the bottom of a plastic cylinder approximately 8.9 cm. in diameter and 10.2 cm. in height. A glass plate of the same kind and thickness as the

cell bottom was placed between the opening and the standard plate when adjusting the instrument. The 2¼ inch optical opening was used for these measurements because exploratory tests had shown that readings made with this size opening agreed more closely with pigment ratios than did readings made with the ½ inch opening.

Duplicate portions of the composited sample were then analyzed for carotene and lycopene. The puree was stirred at moderate speed in a blender and while stirring, 100 gram portions were removed by using a 100 ml. inverted pipette, and weighed into beakers. One hundred milliliters of methyl alcohol was added to each 100 g. of sample and allowed to stand for 30 minutes. Two grams of filter aid were then added and the mixture filtered through a filter aid pad on a Buchner funnel. The filtrate containing the methyl alcohol water soluble substances was discarded. The pigments were extracted from the pulp by blending the filter cake in a Waring Blender[2] with 50 ml. of 50 percent acetone-hexane solution for one minute; then filtering and washing with 20 ml. of the extracting solution. The pulp and pad were blended, filtered, and washed twice more in the same manner and the combined extracts placed in a 1000 ml. separatory funnel; 100 ml. of water was added and the aqueous-acetone layer removed and re-extracted with hexane until the hexane extract was colorless. The combined hexane extracts were washed three times with 100 ml. portions of water, care being taken to prevent emulsions. The washed hexane extracts were passed through a pad of sodium sulfate and made to a volume of 250 ml. with hexane. Readings (percent transmission) were made at 455 millimicrons (mu), and at 505 millimicrons wave length, with a Cenco Sheard Spectrophotolometer.[2] The concentrations of each pigment were obtained by the use of simultaneous equations. Comar and Zscheile (1942) have outlined in detail the use of simultaneous equations for a binary pigment system. Our equations, based on the use of a 1 cm. cell, were:

$$Cc = 4.95\ (B455) - 3.45\ (B505)$$
$$Cl = 4.29\ (B505) - 1.14\ (B455)$$

where:

Cc = concentration of carotene in mg./1.
Cl = concentration of lycopene in mg./1.
B455 = optical density at 455 mu.
B505 = optical density at 505 mu.

Accuracy of the method in determining pure carotene and lycopene was tested by analyses of solutions containing known amounts of added carotenoids.

After removal of the four sections for the reflectance readings, a few milliliters of juice were squeezed by hand from the sections remaining in each half-fruit. The composited juice was used for acid and Brix determinations. This sampling procedure was followed as it more closely corresponds to the method used by processors for maturity measurements.

Results and Discussion

Table 1 shows the comparative precision of readings of the Gardner and Photovolt instruments. Readings were converted to I.C.I. notations and the variance of x/y ratios of each instrument compared. Comparison 1 shows the variation found in x/y ratios on random sections of 29 fruit halves. Standard deviation was about four times greater for the Photovolt than for the Gardner (.078 versus .021). When the color of fruit was measured on marked sections, comparison 2, the variation in x/y ratios was less for each instrument, but the relative precision as measured by the standard deviation of the readings was nearly the same. The standard deviation of x/y ratios of measurements made on a light red enameled plate was low for both instruments: .003 for the Gardner, and .008 for the Photovolt. See comparison 3. The results established the precision of the instruments. Readings during the 1954-55 season were made using the Gardner meter.

The accuracy of the method developed for determining lycopene and carotene in the same solution by measuring absorption at 455 mu. for carotene and at 505 mu. for lycopene, and using simultaneous equations to calculate the respective amounts of each, was checked by analyzing solutions containing known (weighed) amounts of both purified caro-

Table 1. Comparison of standard deviation of Gardner and Photovolt instruments.

Comparison		*Gardner*		*Photovolt*	
		Max.	*Min.*	*Max.*	*Min.*
1. Random sections 29 fruit halves					
x/y ratio		1.065	.968	1.224	1.035
Standard deviation of x/y ratio		.021		.078	
2. Marked sections, 6 readings per section	a	.992	.969	1.049	.969
	b	.984	.968	1.054	.969
	c	.992	.966	1.098	1.021
	d	.989	.966	1.143	.977
Standard deviation of x/y ratio		.009		.038	
3. Standard plate LR1 9 readings					
x/y ratio		1.155	1.145	1.133	1.110
Standard deviation of x/y ratio		.003		.008	

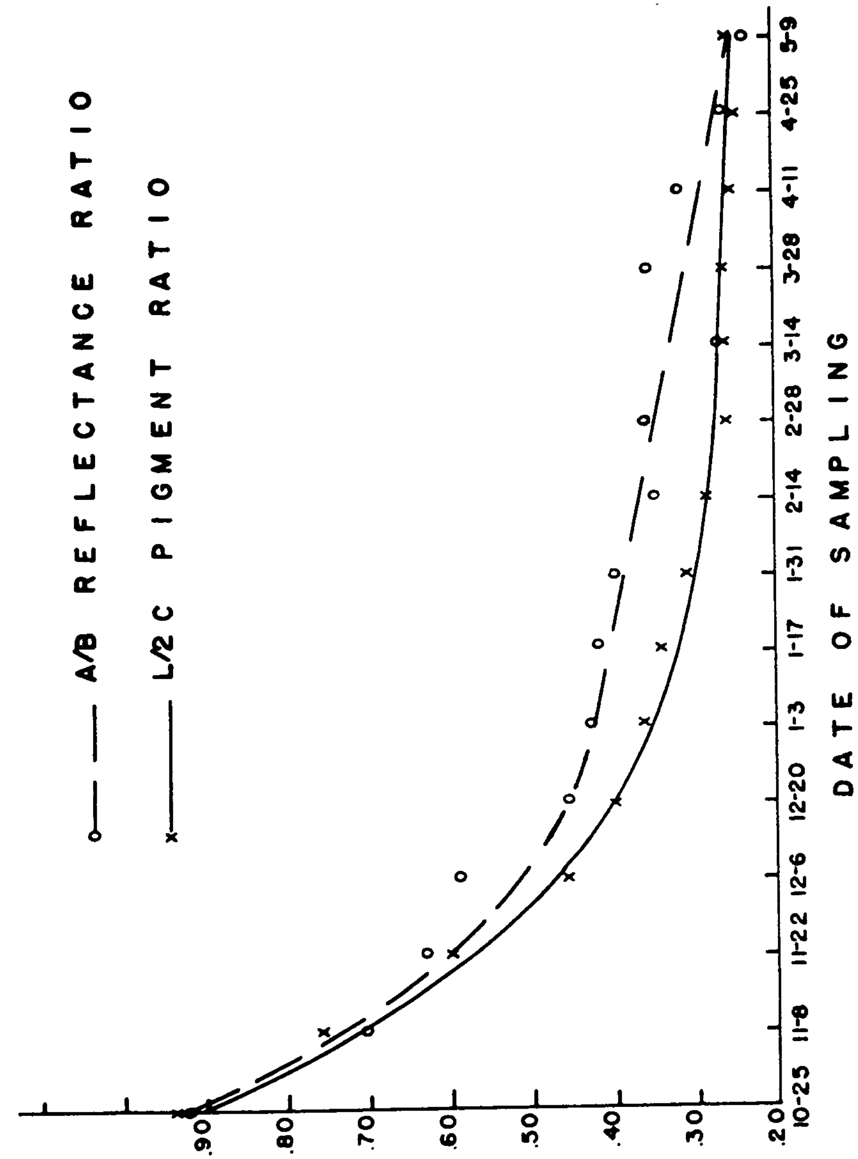

Figure 1. Seasonal Relationship of Reflectance Measurements and Pigment Analysis of Ruby Red Grapefruit.

tene and lycopene. These results, with known concentrations of purified carotene and lycopene in solution, Table 2, show that the procedure is accurate.

A comparison of the data obtained by the new method with those obtained by the chromatographic procedure previously used (Lime *et al*, 1954) show that the newer and shorter procedure gives higher values for both lycopene and carotene. Investigations are now under way to determine the reason for the higher values. The values obtained are, however, representative of the total pigments present in grapefruit. The amounts of these pigments, as obtained by the new method, are reported as lycopene and carotene in Table 3 for the four groves. Carotene is shown to be relatively constant, with lycopene declining as the season progresses. Since lycopene is more responsible for the redness of the fruit than carotene, the change in visual color, or fading due to disappearance of this pigment, is quite marked.

Reflectance measurements of the blended samples of fruit correlate with the pigment analyses. When measuring the color of blended puree samples the ratio of *a* (redness) over *b* (yellowness) corresponds closely with the ratio of lycopene (mg.%) over twice the carotene (mg.%), or *a/b* is similar to L/2C. This relationship for Grove S is shown in Figure 1, and is typical of results for all four groves. It is evident that the *a/b* ratio as determined on the blended samples of grapefruit puree provides a good index of seasonal color variation. Reflectance measurements of the cut grapefruit show considerably less correlation with pigment analyses than reflectance measurements of the blended puree. Seasonal trends were evident but sample variation was greater. Table 4 shows the *a/b* ratios obtained on cut fruit and the corresponding *a/b* ratios of the puree on fruit from Grove S. The pigment ratios L/2C obtained by analyses are shown for comparison.

It has been suggested that the type of soil on which colored grapefruit is grown has a marked effect on color of the fruit. Reflectance measurements of the blended samples of grapefruit puree from the four groves indicate that fruit from trees on the heavy clay soil was slightly lighter in color than fruit from trees on sandy loam. Visual observations indicated that variations between individual fruit in the same sample were of greater magnitude than differences in color intensity of fruit

Table 2. Comparison of calculated and known carotene and lycopene concentrations in hexane solution.

Solution	Known concentration (mg./1.)		Calculated concentration (mg./1.)	
	Lycopene	*Carotene*	*Lycopene*	*Carotene*
1	.67	1.33	.67	1.34
2	1.00	1.00	.99	1.07
3	1.33	.67	1.41	.59

Table 3. Seasonal variation in lycopene and carotene values of fruit from four groves.

Date	Grove S			Grove B			Grove M			Grove W		
	L[1] (mg./100 g.)	C[2]	L/2C[3]	L (mg./100 g.)	C	L/2C	L (mg./100 g.)	C	L/2C	L (mg./100 g.)	C	L/2C
10/25	.64	.34	.941	.63	.36	.875	.59	.26	1.13	.59	.30	.984
11/8	.58	.38	.763	.55	.37	.743	.49	.28	.876	.51	.34	.750
11/22	.49	.41	.598	.51	.41	.622	.46	.35	.657	.48	.38	.631
12/6	.39	.42	.464	.40	.45	.444	.37	.42	.451	.36	.39	.462
12/20	.33	.41	.402	.36	.45	.400	.36	.40	.450	.30	.36	.417
1/3	.31	.42	.369	.33	.46	.359	.30	.46	.326	.29	.37	.392
1/17	.29	.42	.345	.31	.48	.323	.26	.42	.310	.23	.36	.320
1/31	.25	.40	.313	.28	.50	.280	.29	.44	.329	.22	.36	.306
2/14	.25	.44	.284	.31	.48	.323	.24	.43	.279	.22	.37	.297
2/28	.23	.44	.261	.23	.50	.230	.21	.37	.284	.20	.39	.256
3/14	.22	.42	.262	.23	.49	.235						
3/28	.24	.45	.267	.22	.44	.250						
4/11	.22	.43	.256	.21	.46	.228						
4/25	.18	.36	.250	.18	.34	.265						
5/9	.18	.34	.265	.18	.39	.231						

[1] Lycopene
[2] Carotene
[3] Ratio of lycopene to two times the carotene

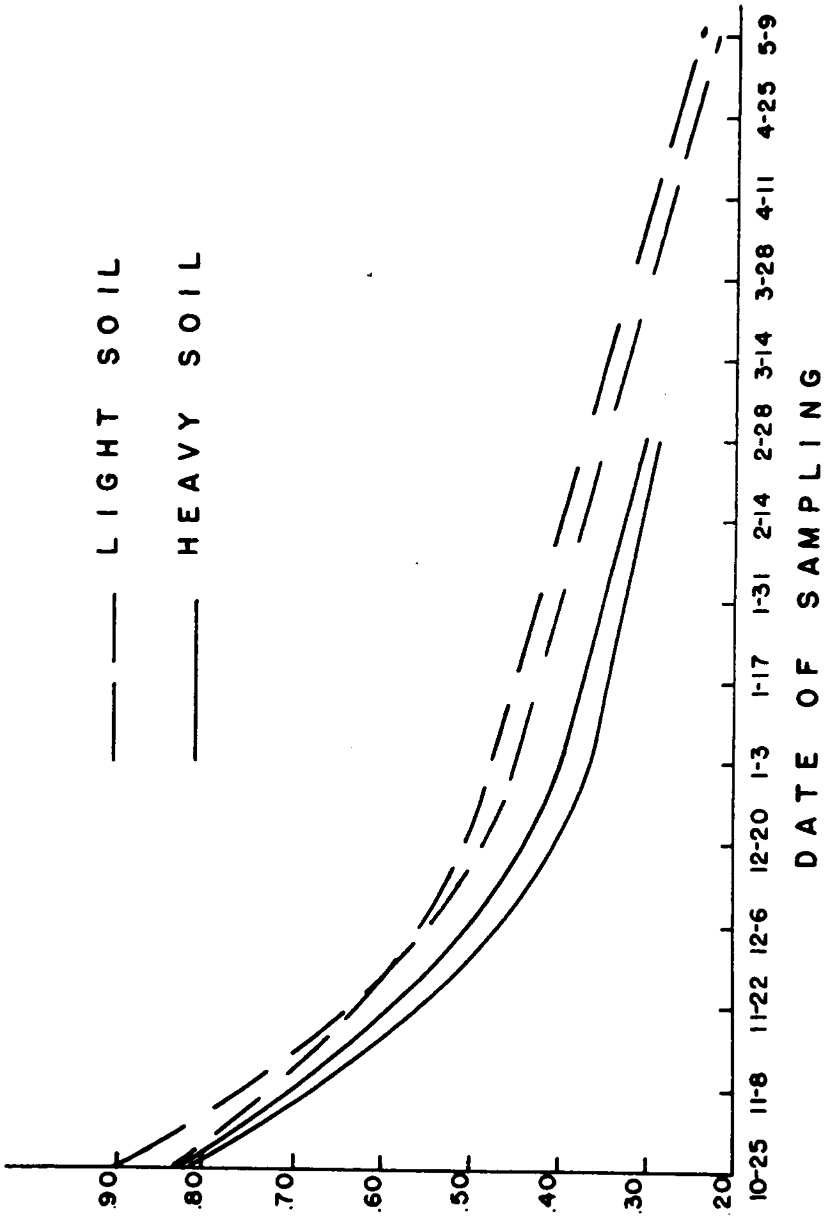

Figure 2. **Seasonal Reflectance Ratio (a/b) of Ruby Red Grapefruit from Four Groves.**

from different groves. Figure 2 shows seasonal reflectance measurements as *a/b* ratios of the four groves.

Maturity of citrus is usually measured by determining the Brix to acid ratio of expressed juice. Immature fruit having a Brix:acid ratio below 8:1 would not be considered suitable for processing. The seasonal changes in Brix:acid noted during the 1954-55 season paralleled those previously reported (Lime *et al,* 1954) and are shown in Table 5.

Observed variations were small and may have been caused by differences in orchard care rather than by differences in soil. A Brix:acid ratio of 8:1 was reached somewhat earlier in fruit from groves M and W (clay types), than in fruit from groves S and B (light soil). The change in Brix:acid ratio was due to a decline in acid rather than an increase in sugar. The middle of November was considered about as early as fruit of acceptable processing quality could be obtained.

Conclusions

Reflectance measurements of the blended puree of Ruby Red grapefruit provide an index of seasonal variations of fruit color. The pigmentation of the puree measured as the ratio of total lycopene to twice the carotene value agrees well with the Gardner Automatic Color Difference

Table 4. Seasonal reflectance measurements on cut fruit and on blended puree samples and pigment ratios, L/2C. (Grove S)

Date	*Fruit segments (½ in. opening)*			*Puree (2¾ inch opening)*			*Pigment Ratio*
	a[1]	*b*[2]	*a/b*	*a*	*b*	*a/b*	*L/2C*
10/25	2.7	9.1	.297	12.4	13.4	.925	.941
11/8	3.2	9.2	.348	9.5	13.5	.704	.763
11/22	2.9	9.3	.312	8.1	13.5	.630	.598
12/6	3.5	10.1	.346	8.7	14.7	.592	.464
12/20	1.0	9.8	.102	7.1	15.1	.467	.402
1/3	1.0	9.7	.103	6.2	14.4	.431	.369
1/17	0.3	10.0	.030	6.7	15.7	.427	.345
1/31	0.8	9.9	.081	6.4	15.7	.408	.313
2/14	0.9	10.2	.088	5.7	16.2	.352	.284
2/28	0.5	9.6	.052	6.0	16.2	.370	.261
3/14	0.1	10.4	.010	4.8	17.3	.277	.262
3/28	–0.3	9.7	.031	6.7	17.3	.387	.267
4/11	–0.6	10.0	–.060	5.6	17.4	.322	.256
4/25	–1.0	9.6	–.104	4.6	17.1	.269	.250
5/9	–0.4	10.7	–.037	3.9	17.6	.222	.265

[1] Redness
[2] Yellowness

Table 5. Seasonal variations of Brix (sugar) and acid of Ruby Red grapefruit from four groves.

Date	*Grove S*			*Grove B*			*Grove M*			*Grove W*		
	Brix°	*Acid (%)*	*B/A*	*Brix°*	*Acid (%)*	*B/A*	*Brix°*	*Acid (%)*	*B/A*	*Brix°*	*Acid (%)*	*B/A*
10/25	9.2	1.20	7.7	9.1	1.18	7.7	9.4	1.18	8.1	9.5	1.13	8.4
11/8	9.2	1.18	7.8	9.3	1.16	8.0	9.8	1.13	8.7	9.2	1.00	9.2
11/22	9.2	1.14	8.1	9.4	1.13	8.3	9.9	1.13	8.8	9.6	0.94	10.2
12/6	9.4	1.10	8.5	9.6	1.13	8.5	10.6	1.24	8.5	9.7	1.00	9.7
12/20	9.4	1.14	8.2	9.6	1.13	8.5	10.6	1.30	8.2	9.4	0.97	9.7
1/3	9.5	1.11	8.6	9.8	1.05	9.3	10.6	1.25	8.5	9.6	0.95	10.1
1/17	10.0	1.08	9.3	9.8	0.95	10.3	10.8	1.18	9.2	9.6	0.92	10.4
1/31	9.4	0.94	10.0	9.8	0.90	10.9	10.8	1.12	9.6	9.6	0.89	10.8
2/14	9.6	1.09	8.8	9.8	0.94	10.4	11.0	1.21	9.1	9.6	0.93	10.3
2/28	9.6	.99	9.7	9.8	0.98	10.0	11.0	1.08	10.2	10.0	0.87	11.5
3/14	9.6	.95	10.1	10.2	0.95	10.7						
3/28	9.4	.97	9.7	9.6	0.96	10.0						
4/11	9.4	.88	10.7	9.2	0.77	11.9						
4/25	9.4	.85	11.1	9.6	0.93	10.3						
5/9	9.4	.77	12.2	9.7	0.79	12.3						

Meter reflectance ratio *a/b*. Seasonal reflectance measurements on fruit samples indicate slightly higher coloration in the fruit from the sandy soil. Color declined and Brix:acid ratio increased as the season progressed.

Literature Cited

Anonymous. 1955. Census of citrus trees in Mexican fruit fly quarantine area. U.S. Agr. Res. Service. Mexican Fruit Fly and Citrus Black Fly Control Project, 2 pp. (Processed).

Comar, C. L. and F. P. Zscheile. 1942. Analysis of plant extracts for chlorophylls *a* and *b* by a photoelectric spectrophotometric method. Plant Physiol. *17*: 198-209.

Cowley, W. R. 1954. Personal communication.

Lime, Bruce J., Thomas S. Stephens and Francis P. Griffiths. 1954. Processing characteristics of colored Texas grapefruit. I. Color and maturity studies of Ruby Red grapefruit. Food Technol. 8: 566-569.

VEGETABLE SECTION

SAM TAYLOE—*Section Chairman*

Control of Serpentine Leaf Miner Infestations on Seedling Tomatoes and Cantaloupes

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The serpentine leaf miner, *Liriomyza subpusilla* (Frost), attacks both tomatoes and cantaloupes as soon as they emerge from soil. The adult leaf miners make numerous punctures on the cotyledons and the leaves, which become lighter in color and ragged in appearance. This injury on the cotyledons causes many growers to apply insecticides in order to prevent the leaf miner attacks on the true leaves. Two experiments, one on tomatoes and one on cantaloupes, were conducted to determine the value of insecticides in controlling leaf miners on seedlings.

Tomatoes

The insecticide treatments, see table 1, were applied as high volume sprays at the rate of 100 gallons per acre. All treatments, except demeton were applied on February 12, 16 and 20. Demeton was applied February 12 and 20. The tomatoes had emerged from the soil 5 days prior to the first treatment application. The tomatoes had been planted in rows spaced 3 feet apart. Each treatment plot consisted of a single row of tomatoes 20 feet in length, and was replicated 3 times.

At the time of the first treatment applications all the cotyledons were yellowish green in color and appeared ragged due to feeding and oviposition punctures of the adult leaf miners.

Two weeks after the last spraying 10 plants were examined in each plot and the percentage of plants having leaf miner mines in the true leaves for each treatment are given in table 1. In the untreated plots

Table 1. Effectiveness of various insecticides in controlling leaf miners on seedling tomatoes. 1953.

Amount insecticide per 100 gallons of water	*Percent plants with true leaves infested with leaf miners*	*Ave. Height of plants in inches*
0.5 Lb. Aldrin	33	3.7
0.2 Lb. Endrin	7	3.8
0.5 Lb. EPN	1	4.1
0.125 Lb. Parathion	1	4.0
0.25 Lb. Parathion	1	3.9
0.5 Lb. Parathion	0	3.2
0.5 Demeton	0	3.8
Untreated	43	3.7

Table 2. Effectiveness of various insecticides in controlling leaf miners on cotyledon leaves of cantaloupes. 1953.

Amount toxicant per 100 gallons water	*Average number mines per cotyledon leaf*
0.25 Lb. Schraden	1.8
0.5 Lbs. Schraden	1.1
1.0 Lb. Schraden	1.4
0.25 Lb. Demeton	1.7
0.5 Lb. Demeton	1.6
1.0 Lb. Demeton	1.2
0.25 Lb. Malathion	2.0
0.5 Lb. Malathion	2.3
1.0 Lb. Malathion	1.6
0.125 Lb. Methyl Parathion	1.5
0.25 Lb. Methyl Parathion	1.4
0.5 Lb. Methyl Parathion	1.3
0.125 Lb. Parathion	1.7
0.25 Lb. Parathion	1.6
0.5 Lb. Parathion	1.5
Untreated	2.9

43 percent of the plants were infested with leaf miners. Applications of endrin, demetron, EPN and parathion were highly effective in preventing leaf miner infestation. Aldrin at the dosage used was not effective in controlling the serpentine leaf miner.

Height measurements also were taken of 10 plants selected at random from each plot. As can be seen by the data in table 1, controlling the serpentine leaf miner on seedling tomatoes with endrin, demeton, EPN and parathion did not result in any significant plant growth, indicating that treatments at this time are of little value.

The serpentine leaf miner usually injures the cotyledons of tomatoes severely. As the true leaves form and grow rapidly the infestation is usually very light and scattered. At the time the plants start setting fruit it has a great number of mature leaves on the lower half of the plant, which the miner will attack. As more leaves mature a damaging infestation of miners may develop, which growers may control by the addition of parathion to the fruitworm insecticide formulation.

Cantaloupes

The treatments, listed in table 2, were applied at the rate of 100 gallons per acre. All treatments, except Schraden and demeton were applied on September 28, October 2 and 7. The Schraden and demeton

treatments were applied on September 28 and October 7. The cantaloupes had been planted in rows spaced three feet apart. Each treatment plot consisted of a single row of cantaloupes 20 feet in length, which was replicated three times.

The cantaloupe seedlings emerged from the soil over a seven day period. The first spray applications were made the second day after the first plants had emerged. Seven days after the last spraying 20 cotyledons from each plot were examined and the number of serpentine leaf miner mines counted. On October 21 the plots were examined for leaf miner infestation on the true leaves.

Since the cantaloupes had emerged over a seven day period many of the seedlings were untreated and exposed for leaf miner attacks for periods of 1 to 4 days between treatment applications. However certain trends can be seen in the data shown in table 2. Schraden and demeton at the 0.5 pound dosage rate gave leaf miner control. The data indicate that methyl parathion and parathion were effective. Malathion was less effective than either demeton, shraden, parathion, or methyl parathion. The examination of the true cantaloupe leaves made on October 21 showed only a few mines in the entire plot. This indicates that the insecticide applications that were made at the cotyledon stage of plant growth did not influence leaf miner infestations.

Serpentine leaf miners seldom attack cantaloupe leaves, which are growing rapidly. Severe leaf miner infestations are usually found on old mature leaves. Because of this, injurious infestations usually develop at the time cantaloupes are setting and maturing fruit.

Summary

Insecticides applied to seedling tomatoes and cantaloupes were of little value because the subsequent true leaves were infested slightly by leaf miners even though the cotyledon leaves had been severely injured.

Injurious infestations may develop on old leaves at the time tomatoes and cantaloupes are setting and maturing fruit.

Recent Trends in Vegetable Production in the Lower Rio Grande Valley

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The production of vegetables has been one of the principal sources of agricultural income in the Lower Rio Grande Valley for the past 40 years, and at the present time is second only to cotton. Production has fluctuated from year to year, but the general trend has been upward particularly with the introduction of other vegetable crops to the Lower Rio Grande Valley.

For the purpose of this paper vegetable production will be based on carlots. Complete records are available for both rail and truck movements during the 5-year period or for the crop seasons of 1950-51 through 1954-55 respectively. Prior to this time only the figures on rail shipments were available, which gave an incomplete picture, since a considerable volume moved out by truck. While some reference will be made to the production prior to 1950-51 the graphs and tables will include only the 5-year period during which time complete records were kept on both rail and truck shipments.

According to Winfrey (1955) 31 different kinds of vegetables are shipped from the Valley, however; of this number only 11 are shipped in quantities exceeding 100 carlots per year. Furthermore of these 11 major vegetables 6 are shipped in excess of 1000 carlots per year. As shown in table 1 these 6 principal or major vegetables are carrots, tomatoes, cabbage, lettuce, dry onions, and cantaloupes. Of these 6 vegetables, 4 of them have been produced here for many years, but only lettuce and cantaloupes are comparatively newcomers, which have come into commercial production during the past few years.

In table 1 it will be noted that following the 6 major vegetables there are 5 others; namely, peppers, green corn, parsley, beets, and white potatoes which are produced in excess of 100 cars per year, based on the 5-year average. Of these crops none have come into commercial importance during the last few years, as was the case of lettuce and cantaloupes in the preceding group. Of this secondary group only green corn and peppers have shown a fairly even upward trend.

As shown in table 1 there are 4 more vegetables with a ranking of 12 through 15 respectively which are shipped in quantities of less than 100 cars per year which places them in a position of relatively minor importance for the vegetable industry as a whole. While these vegetables may be of minor importance they do fill an important place in vegetable shipments particularly in the making up of mixed car and truck shipments. While not used in such large quantities as the other vegetables they do have their place and will continue to be grown in varying quantities from year to year.

In chart 1 it will be seen that there has been a general upward trend of the 6 major vegetables during the last 5-year period. It is of significance to note some of the factors which have brought about these upward trends. In order of rank in regard to volume production carrots hold first place and have shown a steady upward trend during the last 5-year period. One of the most important factors which is responsible for this increase is the introduction of cello-pack marketing in 1951. The cello-packs were very well received by the trade and have continued to gain acceptance since that time. The Texas carrots were found to be well adapted to this type packaging and with the increasing demand the price has been generally good, so the growers have continued to plant more carrots each year. Another factor favoring carrot production is their tolerance to cold weather. Improved cultural practices particularly with regard to the use of the chemical weed-killers has decreased hand-labor of production to a minimum. These factors have made carrot production in the Lower Rio Grande Valley very important and indications are that production will continue to increase in the years to come.

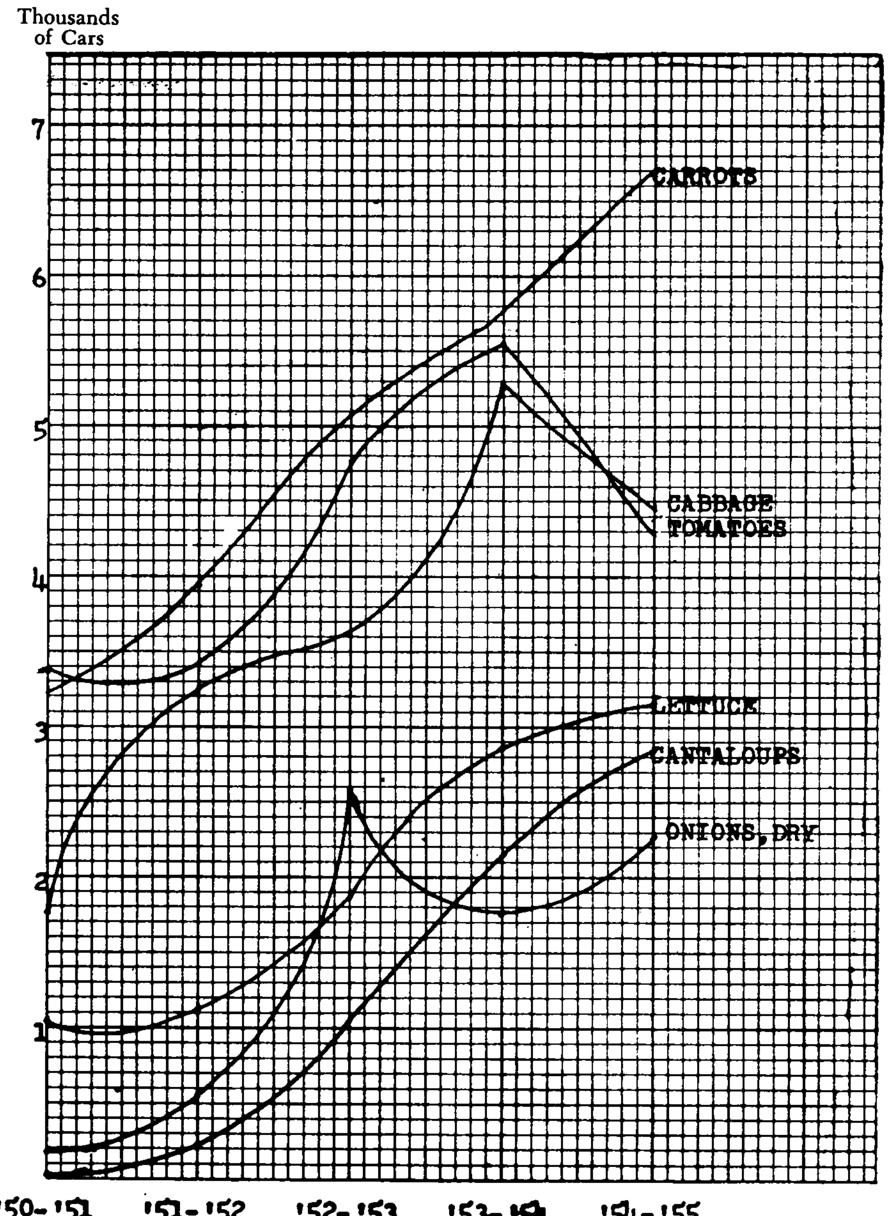
Tomatoes are one of the principal crops of the Valley and the production has shown a marked upward trend during the first 4 seasons of

Table 1. Shipments of Principal Fresh Vegetables from Lower Rio Grande Valley*

Rank	*Vegetable*	*1950-51*	*1951-52*	*1952-53*	*1953-54*	*1954-55*	*5-yr. Ave. 1951-55*
				No. cars**			
1	Carrots	3224	3950	5083	5778	6718	4911
2	Tomatoes	3372	3407	4764	5533	4298	4275
3	Cabbage	1791	3278	3618	5299	4469	3691
4	Lettuce	1042	1132	1873	2862	3167	2015
5	Onions, dry	180	553	2559	1777	2288	1471
6	Cantaloupes	16	221	1056	2144	2855	1258
7	Peppers	505	154	673	816	982	626
8	Corn, green	319	293	410	686	512	445
9	Parsley	138	192	157	153	121	152
10	Beets	116	196	194	101	136	149
11	Potatoes, wh.	151	145	120	170	32	124
12	Radishes	59	66	124	141	62	90
13	Onions, green	29	52	30	93	87	58
14	Broccoli	17	76	35	122	20	54
15	Cucumbers	41	5	–	141	81	54
	Mixed Vegs.	3111	5524	5808	6361	5276	5216

*Only vegetables with largest volume shipments shown.
**Represents both rail and truck shipments. Reported in cars or carlot equivalents. Source of data: Winfrey, R. E., Marketing Texas Misc. Vegetables, Lower Rio Grande Valley of Texas—Summary of 1954-55 Season. U. S. Dept. Agr. Marketing Service, Fruit and Vegetable Division. November, 1955.

CHART 1.—PRODUCTION TRENDS OF PRINCIPAL VEGETABLE CROPS



Source of data: See Table 1.

the 5-year period, but the trend was sharply downward in the 1954-55 season. The upward trend was due in part to the reduction of the cotton acreage with a resulting increase in the spring vegetable crops. Low returns were received during the 1953-54 season which resulted in a decline in production the following year. According to some seedsmen the tomato production will be further reduced for the current spring crop of 1956. High labor requirements for harvesting coupled with low acre returns are having their effects on tomato production.

Cabbage production has shown a steady upward trend except for the season of 1954-55 which showed a sharp drop. This drop can be accounted for by low prices received for cabbage during the previous season. According to Childs (1955) the price per ton in 1954 was only $12.60 as compared with the 5-year average of $31.06. Over the last 10-year period cabbage has been subject to many severe fluctuations, with peak production years with low prices followed by low production with high prices.

Lettuce as a major crop is a relatively new crop for the Valley, although some commercial acreage was grown here over 30 years ago. During those early years lettuce production was not successful since the varieties were very susceptible to bolting and tipburn. During recent years the Great Lakes type of lettuce has been introduced which has proved to be well adapted for production here. The crop has now become of major importance due to the introduction of the Great Lakes type, to the field packing in the 2-dozen-head cartons, and to the use of precooling by means of the vacuum process.

Dry onions have shown an upward trend except for the 1953-54 season. The introduction of the newer and higher yielding varieties such as Grano, Excel, and of the hybrid Granex has been a primary factor in the increased production. These newer varieties have resulted in some cases of yield increases of 100% or more over the older varieties. Improved insect and disease controls have also been major factors in increasing the acre yields and in increasing the over-all production.

Cantaloupes, a very new commercial crop for the Lower Valley have shown phenomenal production increases in the last 5-year period increasing from 16 cars in the 1950-51 season to a high of 2855 cars in the 1954-55 season. Honeydews have also shown heavy gains, since the first commercial shipments were recorded as 88 cars in 1953-54 and in the following season the shipments had increased to 351 cars. The introduction of better adapted varieties coupled with improved insect controls have been largely responsible for these large increases. Improved cultural practices have also been a factor, but the weather still remains as the most important controlling factor for cantaloupe production.

The other crops of secondary importance have shown mixed trends, some upward, some with only fluctuations and without definite trends, while a few have shown general downward trends. Of these crops peppers have shown the greatest upward trend, while green corn has had definite upward trend, but with some fluctuation. This upward trend can be attributed to the use of improved hybrids, along with improved and more effective control measures for the Corn earworm (Heliothis armigera).

The white potato is a crop of only secondary importance and which has had a downward trend during the last 5 years. This production decrease has been brought about by such factors as: low yields, high seed costs compared with other vegetables, disease control costs, and to the high risks in production as compared to the possible returns. The introduction of such newer varieties as Pontiac and La Soda by the Texas Agricultural Experiment Station should have a favorable affect on the potato production and may result in a come-back for the potato industry.

In conclusion it is seen that there has been a general upward trend in the production of 6 principal vegetable crops, namely: carrots, tomatoes, cabbage, lettuce, onions, and cantaloupes. Other crops of secondary importance have shown fluctuations and some crops such as white potatoes and beets have shown downward trends.

Literature Cited

Winfrey, R. E. 1955. Marketing Texas Misc. Vegetables, Lower Rio Grande Valley of Texas—Summary of 1954-55 Season. U. S. Dept. Agr., Agr. Marketing Service, Fruit and Vegetable Div., Nov. 1955.

Childs, V. C. and John C. Mackey. 1955. Annual Summary Texas Commercial Vegetables—U. S. Dept. Agr., Agr. Marketing Service. December, 1955.

Corn Earworm Resistance in Sweet Corn

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Two recent developments—the production of strains somewhat resistant to the earworm and better control with the new insecticides—have made possible the profitable growing of early-market sweet corn in the Southern States, in California, in the Rio Grande Valley of Texas, and in other areas where the insect has been a serious problem for many years. These two findings are complementary, since it has been shown that more effective control with insecticides is obtained on a hybrid having some earworm resistance.

Following the generally severe infestation and damage to corn by the earworm in 1934, U.S.D.A. entomologists gave special attention to the problem of controlling this pest. The senior author was transferred to Lafayette, Ind., and in 1936 R. A. Blanchard was brought to Urbana, Ill., to conduct intensive studies on corn earworm resistance in sweet corn, popcorn, and dent corn.

It was first necessary to learn whether differences in susceptibility of sweet corn to attack and damage by the corn earworm really existed. Differences between varieties showed up, but variation in silking dates and numbers of moths in the field throughout the season made the interpretation of the early data questionable. Methods of hand-infesting the ears to level out the infestation were then devised at Lafayette.

In 1938 arrangements were made in cooperation with the Texas Agricultural Experiment Station to secure a tract of land in the Lower Rio Grande Valley for a test planting, with the hope of obtaining a more uniform natural infestation. Through some fortunate combination of circumstances, J. F. Wood, horticulturist at the Weslaco substation, and W. B. Cook, agricultural agent for the Missouri Pacific Railroad, also arranged small tests. Each investigator had the hybrid known as Ioana and found it more promising for earworm resistance than any other. Hawthorn (1937) had grown this hybrid in 1936 in Winter Haven, Texas, and rated it as the best in his trials. At that time it had not been named and was listed in his trials under the Iowa designation of Iogold P39.145. Mr. Wood and the senior author each tested Ioana again in 1939 and once more found it promising. When the F. H. Vahlsing Company wished to make a trial planting of sweet corn in the Valley in 1940, Ioana was recommended to them.

Following the successful production of Ioana sweet corn for the northern market, nearly all sweet-corn breeders began paying some attention to earworm resistance. Since that time several thousand inbred lines and hybrids have been tested for resistance. Today nearly all new hybrids are tested for resistance before they are put on the market. Tests of inbreds and hybrids under a natural earworm infestation are made annually at Weslaco in cooperation with George Wene, a Texas entomologist, and by hand-infesting the ears, at Lafayette, Ind. In 1954 and 1955 supplementary tests were conducted under conditions of natural infestation at Belle Glade, Fla., in cooperation with W. H. Thames[1] and W. G. Genung, entomologists at the Everglades Experiment Station.

As work progressed, it was recognized that two distinct types of ears were in demand, depending on the expected market. Since green corn is sold by the ear or dozen ears, the southern shipper demanded a long slender ear that would pack five dozen in a bushel bag or crate. A larger ear would run the freight costs too high. On the other hand, the canner wanted a larger ear with deep kernels that would give a high percentage of cut corn. Both wanted a uniform deep yellow with a tender pericarp, and high sugar content. The flavor should also be good and the corn not starchy. The ears should remain in prime condition for several days. The shipper wanted an ear with bright green husks, which made the corn look fresh for a long time. Some markets also demanded flag leaves on the ear, since their customers associated flag leaves with sweet corn and their absence with dent corn. Husk characters were not important to the canners.

With the increased use of power sprayers for earworm control, plant type became of greater importance. The plants should be short enough for the sprayers to pass over them. They should also be relatively free of excess tillers, leaves above the ear, and flag leaves which would interfere with the spray reaching the silks. Most of the sweet corn breeders are in the Northern States. Since few hybrids that are good in one section react the same in another climate or environment, hybrids good in the North had to be tested elsewhere.

Today the sweet corn Ioana has only moderate resistance, and since new strains that have considerable resistance have now been developed, it is among the most susceptible strains grown in the South. Calumet is more resistant and is grown extensively in southern Texas, but because of its poor quality and lack of adaptability it is not popular elsewhere. Huron, Golden Security and Aristogold Bantam Evergreen are somewhat more resistant than Ioana but produce larger ears than the shipper desires. Paymaster is a relatively new hybrid which has only about one-half to two-thirds as much corn earworm injury as Ioana. The plant type is very good in most areas, but the ear is slightly short and rather rough and unattractive in appearance. Many other hybrids have been grown in the South, but they all have some faults, lack of earworm resistance being the most common.

The injury index used for comparing the resistance of strains is based on the mean number of average-sized kernels per ear injured by the earworm when the ears are hand-infested or subjected to a heavy

[1] Now at Florida Agricultural Experiment Station, Gainesville, Fla.

natural infestation. When resistance studies were begun, Golden Cross Bantam with 22 injured kernels per ear was considered about average for all strains being tested. Ioana had 18 injured kernels per ear, and so was considered resistant. The more recent hybrids—Huron, Golden Security, and Aristogold Bantam Evergreen—have 14 to 16 injured kernels per ear. Calumet has about 12 to 14, and Paymaster has 10 to 11. A white hybrid the inbreds of which were released through the Purdue University Agricultural Experiment Station in 1953, and designated by the pedigree 471-U6 x 81-1, has for several years had only 6 to 8 injured kernels per ear, and another white hybrid, still in the experimental stage, has had only 4 to 6. A few other experimental hybrids appear nearly as good.

Unfortunately, the hybrids that have the most earworm resistance are late-maturing and white. The plants are usually rather tall for the spray rigs. The quality and flavor are excellent, but the market demands the yellow color, and the grower and shipper want an earlier corn. Thus, such strains will probably not become popular. However, few new hybrids, yellow or white, that are now being placed on the market have more than 12 to 14 injured kernels per ear. This fact is important, since it means that the sweet-corn grower can expect only half as much damage by the corn earworm today as he had 20 years ago.

The factors responsible for corn earworm resistance are difficult to identify, and some are not well known. Certainly, such factors exist, and the plant breeder can use them and may be able to combine several of them in a single hybrid.

The mechanical factors of length and tightness of husks were perhaps the first to be suggested as responsible for resistance. Poole (1940), Douglas (1947), and others have shown that these factors have no bearing on the percentage of ears infested, but that the tight husks may confine earworm feeding to the tip. This is especially true where the kernels are flat-topped, leaving no channels between the rows.

Another factor appears to be associated with the nutritive value of the corn to the earworm. Frequently larvae matured and left the ear in 16 days on one inbred, whereas larvae from the same batch of eggs would still be feeding on another inbred in an adjacent row up to 10 days later.

Other factors are less understood. Inbred 81-1 has a dominant type of resistance so that nearly all its crosses are resistant. On the other hand, Ill. 107a is highly resistant as an inbred, but its resistance is recessive and lost in a cross.

Still another type of resistance is sometimes found when two susceptible inbreds are crossed. This type appears to be complementary. For example, inbreds Oh55 and C53 are both susceptible to the corn earworm, but their cross, known as Brookhaven, is resistant. On the other hand, as a rule neither of these inbreds contributes resistance to crosses with other susceptible inbreds. A large number of the most resistant inbreds from the Illinois Agricultural Experiment Station are derived from crosses in which the intermediate to moderately susceptible inbred 73c was used as a parent. Inbred LTB is also susceptible, but many of its crosses are fairly resistant. Paymaster (73 x LTB) is one of them.

Usually one can expect crosses between resistant inbreds to give a resistant hybrid, and those between susceptible inbreds a susceptible hybrid, but the exceptions mentioned above show that this is not always the case. It is necessary to study the crosses to be sure.

To produce a satisfactory sweet corn hybrid the corn breeder must give consideration to many factors, including those contributing to resistance to the corn earworm. Such work takes time. Nevertheless, the development of earworm resistance in new hybrids coming on the market today, as the result of the cooperative research of the entomologist and the corn breeder, is another milestone in our search for better crops.

Literature Cited

Hawthorn, Leslie R. 1937. Further tests of vegetable varieties for the winter garden region. Tex. Agr. Expt. Sta. Bul. 546, pp. 8-16.

Poole, Charles F. 1940. Corn earworm resistance and plant characters. Am. Soc. Hort. Sci. 38: 605-609.

Douglas, W. A. 1947. Effect of husk extension and tightness on earworm damage to corn. Jour. Econ. Ent. 40:661-666.

Response of Various Sweet Corn Hybrids to Individual Ear Treatments of DDT and Oil Formulations For Earworm Control

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The corn earworm, *Heliothis armigera* (Hbn.), is still one of the limiting factors of sweet corn production in the Lower Rio Grande Valley of Texas. Wene *et al.* (1952) showed that better earworm control was obtained with individual ear applications of various DDT-oil formulations on an earworm resistant sweet corn hybrid, such as Calumet, than on the less resistant hybrid, Ioana, which was being grown commercially at that time. Since then Calumet has been grown by practically every farmer in the Valley. Sponging a solution of 1% DDT in oil on the silks has been the accepted method of earworm control. However, Calumet is very susceptible to oil injury and the fresh sweet corn market objects to the severe oil injury found on the ear tips of treated sweet corn even though it is worm-free. An experiment was conducted in 1955 for the purpose of finding a variety or hybrid of sweet corn that would be tolerant of oil which is used in the individual ear method of earworm control.

Procedure

Each of the six hybrids, shown in table 1, were planted in four row plots. Each plot was 40 feet in length, and the rows were spaced 40-inches apart. Each hybrid sweet corn plot was replicated four times. Individual rows in each plot were considered sub-plots for use in the earworm treatments shown in table 2. The plots were irrigated, fertilized, thinned, and cultivated in the accepted manner for this area.

The 1% DDT-5% oil-94% water emulsion was made in gallon lots using an emulsifiable DDT, white mineral oil and water. This DDT-oil emulsion was applied to the silks of individual ears by simply dipping a small synthetic sponge in the emulsion and then pressing the sponge on top of the silk mass until approximately one half of a teaspoon of the emulsion ran into the silk channels. The DDT-oil emulsion was applied for the first time when 50% of the corn stalks shows silks. Those sub-plots receiving two applications were treated once more three days later, while those sub-plots receiving three applications were treated two times more at two day intervals.

The 1% DDT-99% oil solution was made by dissolving technical DDT in white mineral oil. This solution was applied only once to the silks, seven days after the first silk appeared in the field. A sponge was used in applying this solution to the silks of individual ears, but only one quarter of a teaspoon per ear.

At harvest time the marketable ears from each sub-plot were pulled and weighed. Then the individual ears were examined for earworm and oil injury.

Results

The data in table 1 show that all the hybrids tested had approximately the same amount of earworm resistance as did Calumet.

The best earworm control was obtained with three applications of the 1% DDT-5% oil-94% water emulsion, as shown by the data in table 2. Paymaster showed no oil injury on the ear tips from three applications of the DDT-oil emulsion; Golden Security averaged only 0.2 of an inch per ear; and Calumet averaged 0.6 of an inch per ear but the three applications of the emulsion also interferred with pollinization which resulted in poorly developed ears with missing kernels along the entire length of the ear. The hybrid Huron showed little oil injury on the ear. The oil injury was severe on both Southern Shipper and Code 526.

Reducing the number of DDT-oil-water emulsions to two applications reduced the amount of oil damage to the ear tips. The percent of worm-free ears obtained was also lower, but commercial earworm control was obtained on the hybrids, Paymaster, Huron and Code 526. Two applications of this emulsion did not interfere with the pollinization of the hybrid, Calumet.

Sponging a 1% DDT-99% oil solution once on the silks of individual ears gave effective earworm control. Paymaster showed the least amount of oil damage on the ear tips. The remaining hybrids showed excessive oil damage on the ear tips as can be seen by the data in table 2.

The hybrid Calumet is grown by most growers in this area because of shippers preference. Calumet has a long slender ear and requires six dozen ears to fill a crate. In order to make a "fancy" pack of corn the

Table 1. Susceptibility of sweet corn hybrids to earworm injury.

Hybrid	*Percent Ears with the Following Inches Earworm Injury on Ear Tip*		
	0	*0.5*	*1.5+*
Code 526[1]	4	24	72
Huron[2]	30	14	56
Golden Security[3]	17	4	79
Paymaster[3]	15	22	63
Southern Shipper[1]	21	19	60
Calumet[2]	8	17	75

[1] Supplied by Ferry-Morse Seed Co.
[2] Supplied by Asgrow Texas Co.
[3] Supplied by F. H. Woodruff & Sons, Inc.

Table 2. Response of sweet corn hybrids to ear worm treatments and the average yield.

Variety	*Percent Worm-Free Ears*	*Ave. In. Oil Injury on Ear Tip*	*Calculated No. 50 lb. Sacks/Acre*
	Three Applications of 1% DDT-5% oil+water[1]		
Code 526	97	1.9	62
Huron	98	0.3	106
Golden Security	96	0.2	140
Paymaster	98	0.0	128
Southern Shipper	88	1.3	135
Calumet	89	0.6	102
	Two Applications of 1% DDT-5% oil+water[2]		
Code 526	77	1.5	67
Huron	83	0	109
Golden Security	67	0.1	127
Paymaster	74	0	130
Southern Shipper	55	1.2	141
Calumet	32	0	105
	One Application of 1% DDT in 99% oil		
Code 526	77	2.3	52
Huron	93	2.6	120
Golden Security	93	1.6	130
Paymaster	86	1.0	145
Southern Shipper	95	2.8	120
Calumet	94	3.0	84
	Untreated for Earworms		
Code 526	4		63
Huron	30		121
Golden Security	17		119
Paymaster	15		148
Southern Shipper	21		128
Calumet	8		98

[1] Applied at 2 day intervals
[2] Applied at 3 day intervals

ears must be of such a size that five dozen will fill a crate. Paymaster has the desired ear diameter. Southern Shipper has an ear about the same size as Calumet, but the yield increase of Southern Shipper over Calumet is not large enough to justify changing hybrids. Code 526 has a smaller ear than Calumet.

The hybrids Huron and Golden Security have too many suckers and leaves which would be a problem in carrying out the earworm control program as too many of the ears would be hidden from the insecticide applicators, especially if the treatments were applied by hand.

As mentioned before, the ears of Paymaster are the size desired by sweet corn shippers. This hybrid also responds well to the earworm treatments. The ear is shorter than that of Calumet. In addition the kernels of Paymaster are larger than those of Calumet. Because of these two factors Paymaster should be grown on a limited scale to determine the market acceptance of this hybrid.

Summary

Paymaster, when various formulations of DDT and oil were applied to the silks of individual ears for earworm control showed less oil injury on the ear tips than did the hybrids, Calumet, Southern Shipper, Huron, Golden Security, and Code 526.

Paymaster and Southern Shipper also yielded more marketable corn than the other hybrids tested.

Although Paymaster has an ear with the desired thickness, the ear is shorter than Calumet, and the kernels are larger. Because of these factors Paymaster should be planted on a limited scale until it has received market acceptance.

Literature Cited

Wene, George P., R. A. Blanchard and E. V. Walter. 1952. Relation of corn earworm resistance in sweet corn to efficiency of insecticide sprays. Jour. Econ. Ent. 45(6):931-3.

Control of the Carrot Looper By a Wasp Parasite

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The carrot looper, *Rachiplusia ou* Gn., is injurious to carrot tops in scattered localities in the Lower Rio Grande Valley and in the Winter Garden area of Texas. This voracious feeder could be a very serious pest on young carrots, reducing the yield or completely destroying the crop. Feeding on more mature plants may be less serious since packaging has eliminated the need of a healthy top for the fresh market.

The carrot looper on carrots was observed in the Winter Garden area in November, 1951 and 1954. A looper on carrots was found there in 1943, which was probably the carrot looper. It was observed in a small area in the Lower Rio Grande Valley in 1953. When the larvae appear in large numbers they cause much damage, consuming one-fourth to one-half of the foliage. Growers generally applied insecticides to control the pest; one grower had good results with 20 percent toxaphene dust. The pupal stage is passed within a protective cocoon of silk and dead leaves webbed together by the larvae. This stage is easily recognized by the brown mass of dead leaves surrounding the pupa. A heavy infestation is very noticeable in the field.

During the 1953 season, the carrot looper was parasitized by an Ichneumonid wasp in the Lower Rio Grande Valley. The carrot looper has not been found since, indicating that this parasite may have controlled this pest. This wasp parasite, identified as *Itoplectis conquisitor* (Say), was found in large numbers in a carrot field heavily infested with carrot loopers near the Winter Haven Experiment Station in November and December, 1954; however, the looper did not occur on later plantings, indicating control. The adult wasp is about one-half inch long and easily found in fields in which parasitized carrot loopers are present in large numbers. No record was kept on the number of adult loopers emerging from the pupae, but 11 parasites emerged from 25 cocoons picked from an infested field; only a few looper moths emerged. The parasite consumes the pupae of the looper and pupates inside the empty pupal shell. The adult parasite emerges from the looper cocoon and seeks out more prey. These observations indicate that good control of the carrot looper is effected by the wasp parasite and reduces the looper population enough to keep it from being a pest of economic importance in the Winter Garden and the Lower Rio Grande Valley.

Transmission of a Spinach Virus By the Beet Leafhopper in the Winter Garden Area

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During the 1954-55 season, Winter Garden spinach growers were alarmed again by serious damage from a disease called mosaic believed to be caused by either the beet curly top or aster yellows virus. Jones (1936) reported the first serious outbreak of curly top in spinach in the Winter Garden area in 1936 and mentioned losses as high as 75 percent in some fields. The disease has caused intermittent losses since that time, varying in severity from year to year and even from month to month. Aster yellows virus was also reported as being found in spinach by Ivanoff and Ewart in 1944. At that time, it caused considerable injury but only in certain fields.

The losses from the virus disease have been increasing in recent years and have caused much concern to the farmers growing spinach for canning operations, freezing plants and fresh markets. Since the two suspected viruses are insect transmitted, curly top by the beet leafhopper and aster yellows by the six-spotted leafhopper, some growers have been adding insecticides to their blue mold and white rust fungicides as a precautionary measure against the leafhoppers as well as a control for budworm and looper.

In the field, the infected plants are conspicuous because of the pronounced yellow discoloration of the leaves. The yellowing may start at the outer margins of the infected plants and progress to the center or it may start at leaves in the center and move to the outer leaves. Eventally the growing point begins to die and soon the whole plant succumbs.

Virus transmission studies during 1952. Transmission studies were started at the Winter Garden Experiment Station in January, 1952. The beet leafhopper, *Circulifer tenellus* (Baker), and the six-spotted leafhopper, *Macrosteles divisus* (Uhl.), were collected from the field and put on caged barley plants in the greenhouse. The beet leafhoppers failed to reproduce on barley but the six-spotted leafhoppers increased rapidly. By taking barley plants containing only eggs and nymphs and caging them separately, virus-free colonies of the six-spotted leafhoppers were built up and maintained. These virus-free leafhoppers and beet leafhoppers (collected from a field of red beets in which there was apparently no curly top infection) were used in inoculation experiments.

Diseased spinach plants were transplanted from the field to pots in the greenhouse and disease-free plants were grown from seed in the greenhouse. Diseased spinach plants used as a source of inoculum and healthy plants being inoculated were covered with cages made of cellulose nitrate or cellulose acetate equipped with cheese cloth tops. The insects were placed first in cages over diseased plants and were allowed

to feed for about a week before they were put in cages over healthy plants. After one to two weeks on the healthy plant, they were removed and the plants observed for symptoms of the disease.

Experiments in which the aster yellows vector, the six-spotted leafhopper, was used failed to reveal transmission. Feeding six-spotted leafhoppers on carrots showing typical aster yellows symptoms and moving them to spinach failed to give transmission. However, disease symptoms developed in all healthy plants on which the beet leafhoppers had fed following a period of feeding on infected plants. Healthy plants exposed to beet leafhoppers brought directy from the field failed to develop the disease.

Dodder, also, was used in an effort to transmit the virus. The dodder was allowed to grow from healthy spinach plants to both virus-infected spinach plants and to carrots infected with aster yellows virus. The experiment indicated a probable transmission to the healthy spinach from the infected spinach plants but further tests are needed to prove this. There was no evidence of transmission of the aster yellows virus by dodder.

With an increase in temperatures, the insect cultures were moved to the Central Power and Light Company Laboratory in an effort to maintain them there. Even though the humidity, temperature and light could be controlled, the cultures eventually died.

Virus transmission studies during 1954-55. Need for further study arose from the increasing importance of the disease. For this study, 2' x 2' x 2' redwood cages were constructed. The cage frame was covered on three sides and the top with 20 x 20 mesh plastic screen. In the front was a door 9" x 20". The rest of the front was covered with glass to aid in examining the contents of the cage. The cages were made with detachable solid wood bottoms so that they could be used in the greenhouse with the bottoms or in the field without them.

Beet leafhoppers were collected in the field and placed on sugar beets in the cages. The leafhoppers used were infective and the sugar beets showed the symptoms of curly top within several weeks. The insects multiplied in the cages and a colony of infective insects was maintained by keeping growing beets in the cage. Insects from these cages, when allowed to feed on healthy sugar beets, transmitted the curly top virus to them. They also transmitted a virus to the spinach plants used in the same inoculation tests. The symptoms appeared in about 25 to 31 days and were typical of the mosaic symptoms occurring in the field on spinach.

In view of the facts that the beet leafhopper is capable of transmitting the mosaic disease of spinach from one infected spinach plant to another and that spinach plants, inoculated by the feeding of leafhoppers known to be infected with the curly top virus, become infected and exhibit symptoms similar to those caused by the unidentified virus as it occurs in the field, it is concluded that at least some of the virus in spinach in the Winter Garden is the curly top virus (Leach, 1940). The fact that the six-spotted leafhopper was practically nonexistent in the area at the time probably eliminates aster yellows as a disease of spinach during the 1945-55 season.

Literature Cited

Ivanoff, S. S. and W. H. Ewart. 1944. Aster yellows on carrots, lettuce, spinach and others crops in the Winter Garden. Texas A.E.S. Progress Rpt 905.

Jones, S. E. 1936. Curly top disease of spinach in the Winter Garden. Texas A.E.S. Progress Rpt. August.

Leach, J. G. 1940 Insect transmission of plant diseases. McGraw Hill, New York. p. 329.

Control of the Cowpea Curculio

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The cowpea curculio, *Chalcodermus aenus* Boh., is a limiting factor in the production of southern peas grown for canning purposes. The injury is severe on southern peas maturing between the months of May and November. Very little cowpea curculio damage can be found on southern peas maturing after November 1. In the past many growers had been planting southern peas at such a time that the harvesting date came in November. However, these late planted southern peas usually had low yields due to adverse weather conditions prevailing during the last half of October. Because of grower interest an experiment on cowpea curculio control was conducted on southern peas maturing in the month of June.

Good control of the cowpea curculio was obtained by Wene (1948) with 3 applications of 5-percent DDT, 5-percent chlordane, 5-percent toxaphene and 40-percent cryolite applied at intervals of 5 to 6 days. In Georgia, Dupree and Beckham (1955) obtained excellent control with 20-percent toxaphene, 2.5-percent heptachlor and 2.5-percent dieldrin. Best results were obtained with 3 or 4 applications applied at intervals of 3 to 5 days.

Procedure

The experiment was conducted in a planting of cream peas. A treatment plot consisted of six rows, spaced 3 feet apart, and 75 feet in length. Each of the treatments listed in table 1, were replicated 3 times. The insecticides were applied with rotary hand dusters at approximately 20 pounds per acre. All treatments were started on June 6, at a time when the earliest pods were about 1.5 inches long. Five days after the fourth application was made in the 4-application plots, 100 southern pea pods were picked at random in each plot and examined for cowpea curculio injury. Pods were collected for insecticide residue analysis at various times after the last insecticidal application.

Results

The data in table 1 show that all treatment effectively reduced the amount of cowpea curculio injury. Three applications at 4 day intervals were slightly more effective than 2 applied at 7 day interval. No benefit was obtained by increasing the number of applications to 4. There was no significant difference between the effectiveness of toxaphene, heptachlor, endrin or dieldrin in controlling the cowpea curculio.

Heptachlor residue analysis[1] showed that the residues in the shelled

[1] Residue determinations were made by the Velsicol Chemical Corporation.

Table 1. Effectiveness of various insecticides in control of the cowpea curculio. 1955.

Treatment	*No. Applications*	*Days Between Applications*	*Percent Injured Pods*
1.5% Endrin	2	7	3.0
	3	4	1.7
	4	4	2.3
5.0% Heptachlor	2	7	3.0
	3	4	2.0
	4	4	3.0
2.5% Dieldrin	2	7	3.7
	3	4	3.0
	4	4	3.0
20.0% Toxaphene	2	7	3.3
	3	4	2.3
	4	4	1.0
Untreated	—	—	19.7
Average of plots receiving 2 applications			3.3
Average of plots receiving 3 applications			2.3
Average of plots receiving 4 applications			2.3

southern peas were below the 0.1 ppm tolerance. Only 0.017 ppm of heptachlor was found in the sample of shelled southern peas collected 5 days after the final heptachlor application in the plots receiving 4 applications. The highest residue of heptachlor, 0.068 ppm, was found in the sample collected 8 days after the 3-application treatment had been completed. A sample taken 6 days later showed that the heptachlor residue had been reduced to 0.023 ppm. Dupree and Beckham (1955) also found that the residue of heptachlor on shelled southern peas at harvest time was below the allowed tolerance.

The samples of southern peas collected from the plots dusted four times with 20 percent toxaphene showed 1.4 ppm of toxaphene on the shelled southern peas 9 days after the final treatment application.[2] This is below the allowed 7 ppm tolerance. These data and that of the Georgia Experiment Station show that certain insecticides can be safely used for cowpea curculio control within a week or so of harvest.

Summary

Good control of the cowpea curculio on southern peas was obtained with 20-percent toxaphene, 5-percent heptachlor, 1.5-percent endrin and 2.5-percent dieldrin, applied as dusts three times at 4 day intervals.

Raising the number of applications to 4 did not give any better cowpea curculio control.

The low residual, 1.4 ppm of toxaphene and 0.068 ppm of heptachlor, found on shelled peas 9 and 8 days after final dust applications indicate that these materials may be safely used on peas 7 to 9 days before harvest.

[2] Residue determinations were made by the Hercules Powder Company.

Literature Cited

Dupree, Minter, and C. M. Beckham. 1055. The cowpea curculio—a pest of southern field peas. Georgia Agri. Expt. Sta. Bull. N. S. 6.

Wene, George P. 1948. Control of the cowpea curculio. Jour. Econ. Ent. 41(3):514.

Variety and Strain Evaluation of Southern Peas

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Canning of Southern peas, (edible varieties of cowpea, *Vigna sinensis*) has become an important item to the processing industry of the South. An increase from 1,234,178 cases in 1949 to 2,216,097 cases in 1953 (National Canners Assoc., 1955) might possibly have been greater if there had been available a more desirable variety. As reported by Brittingham and Mortensen (1951), existing varieties do not mature evenly and must be harvested by hand several times during the season. Some varieties are low in yield and subject to insect and disease damage.

Commercially canned peas too often have a very viscous cloudy liquor, and the peas are dark with excessive mashed and broken pieces, resulting in an unattractive product (Culver and Cain, 1952). The answer to some of these problems would be higher yielding, even maturing varieties adapted to mechanical harvest, and more resistant to disease and insect damage. The canned product should have a clear attractive color, few broken and mashed peas, and a pleasing flavor.

This study presents additional information on adaptability, yield, and canning quality of several varieties and strains of Southern peas grown in the Lower Rio Grande Valley (Correa, 1954).

Materials and Methods

Seven varieties and three strains of Southern peas were grown in the Fall of 1953 and five varieties and seven strains were grown in the Fall of 1954, at Weslaco. The peas were planted in a randomized block with four replications, each plot consisting of two rows 30 feet long and 38 inches apart. Irrigation and other cultural practices were applied as needed during the growing season.

All varieties and strains were harvested twice during the season, i.e., when they reached optimum maturities to produce the largest amounts of green peas. The first harvest was used for processing evaluation. Calculated acre yields as given in table 1, however, include both harvests. As each variety or strain was harvested it was shelled in a paddle and reel type pea sheller operating at 300-325 rpm. and the shelled peas cleaned by dropping through a blast of air. A standard model tenderometer (AR-676) with weights W.C.T. 136A and W.C.T. 137A and scale No. 2 as recommended for English peas was used to obtain tenderometer values.

[1] Research on Bankhead-Jones Project 538.

[2] One of the laboratories of the Southern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

As outlined in the Service Manual of the Food Machinery Corporation Bulletin No. 9 (1953) the position of the weights on the counterweight shaft was changed so that a 117 lb. 3 oz. weight on the test bar would perfectly balance the machine. A 60-gram sample in the grid cup was judged to give the most accurate reading. With larger samples of peas the pointer sometimes went beyond the numerical limits of the scale. Each tenderometer value reported in table 2 was obtained by using four 60-gram samples of each variety and strain from each replication.

A shelled sample of peas from each replication was blanched in water for 4 minutes at 185° F. Four No. 300 (300x407) "C" enamel cans, as recommended by Cain and Brittingham (1950), were filled with 200 grams of blanched peas per can. Boiling 2% brine was then added to a constant headspace, and the cans closed while the center temperature was about 180° F. All these samples were cooked 35 minutes at 240° F. (10 psi) and water-cooled as quickly as possible.

Canned samples were examined for drained weight, defects, and splits, and a sensory evaluation made for color, flavor, and appearance after about 2 months storage at room temperature. Drained weight and defects were determined according to the U. S. Standards (1950) for grades of canned field peas and canned blackeye peas. The term "defect" refers to the presence of extraneous vegetable matter, loose skins, parts of peas, mashed peas, or foreign material. A pea was considered to be split if the skin was separated to a width of 1/16 inch or more (Cain and Brittingham, 1950). The percentage of defects and splits in table 2 were calculated from duplicate 100-gram samples from each of four cans.

Sensory evaluations for color, flavor, and appearance were made by a panel of seven judges. The blackeye and purple hull peas were judged in one group, and the cream peas in another group. The numerical ratings shown in table 2 are averages of two separate evaluations of duplicate samples of four replications. A reference sample of commercially canned peas was used for each group. Judges rated appearance on the amount of loose skins, splits, broken and mashed peas visible in the sample.

Results

Sixteen varieties and new strains of Southern peas were evaluated for yield and processing quality. Comparative yields are shown in table 1. The variety Commercial Purple Hull was the highest producer of green pod peas for the blackeye-purple hull pea group, and Cream 52 Sp 16 strain was the highest producer for the cream group. There were no significant differences between the higher yielding varieties and strains in average total yield of green pod peas for the 1953 season, but in 1954 Commercial Purple Hull and Cream 52 Sp 16 were significantly higher in total yields. Results of the 1953 season show that Purple Hull 52 Sp 5 strain and the varieties, Long Pod Cream and Cream 12, were significantly lower in total yield of green pod peas. In 1954 the Purple Hull 52 Sp 5 and Cream 52 Sp 19 strains, and the variety Cream 40, were significantly lower in total yield. The Purple Hull 52 Sp 5 strain has many desirable characteristics for canning, but according to the results of this test could not be recommended to growers because of its low total yield.

Extra Early Blackeye had the highest average shellout percentage of the blackeye-purple hull pea group, and Cream 40 variety the highest for the cream group. Average shellout percentage was 11.3% lower for all varieties and strains in 1954 than in 1953. This was a greater difference than the 8% reported by Brittingham and Mortensen (1951) but was probably due to differences in maturity at harvest and more careful shelling and cleaning during the 1953 season. Purple hull peas as a group were lowest in shellout percentage for both the 1953 and 1954 trials. Purple Hull 49 was consistently low for both seasons. Large seasonal shellout differences emphasize the need for more uniform maturing varieties and an accurate method for determining field maturity.

Table 2 summarizes the tenderometer values and processing quality obtained from different varieties.

Table 1. Yield and percent shellout of Southern pea varieties and strains; Fall 1953 and 1954.

Variety or Strain	*Green pod peas (lbs./A)*		*Shelled peas (lbs./A)*		*Seasonal shellout (%)*	
	1953	*1954*	*1953*	*1954*	*1953*	*1954*
Calif. Blackeye No. 5	3931.8	3164.8	2279.0	1462.1	58.0	46.2
Extra Early Blackeye	3530.6	3041.0	2132.9	1596.5	60.4	52.5
Comm. Purple Hull	3903.1	4086.7	1980.5	1446.7	50.7	35.4
Purple Hull 49	3410.3	2889.6	1556.6	1040.3	45.5	36.0
Purple Hull 52 Sp 2	–	3495.0	–	1265.2	–	36.2
Purple Hull 52 Sp 4	3232.5	–	1742.4	–	53.9	–
Purple Hull 52 Sp 5	2636.5	1912.6	1489.9	849.2	56.5	44.4
Purple Hull 52 Sp 12	–	3467.5	–	1120.0	–	32.3
Purple Hull 52 Sp 13	–	2889.6	–	1491.0	–	51.6
Cream 40	3192.4	1224.6	1224.6	569.4	57.8	46.5
Cream 12	2735.1	–	1279.3	–	46.8	–
Long Pod Cream	2478.8	–	1535.9	–	56.6	–
Cream 52 Sp 7	–	2999.7	–	1148.9	–	38.3
Cream 52 Sp 8	3742.8	–	2064.4	–	55.1	–
Cream 52 Sp 16	–	3935.4	–	2097.6	–	53.3
Cream 52 Sp 19	–	1499.8	–	539.9	–	36.0
Least significant difference						
.01 level			1091.5	591.7		
.05 level	1034.0	527.3	810.5	426.6		

Table 2. Tenderometer value and processing quality of Southern pea varieties and strains: Fall 1953 and 1954

Variety or strain	*Tenderometer value*		*Drained weight gms.*		*Defects (%)*		*Splits (%)*		*Sensory evaluation* Color		Flavor		Appearance[1]	
	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954
California Blackeye No. 5	135	126	410	308	9.1	2.7	55.7	43.1	4.9	6.1	5.8	5.5	4.1	5.2
Extra Early Blackeye	153	156	411	323	1.1	1.3	37.0	27.3	5.1	5.3	6.0	5.9	5.1	6.1
Commercial Purple Hull	186	131	379	307	2.2	1.7	14.3	26.3	5.6	5.3	5.8	5.4	5.0	5.9
Purple Hull 49	137	129	342	332	.7	1.0	20.9	19.7	6.7	6.6	5.6	6.4	6.8	6.3
Purple Hull 52 Sp 2	–	116	–	297	–	1.8	–	24.5	–	4.7	–	5.3	–	4.8
Purple Hull 52 Sp 4	135	–	411	–	.4	–	9.9	–	5.2	–	5.6	–	6.4	–
Purple Hull 52 Sp 5	189	170	355	375	.2	.3	5.7	8.7	5.0	6.1	5.9	5.8	6.6	6.6
Purple Hull 52 Sp 12	–	108	–	292	–	1.1	–	17.2	–	4.5	–	5.2	–	5.6
Purple Hull 52 Sp 13	–	157	–	334	–	2.3	–	23.6	–	6.6	–	5.9	–	6.3
Cream 40	141	143	413	370	12.7	3.0	66.0	69.2	7.5	6.6	6.6	6.1	5.7	4.9
Cream 12	180	–	411	–	1.0	–	56.2	–	6.9	–	6.7	–	5.9	–
Long Pod Cream	200	–	398	–	1.1	–	32.6	–	7.2	–	6.3	–	7.1	–
Cream 52 Sp 7	–	118	–	355	–	2.9	–	45.3	–	6.2	–	5.9	–	6.0
Cream 52 Sp 8	145	–	408	–	1.2	–	55.2	–	7.2	–	6.7	–	6.7	–
Cream 52 Sp 16	–	167	–	367	–	1.5	–	25.0	–	5.6	–	6.9	–	6.7
Cream 52 Sp 19	–	132	–	289	–	3.7	–	43.5	–	6.0	–	5.0	–	5.9
Least significant difference														
.01 level					2.2	1.5	9.7	14.5						
.05 level					2.0	1.1	8.7	10.8						

[1] These numbers represent numerical opinions of the judges. The word description of each number in the scale is:

1. Very poor
2. Poor
3. Fairly poor
4. Fair
5. Acceptable
6. Fairly good
7. Good
8. Very good
9. Excellent
10. Ideal

In 1953 California Blackeye No. 5 and Cream 40 were significantly higher in average percentage of defective peas, but in 1954 Cream 52 Sp. 19 was significantly higher in defective peas. No highly significant differences were obtained among the other varieties and strains.

The average percentage of split peas of Purple Hull 52 Sp 4, Purple Hull 52 Sp 5 and Commercial Purple Hull, were significantly lower for the 1953 season. Purpe Hull 49, Purple Hull 52 Sp 12, and Purple Hull 52 Sp 5 were significantly lower for the 1954 season than the other varieties and strains. California Blackeye No. 5 and Cream 40 were significantly higher in splits for both years. Because of the high level of splits both these varieties produced unattractive products. The purple hull group was noticeably low in split and defective peas.

There was no relationship between shellout percentage and tenderometer value nor between drained weight and tenderometer value when any one variety or strain was compared with another.

The cream pea group received a slightly higher numerical rating for color, flavor, and appearance than the blackeye-purple hull pea group. The Purple Hull 52 Sp 2 and Purple Hull 52 Sp 12 strains turned a dark brown color during processing. This characteristic would practically eliminate them as canning varieties.

Summary and Conclusions

Extra Early Blackeye and Commercial Purple Hull are the most desirable varieties of the blackeye-purple hull pea group from the standpoint of yield and processing quality.

Cream 52 Sp 16 strain is superior to the other cream varieties and strains tested.

The differences in seasonal shellout percentage emphasize the need for a rapid, accurate method for determining field maturity.

There was no relationship between tenderometer value, shellout percentage, or drained weight as determined in this study.

Because of a dark brown discoloration the Purple Hull 52 Sp 2 and Purple Hull 52 Sp 12 strains are not acceptable for processing.

Progress has been made in selecting more desirable varieties of Southern peas, but more work is needed by the plant breeder and processor so that greater yields of even maturing, excellent quality peas may be obtained.

Literature Cited

Brittingham, W. H. and J. A. Mortensen. 1951. Varietal differences in shellout percentages in the Southern pea. Texas Agr. Expt. Sta. Progress Report 1390, pp 1-7. (Processed)

Cain, R. F. and W. H. Brittingham. 1950. Southern pea varieties for canning. Texas Agr. Expt. Sta. Progress Report 1216, pp. 1-3. (Processed)

Canned Food Pack Statistics 1954. June, 1955. National Canners Assoc.

Correa, R. T. 1954. Southern pea variety and strain test, Lower Rio Grande Valley, fall 1953. Texas Agr. Expt. Sta. Progress Report 1705, pp. 1-4. (Processed)

Culver, W. H. and R. F. Cain. 1952. Nature, causes, and correction of discoloration of canned blackeye and purple hull peas. Texas Agr. Expt. Sta. Bull. 748, pp. 1-23.

Service Manual for the Tenderometer. 1953. Food Machinery and Chemical Corp. Bull. No. 9, pp. 1-10.

U. S. Production and Marketing Administration. April 17, 1950. United States Standards for Grades of Canned Field Peas and Canned Blackeye Peas. pp. 1-7. (Processed)

Effect of Different Levels of Soil Moisture and Fertility Upon the Yield and Quality Of Sweet Corn

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Only limited information is available concerning the effect of different soil moisture regimes and fertility levels upon the yield and quality of sweet corn. Recent soil fertility studies conducted by Gausman and Wene (1953, 1954) indicated that applications of P_2O_5 reduced corn earworm damage in 1952 and 1953. In the same experiments the use of nitrogen increased yields in 1952 but depressed yields in 1953. This decrease was presumably a result of increased salt concentration in the irrigation water. The work of Clore and Viets (1949) showed that nitrogen applications reduced corn earworm damage to sweet corn ears. Similar results have been reported by Klostermeyer (1950) who found that infested sweet corn ears were reduced from 99.5 to 91.0 per cent as the nitrogen was increased from 0 to 160 pounds per acre.

A test was conducted in the spring of 1955 to evaluate the effect of soil moisture availability and different nitrogen levels upon the yield and quality of Calumet sweet corn.

Procedures

The experiment was conducted under field conditions on a Willacy loam soil at the Lower Rio Grande Valley Experiment Station. A randomized block design with four replications was used. Each block consisted of twelve rows and was split into four row plots with three fertility levels. Plots were fifty feet in length.

The following fertilizer treatments, expressed in pounds of elemental nitrogen (N), were included in each block: 0-0-0, 60-0-0 and 120-0-0. The latter nitrogen treatment (120 lbs. N) was applied as a split application, with 60 lbs. applied before planting and 60 lbs. at the time silks appeared. A uniform application of 60 lbs. of phosphoric acid (P_2O_5) was applied to all plots before planting.

Superimposed on the fertility treatments were three soil moisture levels as indicated below:

A. High moisture level—Retain the average soil moisture in the top foot of soil at 75% of field capacity.[1]

B. Medium moisture level—Retain the average soil moisture in the top foot of soil at 50% of field capacity.

[1] Field Capacity—Quantity of water retained in the soil after gravitational water has drained away following an irrigation or period of heavy rainfall.

C. Low moisture level—Retain the average soil moisture in the top foot of soil at 25% of field capacity.

The land was prepared for planting, fertilized, and irrigated with a uniform application of water on February 9, 1955. Calumet sweet corn was planted on February 28. An excellent stand was obtained and was thinned to a spacing of about 9 inches; however, cold winds on March 8 and 21 damaged plants in the northwest part of the experimental area.

Tassels were found in all treatments on April 25 which was fifty-six days after planting. Silking was observed to be somewhat extensive in all treatments on May 2 and 3; no particular treatment was observed as having an outstanding influence on early silking. However, the first silks more often occurred in the high soil moisture level treatments. Generally, the insect infestation was relatively light during the growing season, which necessitated only one dusting with toxaphene for corn budworms.

Soil Moisture Control

After the stand had been thinned, tensiometers were installed at depths of 9, 18, 30 and 42 inches for the purpose of observing the depth from which soil moisture was extracted and also the rate of water use. The high nitrogen level plots were used for soil moisture control, and soil samples were taken at intervals throughout the growing season to depths of five feet for obtaining daily evapotranspiration values. The soil moisture level control zone was the 0-12 inch depth.

Irrigation water was conveyed to individual plots through portable, gated pipe, and measurement was effected by a Sparling flow meter. Good water control on individual blocks was afforded by leaving out a border row between blocks. Such an arrangement helped to minimize moisture movement between individual blocks in each replication.

The dates of irrigation and quantities of water applied to each soil moisture level are shown in table 1. Rainfall was not a contributing factor one way or the other during the course of the experiment.

Results and Discussion

The average daily evapotranspiration rates, as determined from field sampling during different periods of growth, are presented in figure 1. These values were obtained from plots containing the high soil moisture—nitrogen level treatments. There were probably times during the periods shown in figure 1 in which the daily water use was greater than indicated because of strong winds and elevated temperatures that often occurred.

Daily tensiometer readings for the three soil moisture levels have been plotted and are shown in figures 2A, 2B and 2C. Plots of the 9 and 18 inch depths for each moisture level appear to be about the usual moisture extraction patterns that are expected. The most important observation is that throughout the season there was consistently more water contained in the 30 inch zone of soil than in the 18 or 42 inch zone. Such is the case in all moisture levels, and this fact was also observed in the soil moisture sampling program during the season. That such a soil physical condition existed which would contribute to such a problem was not apparent when pre-planting volume weight samples were taken. This indicates, therefore, that a more detailed soil sampling program will often be required in field irrigation experiments before such an adverse physical condition can be found. Further, such a soil condition may have confined the corn roots to a shallow root zone which possibly prevented the efficient use of water and nutrients from lower depths in the soil profile.

A summary of the results of soil moisture and fertility levels is shown in table 2. The data indicate that the most important factor affecting yield in this particular experiment was soil moisture. The difference between fertility levels was smaller than for moisture, and it is apparent that additional work is needed on this phase. It is possible that the second 60 lb. nitrogen application to the high nitrogen level plots was delayed too long to have been completely effective. It probably should have been applied at tasseling or shortly thereafter rather than at silking. In this experiment the second application of nitrogen was applied in the form of ammonium nitrate on the soil surface between the rows prior to an irrigation which occurred at the time of silking. By the use of earlier applications and perhaps higher levels of nitrogen in sweet corn production, it may be possible to obtain a greater response to moisture and fertility differentials.

Table 1. Irrigation water applied to sweet corn irrigation—fertility treatments. (Inches).[1]

	Moisture Level		
Date	*High*	*Medium*	*Low*
March 24	2.5	2.5	2.5
April 18	2.0		
April 22		2.0	
April 26			2.0
April 29	2.0		
May 3		2.0	
May 6	2.0		
May 12			4.1
May 16	3.5	4.2	
Total	12.0	10.7	8.6

[1] Includes only irrigated water. Rainfall for the period February 28 to May 22, inclusive, was 0.35 inch. Maximum rainfall during this period for one rain was 0.27 inch. A pre-planting irrigation was applied to the entire area on February 9, following initial fertilizer application. It is not included in the above values.

The effect of soil moisture and fertility levels upon earworm damage[1] to Calumet sweet corn is presented in table 3. Again fertility does not show very large differences between treatments; however, the percentage of damage was less in the high moisture level plots in every case. This was possibly due to more rapid ear growth and better enclosure by heavier husks. Damage to corn ears in the low moisture level plots was relatively low which could have been due to its later maturity (appx. 10 to 14 days). Also, the ears were not as completely filled out as those in the high moisture level plots. From these data, the medium moisture level plots produced ears with the greatest earworm damage. Apparently, the growth rate, irrigation schedule, and fertility levels favored earworm infestations more in this treatment than the others.

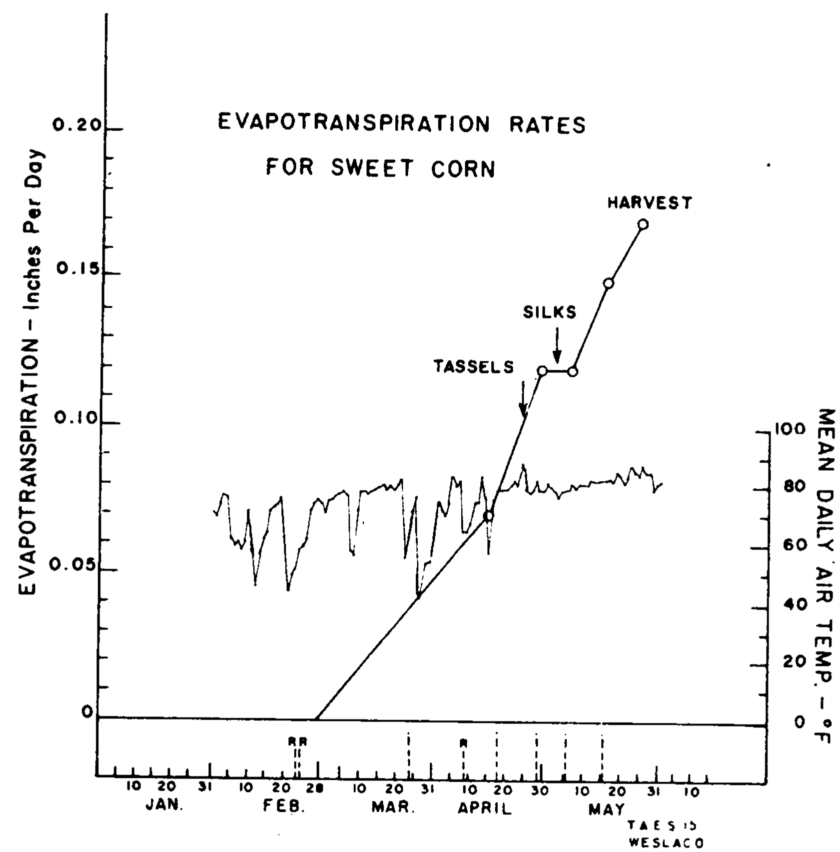
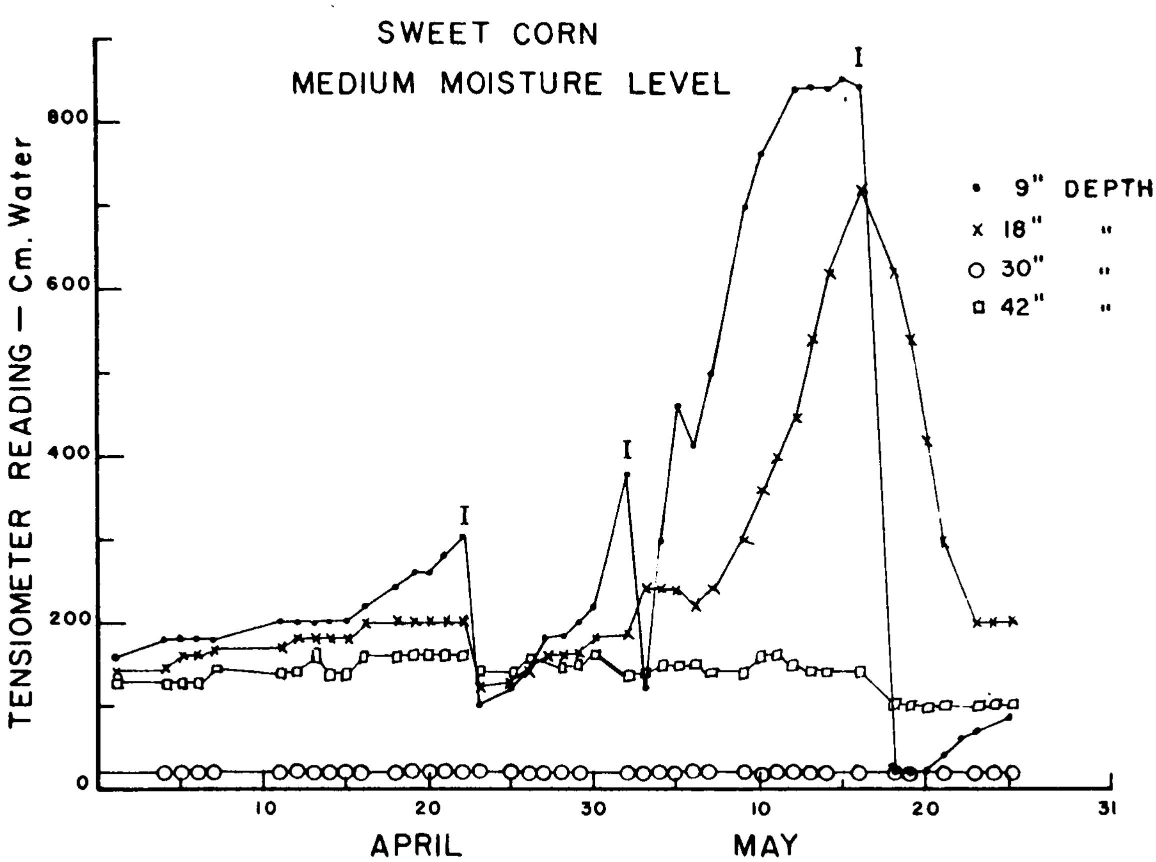


Figure 1. Daily evapotranspiration rates for Calumet sweet corn grown in the Lower Rio Grande Valley of Texas during the spring of 1955.



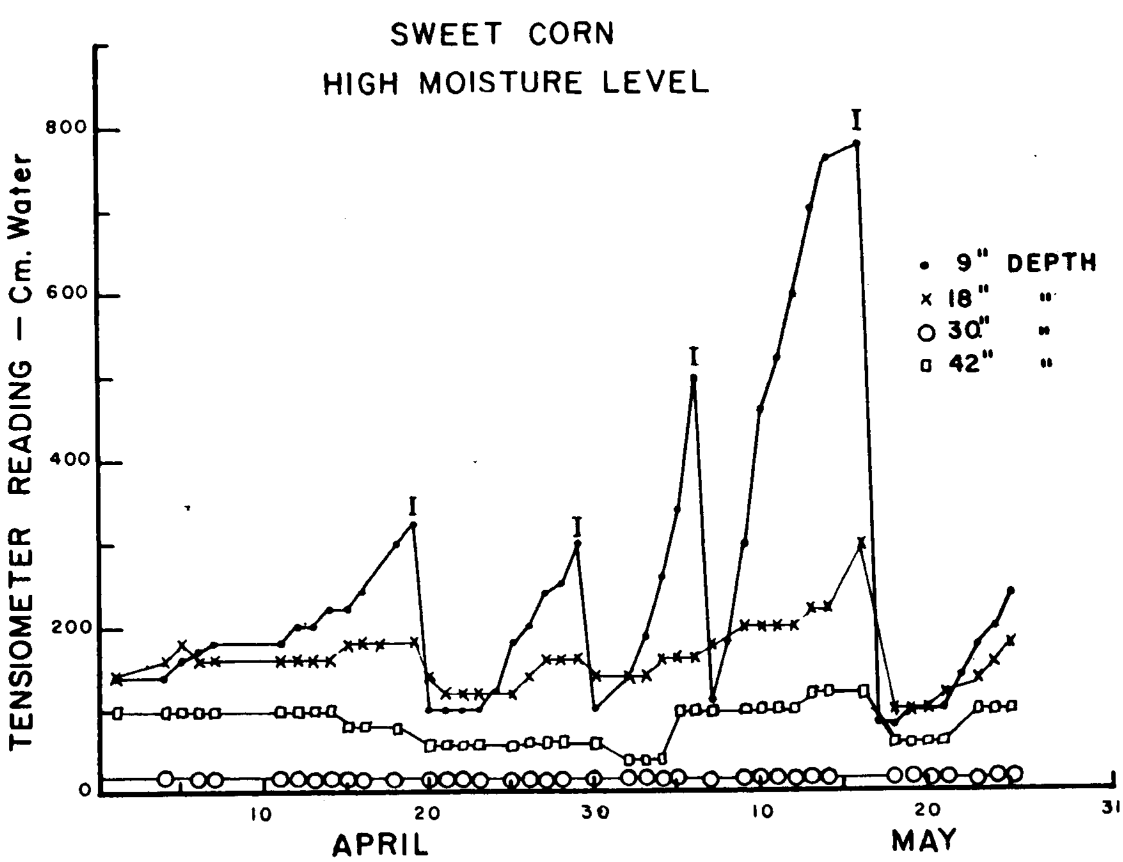
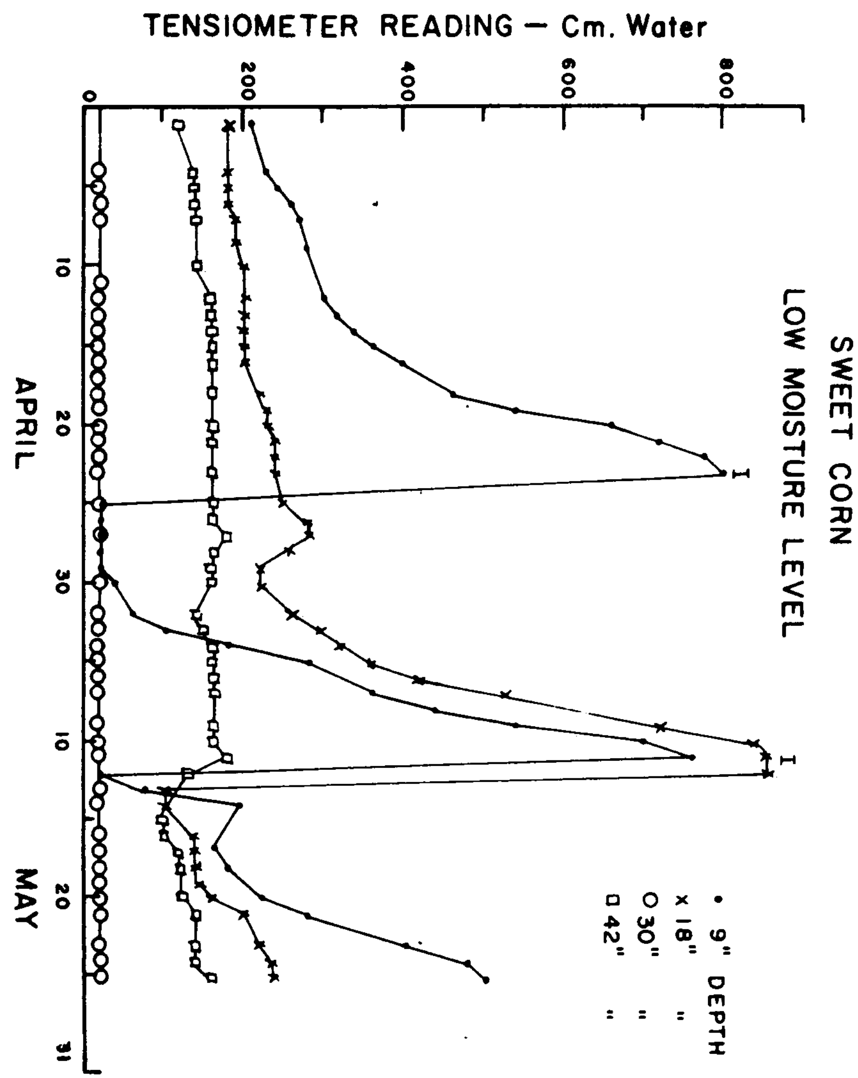


Figure 2. Plots of daily tensiometer readings for sweet corn; (A) high moisture level; (B) medium moisture level; (C) low moisture level.



The data in table 4 indicate that soil moisture-fertility differentials had little effect upon the ear length of Calumet variety of sweet corn. However, it was very apparent during harvest that ears from the high moisture level plots were more fully developed in size and the individual grains were "filled out" better and actually more firm. Although the differences are not significant, there are trends in both soil moisture and fertility which will require further investigations.

Root Distribution Studies

Following the harvest of sweet corn, soil core samples were taken with a Kelley soil sampling machine (1947) to a depth of five feet for the purpose of studying root distribution. The results are shown in table 5.

Table 2. Effect of soil moisture-fertility levels upon the total weight of sweet corn produced per plot. (Pounds—avg. of four plots).

Nitrogen	*Soil Moisture Level*			*Average*
(Lbs./Acre)	*L*	*M*	*H*	*(Pounds)*
0	50.1	51.7	58.1	53.3
60	52.0	53.9	49.9	51.9
120	50.8	53.5	58.0	54.1
Average	51.0	53.0	55.3	159.3 Total
Lbs./Acre	7015.1	7290.2	7606.6	
Sacks/Acre*	127	132	138	

* Assuming approx. weight of 5 doz. ears/sack to be 55 lbs. Not statistically significant at either 05 or 01 levels.

Table 3. Effect of soil moisture-fertility levels upon corn earworm damage (Percent).

Nitrogen	*Soil Moisture Level*			*Average*
(Lbs./Acre)	*L*	*M*	*H*	*(Percent)*
0	9.1	10.0	7.7	8.9
60	8.7	9.0	8.2	8.6
120	9.0	9.7	8.2	9.0
Average (%)*	8.9	9.6	8.0	26.5 Total

* Not statistically significant at either .05 or .01 levels.

[1] Earworm damage reported on following basis: Portions of husked ears unsuitable for eating or canning because of earworm damage were cut off. The weight of that portion of ear removed, divided by the original husked weight X 100 = percentage of earworm damage.

It can be observed from table 5 that over 96% of the root system occupied the top two feet of soil. Whether this shallow root rone was a result of the high moisture content of the 0-30 inch zone as reflected by the tensiometers is not known because the low soil moisture levels contained a similar root distribution pattern. If there had been more roots at the 30 inch depth the tensiometers would have indicated considerably more fluctuations than actually observed. Further, from the small quantities of water (2.0 to 2.5 inches) required at each irrigation during most of the season, one could observe from the soil moisture samples that very little "deep" moisture was being extracted. The tensiometer data of figures 2A, 2B, and 2C further indicate that soil moisture was more efficiently used in the low moisture plots than either of the other two moisture level treatments. A large portion of the water added to the high moisture level plots was probably lost to evaporation as compared to the low moisture levels.

Table 4. Effect of soil moisture-fertility levels upon ear length of Calumet sweet corn. (Average length in centimeters.)

Nitrogen	*Soil Moisture Level*			*Average*
(Lbs./Acre)	*L*	*M*	*H*	*(cm.)*
0	19.6	20.2	20.4	20.1
60	20.1	20.3	20.6	20.3
120	20.1	20.3	20.6	20.3
Avg.	19.1	20.3	20.5	20.2
	19.9			

Not significant at either .05 or .01 level.

Table 5. Root distribution of Calumet sweet corn grown on a Willacy loam soil. (Percentages based on number of roots counted per increment of soil depth.)[1]

Soil Depth (inches)	*Percentage of Roots*	*Total*
0.3	25.2	
3-6	23.4	
6-9	18.5	
9-12	13.0	80.1
12-18	10.5	
18-24	5.8	16.3
24-36	3.1	3.1
36-48	0.4	0.4
48-60	0.1	0.1

[1] High Moisture-nitrogen plots.

Summary

This paper reports the results of a sweet corn irrigation-fertility experiment conducted on Willacy loam soil at the Lower Rio Grande Valley Experiment Station in the spring of 1955.

Neither irrigation nor fertility differentials (nitrogen) significantly affected the yield or corn earworm damage on sweet corn ears; however, the high soil moisture level did have a higher yield and less earworm damage. The lowest yield was obtained from the low moisture level plots and the greatest percentage of corn earworm damage occurred in the medium soil moisture level plots. Nitrogen had little effect on either yield or earworm damage. Ears from the high soil moisture level plots were more fully developed in size, and the individual grains were more firm and "filled out" much better.

Root distribution studies showed that 96.4% of the total root system was contained within the top two feet of soil, with 80.1% being located in the top foot. Whether such a distribution of roots is due entirely to the physiology of the plant, soil physical condition, water management, or a combination of all three is not known; however, studies concerning these problems are in progress.

Literature Cited

Clore, W. J. and Viets, F. G. 1949. Sweet corn fertility trials on newly irrigated lands in the Yakima Valley. Proc. Amer. Soc. Hort. Sci. 54:378-384.

Gausman, H. W. and Wene, G. P. 1954. Effect of fertilizer treatments on earworm damage and on yield of sweet corn. Proc. Amer. Soc. Hort. Sci. 63:304-308.

Gausman, H. W., Wene, G. P. and Cain, N. J. 1953. Effect of fertilizer treatments on yield and on earworm damage of fall planted sweet corn. Texas Agri. Exp. Sta. Prog. Report 1581.

Kelley, O. J. et al. 1947. A soil sampling machine for obtaining two, three, and four inch diameter cores of undisturbed soil to a depth of six feet. Soil Sci. Soc. Amer. Proc. (1946) 12:85-57.

Klostermeyer, E. C. 1950. Effect of soil fertility on corn earworm damage. Jour. Econ. Ent. 43(4):427-429.

Nematodes

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For many years practically all attention with regard to control of plant pests has been devoted to the destruction of insects, diseases and other pests of the above-ground parts of plants. The basic lesson of botany that "healthy roots mean healthy plants" has more or less been ignored. Many research workers, as well as growers, have not been aware of the extent of the root damage caused by such soil-borne pests as nematodes, insects and certain diseases. In many cases the effects of these pests on the growth of the plant have been misinterpreted as being due to malnutrition, drought or some other cause. However, during the last decade much has been learned about these underground pests. It is suggested when plants are not growing properly that their roots be examined for lesions, galls (enlarged sections of roots), bare-rooted condition, stubby roots or some other effect produced by root feeding pests. The extent to which plant roots can be damaged by these pests is often amazing.

Since the discovery of economical and effective soil fumigants like ethylene dibromide and dichloropropene-dichloropropane mixture and with the development of suitable inexpensive applicators, soil-borne pests can be controlled under large scale field conditions. Soil fumigation is now being used effectively in many areas of the United States and is rapidly becoming standard farm practice for tobacco, vegetables, cotton and other crops. The application of soil fumigants is not a substitute for, but an aid to, good farming. It is, therefore, essential that we learn to recognize the presence of root-pest problems, and that they can be controlled by soil fumigation which consists of the application of volatile chemicals into crop lands for the control of soil pests.

WHY USE SOIL FUMIGANTS

The use of soil fumigants for the control of nematodes, white grubs, certain wireworms, mole crickets and many other root-injuring soil pests results in better and more uniform crop stands. The resulting healthier root systems of crops grown in treated soil enable the plants to utilize available foods and moisture, to resist entry of soil-borne disease organisms and to withstand certain adverse growing conditions more effectively. The benefits derived from soil fumigation such as increased yields, higher quality produce, little or no replanting, restoration of badly infested land all add up to a greater income per acre.

TYPES OF SOIL FUMIGANTS AND DOSAGES

There are two types of fumigants commonly used in tobacco-soil fumigation in the United States. One is a gas (Example: methylbromide with 2% chloropicrin added as a warning agent) which is used for seed bed fumigation.

The gas is released under a gasproof cover by means of a special inexpensive applicator. Methyl Bromide kills practically all soil-borne pests and weed seeds. Seed beds must be fumigated because it is imperitive that nematode-free transplants be available for field use.

The other type of fumigant is a liquid (Example: ethylene dibromide and dichloropropene-dichloropropane mixture) which is designed for large scale field use. This type of material is applied directly into the ground by especially designed pressure or gravity-flow equipment.

EQUIPMENT AND APPLICATORS

Since soil fumigation has become more widely known and used in the United States, inexpensive equipment that can be attached to existing farm machinery has become available commercially as follows: A constant-pressure soil fumigant applicator for tractor mounting consists of a pump, hoses, strainers, drum-mounting brackets, control panel, and nozzles and tubes for attachment behind the cultivator shanks. A similar applicator is also available for mounting on tractor-drawn plows. Gravity flow soil-fumigation units are also available for mounting on horse-drawn or tractor equipment.

Over-all or broadcast soil fumigation means treating the entire area of the field. Tooth or chisel applicators, tractor or trailer-mounted, with chisels set 10 to 12 inches apart and staggered in two rows are used to inject the fumigant 6 to 8 inches into the ground.

It is important that the soil be sealed immediately following application of the fumigant. Sealing is usually accomplished by means of various implements such as spike-toothed harrows, cultipackers, drags or floats and rollers. Heavier soils require harrowing before floating or rolling for best results. Good sealing is a "must" in successful soil fumigation.

In row application to be distinguished from over-all coverage, the fumigant is applied only to narrow strips where the crop row is to be located. Sealing the fumigant in the ground is accomplished by listing on the row so that the fumigant will be at least 12 inches below the top of the bed. This type of application can be made with a substantial reduction in the amount of fumigant required per acre as compared to over-all fumigation. Row application may be done by tractor-mounted or trailer equipment that delivers the fumigant under constant pressure. It may be done by constant-flow gravity equipment that is mounted on a tractor or animal-drawn plow stock.

FACTORS INFLUENCING RESULTS

The numerous factors which affect soil fumigation results must be appreciated for successful pest control.

The type, texture and condition of the soil is one of the most important considerations in soil fumigation. Results from soil fumigation have been consistently better in sands and lighter loams than in heavier loams, clays and highly organic soil types. Fumigants do not diffuse as well through the heavy or highly organic soils, apparently because of high sorptive capacity. In addition, heavy soils are more difficult to prepare for satisfactory application, as the soil must be in a good friable condition and free from clods. Heavier soils can be fumigated, but the dosage must be increased considerably over that used in light soils.

The moisture content of the soil should be near field capacity for best results when using ethylene dibromide for the control of soil-borne pests, because it performs better under high than under low soil-moisture conditions. This is especially true in lighter mineral soils as well as in the highly organic types. High soil moisture appears to increase the effectiveness of this fumigant by: Allowing fumigant to diffuse readily; reducing the porosity of the soil so that higher concentrations are obtained throughout the soil.

Soil can be fumigated with ethylene dibromide when the soil temperatures range between 40° and 85° F. at a depth of six to eight inches. When the soil temperature is too high, the fumigant diffuses out of the soil too rapidly for best control. This is especially true when the soil moisture is low. Low soil temperatures retard diffusion with the result that uniform toxic concentrations are not obtained throughout the soil mass. Low temperatures also reduce the activity of the pests and interfere with the proper aeration of the fumigant from the soil, thus longer aeration periods are required.

The condition of the soil is important in the retention and the diffusion of the fumigant. It is desirable that the soil be well worked and that all trash and crop remains be chopped up, plowed under and decomposed prior to fumigation. Coarse, bulky plant residues not only interfere with the diffusion and retention of the gas, but also with application. It is a well-known fact that nematodes in undecomposed roots and galls are protected from the fumigant and this lends for poor control.

Conclusion

Soil fumigation in many areas in the United States is becoming a regular farm procedure. Nematodes are no longer a limiting factor in production, since soil fumigation can control them economically.

Errors and Opportunities in Diagnosing Valley Soil Conditions

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What are we doing with our Valley soils? How do we think about our Valley soils? Pondering these questions, we soon find ourselves in a rather disturbing state of bewilderment. Two opposing facts seem to be the reason for this perplexity.

First, *we are approaching our soils with a high degree of uncertainty.* For instance—Farmer A has a tomato field which is not doing well. He thinks the tomatoes need nitrogen. Actually, the field suffers from excess salt. Nitrogen is beginning to accumulate. Farmer B, also, has a poor tomato field. He thinks he has not watered enough. Actually, the field is low in nitrogen. Farmer C is dissatisfied with fruit sizes in his orchard. You hear him say, "Next year, I guess I'll try subsoiling."

Soil management is still too much a matter of "I guess—I'll try." We do not see clearly enough what we ought to see.

On the other hand, *the progress in soil science has been as remarkable as in any other field of science.* The accumulated knowledge in all phases of soil behavior, reported in hundreds of research papers, represents a most valuable back log of information.

The distressing fact is the discrepancy between this progress in soil knowledge and the way the farmer understands the soil he is working with. It is like a missing link in a chain, connecting soil research and soil management.

This does not mean that the farmer needs to become a soil scientist. Science works with highly accurate figures, which can be compiled into tables and curves. This enables the scientist to recognize trends and connections. As a result, we all gain a better insight into what actually happens in nature, so that everything begins to make sense and takes on meaning.

It is a known fact that formerly fertile Valley soils have become unfertile. The reasons for this can nowadays be detected and understood. The more practical question is, how to make unfertile soils fertile and how to keep them fertile. *Scientifically,* the forces and conditions to accomplish this are largely known. *Practically,* soil management can come nearer to this goal with a change in attitude toward soil problems. *What is needed is more maturity in our "soil thinking."* This greater maturity can be characterized by the following four basic requirements:

FIRST. We must learn to consider nature first. Our opinions should be formed by what our crops and soils need. Opinions based upon shallow prejudice and pet ideas must take the backseat.

We are so much taken in by the technical progress of our days. We are able to purchase any plant nutrient in any amount we desire. We are able to pump water by the thousands of gallons in a few minutes. We are able to plow the land with a speed and thoroughness our grandfathers would never have dreamed. We are intensely interested in making use of all this progress, but—we strangely forget about the soil.

The essential thing is not just to apply fertilizer—but to apply the nutrients needed for better production. The essential thing is not just to pump water—but to furnish adequate moisture to the soil (considering aeration and healthy root growth). The essential thing is not just to plow—but to prepare a soil bed ideally suited for germination and root growth. To accomplish these essentials, we must work with nature and not against her.

SECOND. All factors essential to plant growth and soil fertility must be considered. Scientists are often blamed for being one-sided. There are specialists on nutrient availability or on soil reaction. Specialists are needed, to some extent, to exhaust the research possibilities of a certain phase. The practical farmer cannot afford to be a specialist because he is always faced with the total complexity of his soil. Unfortunately, many Valley farmers are specialists. For instance, Farmer A plans his irrigations with great care and skill. Unfortunately, he does not pay attention to his nutrient problems. He misses an opportunity for better production. Farmer B applies anything that appears on the market from high percentage fertilizers to questionable "cure-alls." Wherever something goes wrong, the applied material is supposed to do the trick. His irrigation and cultivation practices, however, are conducted with such lack of understanding, that the fertility of his soil declines year after year. The successful farmer considers *all* that is important.

THIRD. More concentration upon individual conditions is essential. Not many blocks of land are completely uniform. But even within an area of the same soil type, uniform by nature, there are differences from lot to lot. One farmer plows deeper, one waters heavier than the other. This results in differences in soil condition. These differences, not evident to the eye, count in crop production. Therefore, what is best for your neighbor is not best for you. "The golden rule is, that there is no golden rule." The farmer must find the facts of *his* land.

FOURTH. Soil conditions are forever changing. For instance, a field high in salts is planted two years into cotton. The salt content did not change materially during this period. In the first year, cloudy weather with some rain diluted the salts around the seed sufficiently, so that the cotton germinated. Or—for another example—the same calendar period may be moist and warm in one year, so that there is accelerated bacterial activity, releasing abundant plant nutrients. Next year, the same period may be dry and cool, causing no change in nutrient availability. If a farmer has good results for a certain fertilizer one year, he may not have the same results the next year. Failure to recognize soil changes keeps farmers frequently from understanding their soils. Our

approach is too "mechanical." It should be more "biological," recognizing the soil as something partly alive.

Summarizing the requirements for a more mature approach to our soils, leading to better understanding, we must consider:

1. that *nature* comes first.
2. that *all* factors important to growth must be regarded.
3. that the *individual* counts.
4. that soil conditions are *changing*.

These four considerations in our approach toward soils should, in general, be more or less useful in any area. In different regions, different soil factors are essential to fertility and production. In this light let us now consider a number of essential soil factors in our Valley.

The seemingly simplest soil factors are often the easiest overlooked as, for instance, *the texture of the soil*—whether a soil is heavy or light—the proportion of sand, silt and clay. Even experts often go into long discussions about pH before mentioning the kind of soil. Texture is extremely important because it has much to do with salt movements, with moisture and plant food holding capacity. In many cases it explains crop differences in the same field. The texture of the *subsoil* is of great importance when it comes to proper planning of irrigation or to install a drainage system. The deeper roots of citrus trees may suffocate in one orchard in a tight, water saturated clay, while in another orchard the deep roots in an open sand may suffer from lack of moisture. Not only is soil texture important for many reasons, we must also keep in mind, that it is something basic because *it is given by nature. We cannot change it.* We'd better learn to recognize it and adjust ourselves to it.

Within an area of the same kind of soil, as far as texture is concerned, we may have pronounced differences in *soil structure*. Fifteen years ago the word 'structure' was hardly mentioned in the Valley. It is not at all mentioned enough now. In thousands of Valley acres fertility is slowly declining because soil structure is gradually becoming poorer. The farmer must become "structure conscious."

How should the farmer think of structure? In a soil of good structure, the small, single soil particles are placed together into aggregates (crumbs). The better the soil, the larger and firmer these aggregates are, leaving large pore spaces between them, containing free air and water. *A high degree of porosity is the secret to healthy and rapid root growth.* This is of importance to all crops, especially where the quality of the product depends to a high degree upon rapid, uninterrupted root growth (lettuce, for instance). The effect of soil structure upon growth is much more immediate and direct than the farmer thinks.

Soil structure is something extremely delicate. If one had two flowerpots, filled with soil in perfect structure and one were accidentally dropped to the ground, the effects of the fall upon porosity would very likely be reflected in poorer growth condition. Good soil structure can be spoiled by exposing the soil to excess water for prolonged periods, by working it when too wet, or when too dry.

There are *many misconceptions regarding soil structure*. Frequently farmers believe that all that is needed to improve aeration is a good discing. Actually, discing breaks the soil up into larger and smaller clods. The dense net of active roots of our growing crops, however, is effected in an efficient manner only by improvement of structure throughout the total soil body. In remaking such overall good soil structure, we depend upon co-operation with nature. One of the most essential factors in this effort is organic matter.

What is the function of organic matter with respect to soil structure? When organic matter is added to the soil, we are stimulating and feeding the population of microorganisms. They increase many fold. The gums and slimes resulting from their life activities and their dying bodies provide the glue material for the formation of large and firm soil aggregates throughout the entire soil mass.

Certain facts regarding organic matter should be emphasized, since they are frequently not understood. Virgil soil, high in organic matter may produce good crops for many years. If organic matter is applied, there will be no response. After years of cultivation and cropping, organic matter gradually approaches a critically low point. When organic matter then is added, it will exert its favorable effect upon structure, and response in crop improvement can be expected.

Some farmers believe that with two or three covercrops the former organic matter level will be re-established. This is usually not the case. Each application will have its favorable effect, but the final over-all increase in total organic matter percentage, (after the added covercrop has decomposed) is small. It takes years to rebuild it. *Good soil management is always a long range proposition.* A grower would naturally like to know where he stands with respect to the organic matter content of his soil. He will be able to get some kind of an idea from past history of cultural practices as well as from observations after organic matter applications. More accurately, the organic matter content can be measured by determining the *organic matter percentage of the soil.* The proper evaluation of such percentage figure is not simple. First, there exists a relation between soil organic matter and the climate of a certain region. Second, soils of different texture have different capacities or requirements for organic matter. The table below shows the relationship between soil texture and organic matter percentage in the Rio Grande Valley.

ORGANIC MATTER—PER CENT

Its evaluation in relation to soil type

Rating	*Sand*	*Sandy Loam*	*Loam*	*Clay Loam*	*Clay*	*Heavy Clay*
Poor	Below 0.8	Below 0.9	Below 1.1	Below 1.4	Below 1.6	Below 1.8
Medium	0.8-1.2	0.9-1.5	1.1-1.9	1.4-2.3	1.6-2.5	1.8-2.8
High	Above 1.2	Above 1.5	Above 1.9	Above 2.3	Above 2.5	Above 2.8

To improve and preserve good soil structure, the farmer must be aware of:

A. Biological forces (microorganisms in their relation to organic matter).

B. Mechanical forces (proper irrigation-cultivation methods).

So far not mentioned are

C. Chemical forces.

Certain chemical elements are unfavorable to good structure formation, others are favorable. When, for instance, the clay particles of the soil are impregnated with sodium, the soil aggregates tend to become weak and fall apart—into a gelatin-like mass when wet and a cement-like hard mass when dry. Active calcium is able to replace the sodium in the soil. *Calcium will improve structure where structural deterioration is of chemical nature.*

A soil may contain a great deal of calcium but this native calcium is usually not soluble enough to do the job. *Gypsum* is applied because it is a cheap source of a more soluble calcium. *Acid,* added to the soil, will change insoluble forms of calcium in the soil to soluble ones. *Sulfur,* added to the soil will gradually change to sulfuric acid and then also release calcium. This—in a nutshell—explains the action of soil ammending materials upon structure. As these materials are more and more used, a new way of thinking, regarding structure improvement, is gradually entering the farmer's mind. Unfortunately, this thinking is not always too clear and correct.

Recently, scientists have developed methods to test the gypsum need in soils, telling whether a *requirement for active calcium* exists and to what extent. There are farmers in the Valley—in dry land areas—who have only one source of high sodium well water available for irrigation. Not being aware of the mentioned sodium-calcium relation, their soils could be ruined in a few years. By doing everything necessary to preserve a healthy soil structure—proper calcium applications, organic matter increase, crop rotation and sensible use of the available water—these farmers have evidently been able to establish a permanent agriculture. This is just another example of how practice benefits from the insight gained by science.

As much discussed as the *salt problem* is in the Valley, as much damage as salts have caused, it is surprising how many half measured ways are still tried to overcome injurious salt concentrations.

In case of salt excess, the essential questions are: *First.* Why do I have excess salts? Because of tight subsoil, excess irrigation, seepage from canals or low areas? It is first of all essential to *remove the cause. Second,* excess salts must be *washed below the root zone.* Sufficient amounts of water are needed to accomplish this. If the water is too slow in moving down, drain tiles are necessary. In many cases soil structure must be rebuilt to improve the permeability of the soil. This may require thorough drying out between washings, increase of organic matter and application of materials to increase active calcium. There are, however, no materials which tie down salts, thus making them unavailable. That is a wide-spread, but erroneous idea.

Important soil factors like aeration or salts are naturally different in different layers and areas of the land. The question is, where do these factors most directly affect our plants? We should become more conscious of the *area in which soils and crops meet.* That means, we should be aware of how the roots are growing and where they are in the soil at a particular time. Think, for instance, of a small fall tomato plant, growing on top of the ridge between the furrows in the hot sun. The soil, occupying the small roots dries out fast. We therefore have to water frequently. But, in doing so, won't we waterlog and affect the structure of lower layers in which roots are expected to grow later? Are we causing excess salts in the upper inches of the ridge? Simultaneausly, a number of problems enter into the picture: What is the best shape of the beds between furrows? What is the most ideal method of watering? What is the quality of the water? Which kinds of soils could be favorably used for such fall plantings and which kind of soils should not be used for this particular purpose? To know, where the roots of our crops are, and what soil conditions they encounter under certain circumstances—that means farming with understanding.

When roots are able to grow rapidly and in a healthy manner, they will absorb high amounts of *plant nutrients.* Let us consider two fields, both deficient in the same nutrient element. One field is of generally high fertility, the other one of low fertility. The highest possible yield obtainable with the application of the deficient element will be much greater in the field of high fertility than in the field of low fertility. The supply of adequate nutrients is of great importance. Nevertheless it is one phase among others in the picture of soil fertility. Much fertilizer is wasted every years to improve conditions which have nothing to do with plant nutrients at all.

Farmers underestimate the role that nature plays in the turn over of plant nutrients in their soils. They are inclined to think that their fertilizer applications are the making of their crops. The truth of the matter is, that soils are able to produce crops for centuries to come. From the storage of elements locked up in the soil, nutrient elements gradually become available. The status of plant nutrients in the soil depends upon many factors, like bacterial action, weathering, decomposition, leaching, absorbtion by crops, chemical tie up, etc. *The ideal fertilizer program aims to supplement the nutrient needed for efficient production.*

When the scientist mentions nutrients, the grower frequently throws up his defenses, imagining results of laboratory procedures of more or less theoretical value only. As a matter of fact, the scientist is most intensely interested in what the farmer actually wants to know. That is, in the amount of available nutrients, as they effect crop yields.

The search for methods to extract from the soil the portion of nutritive elements available to plant growth has been most concentrated during recent decades. Furthermore, mathematical relationships between available nutrients and crop yields have been established. They are characteristic for each kind of nutrient. All this is, of course, of great importance. In practical and highly simplified terms it means: When an available plant nutrient is low, high response in crop increase can be expected from applying this nutrient. When, on the other hand, the nutrient is present in reserve amounts, there will be no response from its application.

A survey of 1600 surface soil examples taken from all parts of the Valley during the past season showed 29% with low available phosphate —definite response to be expected—; 36% with medium phosphate—response questionable, depending upon other factors; and 35% with high reserves—no response to be expected. Such methods for determining nutrient availability are not 100% accurate as far as exact crop prediction is concerned. If they reflect the actual condition with 80%—they are of great practical significance.

The understanding gained from soil research is of great benefit, if it explains in a general way what is going on in the soil. As time goes on, the farmer will want to know more exactly, "What does all this mean on my own field?" "Where do I stand with respect to organic matter or nutrient availability?" He should have the best answer possible. Testing procedures should conducted with utmost consciousness and they should be interpreted with great understanding and unbiased devotion to truth.

The diagnosis of a soil condition becomes more reliable, if more than one piece of evidence points toward a particular conclusion. For instance, leaf symptoms may indicate nitrogen deficiency. If nitrogen is found to be low in the soil, we are that much surer of our assumption. Correlations between various soil findings are a great help confirming our diagnosis. The table below shows examples of a number of soil characteristics found in a few Valley soils and their evaluation.

	A	*B*	*C*	*D*	*E*	*F*
Soil Texture	Clay	Clay	Clay Loam	Loam	Clay Loam	Sandy Loam
Salts Tons Per Acre	2.6	1.3	7.8	.3	1.1	.8
Gypsum Requirements Pounds Per Acre	1400	300	0	100	0	200
Organic Matter Per Cent	2.7-High	1.4-Low	1.6-Med.	2.1-High	.8 - VL	1.2-Med.
Available Nitrogen Pounds Per Acre	430	290	280	310	130	230
Nitrates Pounds Per Acre	60	20	120	5	15	10
Available Phosphate Pounds Per Acre	85	30	45	130	20	80

Notes to above soil findings:

A. Represents a rather heavy soil, only a few years in cultivation. Organic matter and available nutrients are high. Poor quality water has been used. Irrigations have been excessive. There are indications of increasing salt concentrations. Gypsum requirements are high. The field needed change in irrigation practices and applications of gypsum.

B. Same type of soil as above but many more years in cultivation. Crops declined gradually over the past three years. Organic matter has reached a low level. In connection with this, less nitrogen is being released. Few fertilizer applications of low grade materials were made in the past. This is a case where increase in organic matter and moderate fertilizer applications will show good response.

C. Salts are extremely high. There is no need to increase available calcium. Gypsum or sulfur will not show results under the present condition. Nitrates are accumulating in high amounts because of no absorbtion by crops. Applications of plant nutrients are useless. This is simply a case of washing down salts.

D. An excellent open loam. Low salts, good organic matter. Note the high availability of phosphates. The total amount of available nitrogen is satisfactory. Nitrates are low. Sample was taken while vigorously growing cotton crop had reached the stage of square formation. Nitrates were absorbed by the plants as rapidly as released by bacterial action.

E. This is a soil from which about 16 inches were scraped off in leveling the land. Frequently, salts are higher in these lower layers than in the topsoil. Not in this case. Salts are low. Note, however, the extremely low organic matter together with very low availability of nitrogen and phosphate. It will take considerable time to build the organic matter to a normal level. Covercrop should be well fertilized.

F. This is a sandy soil, satisfactory in organic matter. Phosphate availability is good. Nitrogen has apparently been neglected. There will be good response to nitrogen application.

Modern soil management is not a question of just *one* material to improve crops. It is not a question of *one* test to show what the case is. It is not a question of *one* way of irrigation or plowing. It is rather a question of seeing how it all fits together in nature's workshop, how everything makes sense and has meaning. In the last analysis, what counts is the man who decides what to do with the soil, his understanding for the soil that is entrusted to his care.

Diagnosing soils is an art. One can make a mess of it or one can become a master of this art. Managing soils is a vocation—a craftsmanship. There are no shortcuts toward accomplishment, since there are no shortcuts to the ways of nature. The simple formula is to understand nature and then to do what ought to be done; to be deeply concerned and have an intimate personal contact with all things concerning growth and soils.

NOTES ON METHODS USED:

Soluble salts: Conductivity

Gysum requirements: Schoonover (USDA Handbook #60, 1954)

Organic matter: Modified Graham (Soil Science Vol. 66, #4)

Available Nitrogen: Truog, Hull and Shihata (ASA abstracts 1953)

Nitrates: 1:5, soil to water—Brucine—Peach and English (Soil Science Vol. 57 #3)

Phosphates: Sodium Bicarbonates extract (USDA circular #939)

AVOCADO SECTION

J. B. Chambers, Jr. — *Section Chairman*

Research On the Avocado and Other Subtropical Fruits In Florida

G. D. Ruehle, *Florida Sub-Tropical Experiment Station*

When horticultural research is mentioned in Florida, the listener usually thinks first of citrus, for the growth and development of Florida's great citrus industry furnishes an excellent example of the impact of research on an agricultural industry. Some figures on production are revealing. In 1930-31 Florida's production of oranges, grapefruit, and tangerines totalled 35 million boxes. By 1950-51 this had risen to 105 million boxes, and production is still increasing steadily.

Most of Florida's tremendous citrus crop is produced on soils of very low natural fertility. It has been in the field of plant nutrition that research has been most effective in increasing production as well as in improving the quality of Florida citrus. It has not always been clear sailing for Florida citrus growers. There were times when production expanded more rapidly than had the program for disposing of the crop profitably. Advertising and sales promotion expanded the market for fresh fruit somewhat. Then processing came into the picture and with the development of citrus concentrates, over production was well taken care of. These and the various by-products industries were made possible by exhaustive and expensive research. It is safe to say, however, that every dollar spent on such research has been returned many fold by the expanded economy made possible by it. Today, Florida is planting many new citrus groves every year.

Similar progress is being made with some of the minor fruits in Florida. These will never rival citrus because they will never attain the universal appeal of citrus fruits and furthermore, their production will be limited by soil and climatic factors. The progress made with some of these fruits has been considerable and very worthwhite considering the small amount of time and effort that they have received from research agencies. Most of this progress has been made since 1931, when Florida's Sub-Tropical Station was established.

Of the more than three dozen kinds of fruit plants under study at Florida's Sub-Tropical Station, six have been selected for discussion. These are avocado, mango, lychee, guava, rubus, and sapodilla.

Avocado

The first recorded importation of avocados into Florida was in 1833. By 1900 there were several groves of West Indian seedling avocados established near Miami for commercial production but in 1930-31, the total production of Florida avocados was still only about 33,000 bushels.

In the season just drawing to a close, Florida has already shipped about 500,000 bushels of avocados and the final figures probably will reach 525,000 bushels. Production has approximately doubled during the past five years.

We can expect still further increase without much increase in planting since many of the avocado trees in Florida are either of non-bearing age or have not yet reached full bearing in the 9 to 10 thousand acres planted to this crop. Florida's annual production probably will reach three-quarters of a million bushels by 1960, provided freezes and hurricanes do not interfere.

The rapid increase in production is attributed mainly to the finding of new varieties more productive than many of those grown prior to 1930, and to improvement in cultural methods resulting from research findings.

The new varieties have not only been planted widely in new groves, but trees of many of the less productive older varieties have been top-worked to the better ones. Booth-8 is now crowding Lula as the leading variety and in a few years should surpass it. Booth-7, Hickson, Booth-3 and other new varieties are gradually replacing some of the old favorites such as Collinson, Trapp, and Winslowson. Despite the improvement in varieties, no variety now grown in Florida is without serious fault, and the search for better ones continues. We are looking especially for improved summer-maturing sorts and for good hardy late varieties; for varieties with greater cold tolerance, greater disease resistance, and less tendency to sunburning and wind scarring. The recent discovery that the burrowing nematode, the cause of spreading decline of citrus, also attacks avocado roots in sand soils, has caused us to start investigation of this problem from many angles. Fortunately the avocados growing on limestone soils in the principal producing area appear to be entirely free of burrowing nematode infestation thus far. The roots of these trees are, however, infested with a meadow nematode, which is also under investigation.

The rapid increase in production, especially during the months of October through December has created problems of marketing and has caused low prices. A marketing agreement was entered into by growers and handlers about 18 months ago. The establishment of grade standards designed to eliminate immature and cull fruit from the market, and assessment on each box of fruit to finance advertising of Florida avocados quickly followed, but these measures have failed to improve prices to the grower. The real difficulty probably lies with the lack of an orderly system of distribution and sales of the packed fruit.

The establishment of grades and their enforcement by government inspectors has forced growers to pay more attention to control of diseases and insects. In most of the older groves, the trees are planted so close together that the fruit and foliage of the tree tops cannot be covered adequately for effective control with the available spray machinery. This has made it necessary for us to study methods of pruning and thinning out of trees as an aid to better pest control.

For a number of years the Sub-Tropical Station has made a study of avocado maturity to determine when the various varieties were ready for harvest. This work has now been greatly increased by the U.S.D.A. participating cooperatively on the problem. Harvesting dates for each variety are set by the Avocado Administrative Committee on the basis of recommendations of the cooperating research agencies.

Research on fertilizer requirements and other cultural aspects of avocado production are being continued with the idea of reducing costs whenever possible while maintaining production. There is little prospect of a processing industry being developed on cull avocados that will help the grower with his overproduction problems.

Mango

The first successful introduction of seedling mangos to Florida was made in the 1860's and the first grafted Indian varieties were introduced about 1889 by the U.S.D.A. Many Indian mangos have been introduced subsequently but none has proven worthwhile as a commercial variety in Florida.

The first Florida seedling to attain prominence as a commercial variety was the Haden, discovered in 1910. With the development of a method of nursery propagation, it appeared that a sizeable mango industry was now possible and hundreds of acres of Haden mangos were planted during the 1920's and 1930's. By 1940, the need for new improved varieties was readily apparent. Young Haden trees proved to be fairly good bearers, but as the trees attained age and size and especially when crowded from planting too closely in the grove, they became unreliable bearers.

Seedling selection appears to be the best method of developing new varieties. Hand-pollination has been tried in Florida, India and Hawaii. In India a few varieties developed from this practice are said to show promise, and in Florida the Edward mango is said to have originated as a cross made in the 1920's. It is usually necessary to make hundreds or even thousands of hand pollinations to obtain a few fruits and the results obtained generally are discouraging. All but a few of the better Florida varieties have originated as open pollinated seedlings.

Thirty-nine varieties originating in Florida have been named, and of these only about a dozen are being planted widely today. The Kent appears to be the best new commercial variety, being fairly reliable in its annual production and possessing good quality and appearance. Others recommended as commercial varieties are Irwin, Palmer, Keitt, and Zill. The Sensation, named very recently, is being planted because of its attractive appearance and the heavy bearing habit of young trees. It is scarcely old enough for us to be sure of its real commercial value. The Haden is still being planted to some extent, both in commercial groves and in home gardens.

There are many good home garden varieties. In addition to the above named sorts, the Florigon and Carrie are good mangos for home planting. They are fairly reliable bearers, with fruit of excellent quality both for eating as fresh fruit or for deep freezing. The Edward is of the highest quality but is a shy bearer.

The search for better varieties continues. Since 1948 hundreds of seedlings have been set out at the Sub-Tropical Station and every year after the fruits have been sampled, the undesirable ones are removed and new ones put in their place. So far, over 100 seedlings have fruited and only one is considered worthy of further testing. The Station also has over 100 varieties of mango in its collection, mostly planted since 1948. They represent varieties from India, Philippines, Indo-China, West Indies and South America, but the majority originated in Florida. Growth behavior, disease resistance, flowering and fruiting are studied on these in order to compare and evaluate them.

In addition to the varietal work, mass production of grafted or budded nursery trees has been made possible by research on methods of propagation conducted by the Sub-Tropical Station, by the University of Miami and by several commercial nurserymen. Improved methods of control of diseases and insects have been developed in recent years and we have learned considerable concerning the nutritional requirements of the mango.

The finding of improved varieties and the development of improved cultural methods has resulted in a steady increase in commercial plantings in recent years. It is estimated that there are now about 4,000 acres in commercial groves. In addition probably half as many trees are planted in home gardens.

Lychee

The lychee was introduced into Florida about 80 years ago, but was a neglected fruit until about 10 years ago. The late Col. Wm. R. Grove, a retired army officer who had served in the Orient and had learned to like the fruit while in service. was responsible for starting a lychee industry in Florida. During the past decade a grove containing about 1000 trees was established and brought into bearing near Sarasota on the west coast of Florida and smaller scattered groves are bearing from Orlando southward in the State.

The scarcity of nursery trees available at a reasonable price has held back more rapid expansion of planting. Interest in using the lychee as a replacement for citrus infested with burrowing nematode has been stimulated by the finding that this pest does not attack lychee roots. The tree grows very well in acid sandy soils and is about as hardy as the sweet orange, so it should fit in very well for this purpose.

The lychee is a very good fruit, but is practically unknown to the American public, so that sales promotion has been necessary from the start. The first light crops produced were sold mainly to Chinese living in our larger cities for $1.00 to $1.50 per pound, but the Florida

Lychee Growers Association found it impossible last year to sell the crop of 25,000 pounds at these exorbitant prices. Even 50 cents per pound was too high for repeat sales. With prospects of production increasing to many times last year's crop within a few years, a real sales program is needed. Research is needed on packaging, methods of freezing lychees and of eliminating spoilage and other hazards of the short shelf life of this fruit. Some phases of research along these lines is already under way.

From the production standpoint, the U.S.D.A., the U. of Florida, and the U. of Miami, all have research programs underway to study new varieties, methods of propagation, nutritional requirements and disease and insect control. It is thought that the lychee will become a rather important commercial crop in Florida provided a satisfactory method of merchandising the crop can be developed.

Guava

Seedling guavas have been grown and the fruit used for processing in Florida for many years, but the common guava was almost completely neglected by horticulturists until the early 1940's. At that time a number of desirable seedlings were in the collection at the Sub-Tropical Station. Many of these were first or second generation seedlings of U.S.D.A. introductions; some were named varieties from California selected by Dr. Weber; and others were selections of Florida seedlings.

Three of the seedlings were named as varieties in the early 1940's. The Ruby produces pink-fleshed large fruit with good sweet flavor and lacking most of the offensive odor usually associated with the common guava, but bearing light crops. The Supreme produces heavy crops of white fleshed, sub-acid fruit of good quality. Both these varieties produce thick shelled fruit with relatively few seeds. These were crossed and one fruit from the cross salvaged after the hurricane in 1945. Of the 130 seedlings grown from this cross, a number produced fruit superior to that of either parent and 18 selections are still under study. The Webber from California was crossed with Supreme in 1947. One tree of this cross produces white-fleshed fruit of unusual quality and a sweet flavor. It will be tested further in the field and eventually will be named and released.

These clones producing large fruit with mild, sweet flavor, and few seeds are good for eating fresh, or for preserving, but lack sufficient acidity for making jelly. Additional crosses were made between some of the selections from the early crosses with a very acid guava, and selections from these crosses have given us a range in acidity from sweet to very acid in taste and from white to deep pink in flesh color. These selections are being field tested. The fruit of all of the selections run fairly high in Vitamin C, ranging from 150 to 225 mg. of ascorbic acid to 100 grams of fruit pulp.

The Station is still introducing guavas from Brazil, India and many other countries and recently acquired one of the nearly seedless types from India. The latter will be used in further crossing in an attempt to reduce the seed content of high quality guava fruit.

Serious problems stand in the way of developing a fresh fruit industry with the guava. The larvae of a fruit moth often ruin a large portion of the crop. The biology of this insect is being studied and it is possible that a satisfactory control will eventually be developed.

Guava fruits do not all ripen at one time. In our trials we have harvested as many as 18 times to gather the fruit of one crop in the right stage of development for shipment to market. The trees are very susceptible to infestation of several species of parasitic nematodes, as well as mushroom root-rot when grown on sandy soils. For the present at least, the common guava does not appear to offer much possibility as a commercial fruit to be marketed fresh for sale on northern markets.

It will continue to be popular for inclusion in home gardens and for growing on poorer land as a processing fruit.

Rubus

Varieties of raspberry, blackberry, and dewberry grown in temperate climates do not succeed in South Florida, because their chilling requirements are not met in our subtropical climate. But there are many species of Rubus that grow and produce fruit in tropical and subtropical countries. Apparently these do not have chilling requirements comparable to those of temperate zone species.

In 1948 seeds of *Rubus albescens*, a tropical black raspberry from India, were introduced from Natal, South Africa. Growth, flowering and fruiting have been so successful, that the species is now well established as a dooryard fruit plant and a few small commercial plantings have been made, the fruit being sold principally on roadside fruit stands. *Rubus albescens* flowers and fruits from December to June and produces heavy yields, if properly grown. Thus far it has been free of serious insect pests and diseases.

The flavor of the fruit is good but is somewhat lacking in acidity and character so breeding work was initiated in 1950 in an attempt to improve it. The first crosses were made using pollen of Taylor, Sunrise, and Latham red raspberries, sent to us by air from North Carolina. Seedlings of these crosses fruited in 1951. Some of these possessed not only the vigor of *R. albescens*, but also produced red fruit. These fruits, however fell apart easily at harvest, although they had good flavor.

Seedlings of the F_1 red fruits were grown and these F_2 plants fruited in 1954. Plants with black, red, or purple fruits were obtained. Some possessed larger size than *R. albescens* fruit, but the red raspberry flavor was lost. Pollen of Sunrise and Latham red raspberries were obtained again from North Carolina and back crosses were made on F_2 purple fruited seedlings. At the same time pollen of black raspberry varieties

was obtained and crosses made on *R. albescens*. Seedlings of these crosses are now under observation.

While we have not yet succeeded in improving *R. albescens*, we are very hopeful that we will be able to accomplish this. The fact that crosses are readily obtainable without losing the vigor of the tropical black raspberry is encouraging. Our work with this plant has attracted attention of other rubus breeders and we have sent material of it to a number of institutions in the United States and other countries for use in breeding work.

Sapodilla

The sapodilla or chicle tree is another example of a desirable fruit that has been growing in Florida for many years before it received attention by horticulturists. The fruit is very sweet and is not universally liked on first acquaintance, but it is relished by many people who have had an opportunity to try the better sorts. We have found that one of the best ways to use the fruit is to freeze it whole and to serve it in a partially thawed condition as a sapodilla ice. The development of a more extensive market for the fresh fruit should prove possible.

The tree is handsome as an ornamental, grows well on limestone soils and is tolerant to salt spray. Several outstanding seedlings were known, but a satisfactory method of propagation adaptable to nursery practice was not known until 1950, when the Sub-Tropical Station developed a method of side grafting whereby the sapodilla can be propagated as readily as the mango. The method involves pre-conditioning the scion wood by girdling suitable branches six weeks to several months before the scions are to be grafted, and the bleeding of latex from the stocks several minutes before the cut for a veneer graft is made. Grafted sapodilla trees are now available in a few nurseries.

The Station has also named and released two varieties of sapodilla and maintains a variety collection. At least one other clone obtained from Nassau in the Bahamas, is now considered worthy of varietal rank. A few small groves of sapodillas have been planted during the past two or three years. A study is being made of the few diseases and insects attacking this fruit tree and we now have the knowledge to start a minor fruit industry on soils in South Florida not well adapted to production of more important fruits.

Similar studies are being made on at least two dozen other fruits. The examples discussed serve to show what can be accomplished and what a varied program may be involved with this type of work. Those who have been connected with agricultural research for many years feel that a research program, if well planned and conducted, can scarcely fail to produce worthwhile results. The improvement of new fruit crops takes a great deal of time, and results are not always obtained as quickly as growers would like.

The Search For Avocado Varieties Adapted To The Rio Grande Valley

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Introduction

Avocado trees grown in the Rio Grande Valley are subject to hazards uncommon in other subtropical regions. To encourage the study of problems limiting the culture of avocados the Texas Avocado Society was organized in 1948. This Society initiated a research program in which nurserymen, and Experiment Station and U. S. D. A. research workers have participated. Studies to date have been concerned largely with the performance of varieties as scions or rootstocks, importations of varieties from California and Florida, numerous explorations into Mexico in search of superior varieties, freeze damage, and salt tolerance. These studies are reviewed in this paper. Variety recommendations based on the results of these studies are given elsewhere.[1]

IMPORTATIONS FROM CALIFORNIA

(Mexican, Guatemalan, and Mexican – Guatemalan hybrid varieties)[2]

California avocado varieties were imported into Texas long before the formation of the Texas Avocado Society. In 1927 Everett Ballard of Weslaco imported 1500 grafted avocado trees of many named Mexican varieties. By 1955 only a single tree remained. In 1941 Karl Hoblitzelle obtained 1558 trees of 11 named varieties from Armstrong Nursery at Ontario, California, and planted them at his ranch at Mercedes (Coit, 1947). The varieties consisted of 6 Mexican (Duke, Leucadia, Jalna, Zutano, Middleton and Benedict), 3 Guatemalan (Nabal, Edranol and Hellen) and 2 Mexican – Guatemalan hybrids (Fuerte and Ryan). The trees were on Mexican rootstocks, used exclusively in California. Trees planted on flat clay land died, while those planted on sand hills with good subdrainage grew fairly well (Coit, 1947). However, the trees on sandy soil did not produce marketable crops. The Guatemalan varieties did not produce a single fruit; fruit set was poor on the Leucadia, Zutano, and Middleton; and anthracnose rot destroyed much of the fruit produced by the other varieties (Coit, 1947).

The foliage of Mexican and Mexican – Guatemalan hybrid varieties showed considerable leaf burn while that of the Guatemalan varieties showed very little. Cooper and Gorton (1950) found that leaf-burning of avocados at the Hoblitzelle Ranch was associated with a large accumulation of chlorides in the leaves and this chloride accumulation was greater in the Mexican and Mexican – Guatemalan hybrid varieties than in the Guatemalan varieties. Further studies (Cooper, 1951) revealed that grafted trees on Mexican rootstock, such as those at Hoblitzelle Ranch, accumulate more chloride and show less salt tolerance than trees of the same scion grafted on West Indian rootstock. Therefore, the poor salt tolerance of the Mexican varieties on Mexican rootstock may have contributed greatly to their poor adaptability. Windy spring weather may have reduced fruit set and high humidity during the fruit-ripening period very likely contributed to the high incidence of anthracnose rot.

[1] Chambers, J. B. 1955. Manuscript in preparation.

[2] Mexican and Guatemalan refer to races of avocados. West Indian is a third race referred to in this paper. These names are not used in this paper as adjectives describing the probable parentage of selections and varieties and do not refer to the countries where the selection was found.

IMPORTATIONS FROM FLORIDA

(Guatemalan – West Indian hybrid varieties)

In 1948 a survey of bearing avocado trees in the Rio Grande Valley revealed a small planting of Lula (Guatemalan – West Indian hybrid) avocado trees at the Kennedy place near La Feria. These trees, on West Indian rootstock, had been imported from Florida. They were 40 feet high and bore heavy crops of fine fruit with no sign of anthracnose; there was little tip burn of leaves. The vigor of growth, apparent salt tolerance, and large yields of fruit by these trees prompted the Texas Avocado Society to recommend the planting of the Lula variety on West Indian rootstock (Cintron, 1948).

Several nurserymen began commercial propagation of Lula on West Indian rootstock. The West Indian seed was obtained from Cuba or Florida; Lula budwood came from the Kennedy place and from Coral Reef Nurseries at Homestead, Florida.

Coincident with this increased interest in the Lula variety in 1948, importations of grafted avocados of several other named varieties of Guatemalan – West Indian hybrids from Florida took place during 1948. These included Booth 1, Booth 7, Booth 8, Choquette, Herman, and Hickman. These trees were scattered over the Valley in small plantings and in dooryards. Trees of all varieties grew well and the foliage showed very little leaf burn except when they were grown in poorly drained soils or soils irrigated with saline water. However, many trees of these varieties were severely injured by the freezes of 1949, 1950 and 1951.

The freezes focused attention on cold hardiness as a factor in the selection of avocado varieties adapted to the Rio Grande Valley. Trees of a given variety may bear abundant crops of high-quality fruit during warm winters, but if the variety is not cold-hardy, it will not be profitable over a period of years. The moderate freeze of December 1950 (24-26°F for 4 hours) killed the tops of many young trees of the Lula and other Guatemalan – West Indian hybrids down to the banks. However, trees of these varieties made a remarkably rapid recovery. Two years after the 1951 freeze the size of new tops of Lula trees was larger than the average new tops made by freeze-injured grapefruit trees (Chambers, 1951). By 1955 the difference was even greater.

The Mexican and Mexican hybrid varieties on West Indian rootstock were considerably more cold-hardy than the Lula variety on the same rootstock. The December 1950 freeze caused no leaf or twig injury on many of the Mexican varieties and only partial defoliation of many of the Mexican hybrids (Cooper, 1952; Maxwell, 1954). It, therefore, appears that the search for an adapted variety should be directed towards hardier Mexican and Mexican hybrid types.

AVOCADO SEEDLINGS IN THE RIO GRANDE VALLEY

While plant breeders have produced outstanding varieties of many other plants, the present-day California and Florida varieties of avocados resulted from seedling selections, usually originating as dooryard seedlings. About 60 years ago the parent Fuerte avocado was a dooryard seedling at Atlixco, Mexico. This seedling tree, now dead, gave rise to the greater part of the present avocado industry in California. An avocado industry for Texas also might arise from an avocado seedling, grown locally or elsewhere. The superior qualities of an outstanding seedling could be perpetuated by grafting onto West Indian rootstock.

The survey of bearing avocado trees in the Rio Grande Valley made in 1948 revealed several hundred seedling trees of the Mexican and West Indian races. There were also a few seedlings of the Guatemalan race, and some trees presumed to be Mexican – Guatemalan and Mexican – West Indian hybrids. Most of these trees occurred in small dooryard plantings. The owners had presumably planted seed of fruit from California, Florida, Cuba and Mexico that they had purchased on the local market.

A few of the seedlings produced fruit of good quality and these selections were propagated on West Indian rootstock for testing. The named selections of the Mexican race which have produced well in the test plots include Pancho and R-1. One apparent Mexican – West Indian hybrid, named Amidon, also produces large crops of good quality fruit.

In 1949 two seedling plantings were made in the Rio Grande Valley to provide seedlings for selections in the future (Chambers and Padgett, 1953). The seed for these plantings were obtained from the selected Valley seedlings which produced fruit of good quality. One planting of 300 seedling trees was made by J. R. Padgett, Rio Farms, Inc., Monte Alto. The other plantings, consisted of 100 trees, was made by J. B. Chambers, Jr., at Stuart Place. Both plantings were irrigated with saline well water during 1953; some trees were killed, others completely defoliated and others showed only a slight amount of leaf burn. Thus considerable variation in salt tolerance is indicated.

SEARCH FOR AVOCADOS IN MEXICO

While growing avocado seedlings in the Valley may give rise to a new variety, exploring for superior seedlings in Mexico, where many thousands of seedlings are bearing fruit, seems a more promising procedure. Propagation of avocado trees in Mexico is usually by planting

seed from selected fruit. Fruit growers there commonly believe that budded trees are short-lived (Crawford, 1948). Named varieties of avocados are almost non-existent in Mexico; the names "Aguacate," "Aguacate de China," "Corriente," "Pagua" and "Aguacate Pagua," generally used in Mexico, designate types rather than varieties. "Aguacate" and "Corriente" refer to small Mexican fruit; "Pagua" to either West Indian or Guatemalan fruit of low oil content; "Aguacate de China" to superior hybrid fruits of the Fuerte type; and "Aguacate-Pagua" to Mexican – West Indian hybrids.

The most note-worthy avocado planting in Mexico is probably the grove founded by Sr. Adolfo Rodiles at the Hacienda de San Diego, about 3 miles south of Atlixco, in the state of Puebla. It is a collection of some 3500 bearing-age avocado trees grown from seed of selected fruits purchased in the various markets at various times since 1915. Cintron, Cooper and Padgett (1948), along with Dr. Wilson Popenoe and members of the California Avocado Society, inspected the trees in this seedling planting. They brought back to Texas budwood of 18 promising selections of Mexican – Guatemalan hybrids (Popenoe and Williams, 1948). Hundreds of trees of apparently Mexican and Guatemalan races were observed in this planting, but there was no evidence of trees of the West Indian race.

At about the time of the Atlixco explorations, Chambers (1948) began a survey of avocados in the area near Victoria in the State of Tamaulipas. In this area seedlings of the Mexican and West Indian races were found in abundance, but there was little evidence of trees of the Guatemalan race. The interplanting of seedlings of the West Indian and Mexican races provided an excellent opportunity for cross-pollination. Mingled characteristics of both races were evident on many trees. In some trees the leaves had a moderate to faint anise scent characterteristic of the Mexican race but the foliage resembled that of the West Indian. Trees with these characteristics are presumed to be hybrids. Very little has been reported elsewhere on the behavior of this class of hybrid; Florida has given most attention to West Indian – Guatemalan hybrids, while California has emphasized the Mexican – Guatemalan hybrids.

During the period 1948-1955 members of the Texas Avocado Society made 20 trips into northeast Mexico to locate, study, and import to Texas superior selections of the Mexican – West Indian hybrids. Interesting seedlings have been located at Hacienda Santa Eugracia (Chambers, 1948; Martinez, 1950); the Castro place in Victoria(Chambers, 1948, 1952); the Arsola planting at Llera (Chambers, 1949, 1950, 1951; Chambers and Maxwell, 1952; Cintron, Cooper and Olson, 1952); Gomez Ferios (Ballard, 1953); Musquiz and Monterrey (Chambers et al, 1951); Tamazunchale, Aguacatlan and Tuxpan (Cooper et al, 1954); and Sabinas Hidalgo and Reyones. These Mexican and Mexican – West Indian selections are listed and described in the Yearbooks of the Texas Avocado Society. In general only Mexican selections were found around Reyones, Monterrey, Sabinas Hidalgo, and Musquiz while mostly hybrid selections were made at Santa Engracia, the Castro place and the Arsola planting at Llera.

Fruit of selections of the Mexican race had purple skins and ripened from June to September. Individual fruit weighed 4 to 8 ounces. Fruit of the hybrid selections ripened from June to September; the size ranged from 8 to 12 ounces and the skin color varied from purple to green.

All selected trees bore fruit of excellent quality. Fruit varied from oval, pyriform, obovate, elliptical and necked. Trees with either green or purple-skinned fruits were selected since either has good consumer acceptance in Texas.

A primary objective was to find selections that were cold-hardy. The January 1951 freeze extended into northeast Mexico and caused varying degrees of damage to wood of avocado trees. When the Arsola planting of 600 six-year-old bearing trees at Llera was inspected in July 1952 wood killed by the 1951 freeze was still present, the amount varying from tree to tree. A survey (Cintron, Cooper and Olson, 1952) of dead wood and anise scent in leaves of the trees in this planting revealed no freeze injury on trees of the Mexican race, severe injury on trees of the West Indian race and variations in freeze injury on trees presumed to be Mexican – West Indian hybrids. Many of the hybrids with fruit of excellent quality showed considerable cold hardiness.

Tolerance to anthracnose was also considered in the selections. The Mexican and Mexican – Guatemalan hybrids varieties from California have been susceptible to anthracnose under Texas conditions. In the Victoria and Llera areas of Mexico the relative humidity of the air during the ripening period is similar to that in the Rio Grande Valley; considerable anthracnose may be found on the fruit of some Mexican – West Indian hybrid trees while other adjacent hybrid trees are free of it. Some trees of the Mexican – West Indian hybrids, therefore, appeared to have anthracnose tolerance and selections of these types were made.

Determining the degree of tolerance to anthracnose is difficult. While the mature fruit on a tree may be free of anthracnose rot, it sometimes develops after they are held for several days in the grocery store or on the pantry shelf. Differences in weather from year to year at the same location also influences the incidence of anthracnose. Dry weather in the Valley during 1950 was not favorable for anthracnose development and most Mexican selections were free of it. During 1955, a wet year, many varieties developed anthracnose. In the area around Sabinas Hidalgo many Mexican avocados with large excellent fruit are free of anthracnose; the climate, however, is dry and anthracnose does not occur even on susceptible varieties. Selections from this area may possibly lack anthracnose tolerance. A method of testing anthracnose tolerance of fruit samples is highly desirable in the search for tolerant selections.

AVOCADO TEST PLOTS

The new and promising selections of avocados from Mexico and in

the Valley are being grown in trial plantings at six locations in the Valley. These are the J. B. Chambers and Stanley Crockett properties near Stuart Place; Hoblitzelle Ranch at Mercedes; the Texas Agricultural Experiment Station at Weslaco; Rio Farms, Inc. at Monte Alto; and Boone-LaGrande at Rio Grande City. The freezes of 1949 to 1951 and the droughts of 1951-53 slowed the development of these trees. However, many introductions from Mexico and local selections from the Valley were successfully grown and fruited in the Chambers and Experiment Station test plots. More favorable climatic conditions since 1953 have encouraged the establishment of many selections in other plots.

Nine of the 16 Atlixco (Mexican – Guatemalan) selections have been successfully established at the Experiment Station (Maxwell, 1954). These trees were planted in April 1950 and are now approximately 15 feet tall. They bloomed in 1954 and 1955 but set no fruit. In the spring of 1955 poor fruit set occurred on all varieties at this location; several more years trial may be required to determine whether a poor fruit set may limit the value of these Mexican – Guatemalan hybrid selections.

The Fuerte, a Mexican – Guatemalan hybrid, was propagated on West Indian rootstock and planted in the test plot of J. B. Chambers. The trees did not grow as well as the adjacent Mexican – West Indian hybrids and were injured more severely by the 1950 freeze. Other varieties from California should be propagated on West Indian rootstock and tested in the Valley for further evaluation of their adaptability.

Practically all of the Mexican – West Indian hybrid selections were grown in the Chambers test plots. Many selections were eliminated in 1951 and 1952 because they lacked cold hardiness and salt tolerance. Many selections bore fruit in 1954 and 1955; some were susceptible to anthracnose. The Castro and Pancho (selections of the Mexican race) appear to be cold-hardy and salt-tolerant and produce large yields of excellent fruit. The Pancho is free of anthracnose while the Castro is susceptible to it. The Santa Engracia (Mexican – West Indian hybrid) produces large crops of good-quality fruit, but it has an alternate-bearing habit. The Diaz selection (Mexican – West Indian) produces large yields of excellent fruit, but a tendency to skin cracking may limit its successful commercial use. The Amidon (Mexican – West Indian) produces large yields of good-quality fruit with a green skin.

Most of the more promising Mexican – West Indian selections were made from the Arsola planting at Llera. These have been established in all the test plots; a few set fruit in 1955 and many more should do so in 1956. An evaluation of the usefulness of these selections awaits several more years of trial in the test plots.

LITERATURE CITED

Ballard, E. B. 1953. Mexican explorations during 1953. Yearbook Tex. Avo. Soc. for 1953:11-13.

Chambers, J. B. 1948. Observations of avocados in the Victoria, Mexico area. Yearbook Tex. Avo. Soc. for 1948:65-66.

____________, 1949. Report of the subcommittee on Mexican intraductions. Yearbook Tex. Avo. Soc. for 1948:31-33.

____________, 1950. Potentialities of the state of Tamaulipas, Mexico for new avocado varieties. Yearbook Tex. Avo. Soc. for 1950:22-24.

____________, 1951. Annual report of the president. Yearbook Tex. Avo. Soc. for 1951:6-7.

____________, 1952. The joint California-Texas expedition to Victoria, Tamps., Mexico. Yearbook Tex. Avo. Soc. for 1952:10-15.

____________, N. P. Maxwell, G. Adriance, and F. Whitman. 1951. Report of the committee on Mexican introductions. Yearbook Tex. Avo. Soc. for 1951:17-19.

____________, and N. P. Maxwell. 1952. Avocado seedling selections in the Arsola grove at Llera, Tamps., Mexico—II. Selections made 1949-1952. Yearbook Tex. Avo. Soc. for 1952:23.

____________ and J. R. Padgett. 1953. Avocado seedling plantings. Yearbook Tex. Avo. Soc. for 1953:18-19.

Cintron, R. H. 1948. Report of the Committee on varieties. Yearbook Tex. Avo. Soc. for 1948:20-23.

____________, W. C. Cooper and J. R. Padgett. 1948. The 1948 expedition to Atlixco, Mexico. Yearbook Tex. Avo. Soc. for 1948:67-69.

____________, ____________ and E. O. Olson. 1952. Avocado seedling selections in the Arsola grove at Llera, Tamps., Mexico-I. Freeze injury to trees of Mexican and West Indian races and their hybrids. Yearbook Tex. Avo. Soc. for 1952:19-22.

Coit, J. Eliot. 1947. Experiments with Avocados in Lower Rio Grande Valley of Texas. Yearbook Calif. Avo. Soc. for 1947:57-61.

Cooper, W. C. 1951. Salt tolerance of avocados on various rootstocks. Yearbook Tex. Avo. Soc. for 1951:24-28.

____________, 1952. Annual report of the president. Yearbook Tex. Avo. Soc. for 1952:5-6.

____________, and B. S. Gorton. 1950. Relation of leaf composition to leaf burn of avocados and other subtropical fruits. Yearbook Tex. Avo. Soc. for 1950:32-38.

____________, J. B. Chambers, E. B. Ballard, and J. Barrera. 1954. Report of the committee on Mexican explorations. Yearbook Tex. Avo. Soc. for 1954:14-19.

Crawford, Carl. 1948. Avocado variety situation in Mexico. Yearbook Tex. Avo. Soc. for 1948:34.

Martinez, Jose Gomez. 1950. Hacienda Santa Engracia. Yearbook Tex. Avo. Soc. for 1950:19-21.

Maxwell, N. P. 1954. Freeze damage report on the Experiment Station avocado test plot. Yearbook Tex. Avo. Soc. for 1954:33-34.

Popenoe, Wilson and L. O. Williams. 1948. Mexican explorations of 1948. Yearbook Calif. Avo. Soc. for 1948:54-58.

Expeditions To Northern Mexico During 1955 In Search of Avocado Varieties

Norman Maxwell and William C. Cooper, *Avocado Committee, Rio Grande Valley Horticultural Society*

This paper is one of a series of reports describing various expeditions into Mexico by members of the Texas Avocado Society, now the Avocado Section of the Rio Grande Valley Horticultural Society, in search of superior selections of avocados for Texas. The previous reports have been published in the Yearbook of the Texas Avocado Society for 1948 to 1954. A current review of the avocado variety problem in the Rio Grande Valley and the reasons for exploring Mexico for new varieties are given in another paper in this Journal (Cooper and Maxwell, 1956).

State of Coahuila, Mexico

During late June, Guy Adriance, Joseph Woolcott and Norman Maxwell surveyed the fruit growing areas in the State of Coahuila. They were accompanied by Ing. Reuben Estrado and Ing. Antonio Mercado from the Antonio Narro School of Agriculture in Saltillo, Mexico.

Seedling Mexican avocado trees were found in Torreon, Parras, Quatro Cienegas, Musquiz, Allende and Nava. The heaviest concentrations seemed to be in the northern part of the State at Musquiz, Allende and Nava. Residents of Quatro Cienegas, located in the mountains west of Monclova, claimed that the fruit of numerous backyard avocado trees matured in September and October. No avocado fruits were mature in late June.

Quatro Cienegas, Musquiz, Allende and Nava are located west and north of the Rio Grande Valley so the temperatures during the 1951 freeze were as low or lower than in the Lower Rio Grande Valley. Many old trees had survived the 1951 freeze with small wood damage; the progeny of these trees might be cold-tolerant under Texas conditions. The humidity in this section of Mexico is very low, therefore, it would be difficult to select trees for anthracnose resistance. Probably, selections for cold tolerance and commercial fruit possibilities could be made in Mexico and anthracnose resistance could be determined in the Valley test plots.

Cerralvo, Nuevo Leon, Mexico

On July 15, 1955, Norman Maxwell and Edwin LaGrange visited the town of Cerralvo, which is located about thirty miles from Roma, Texas. Many seedling avocado trees of the Mexican race were growing in back yards and in the plaza. Effects of the 1951 freeze were still very apparent. Some trees had been killed to the ground while others had only small wood frozen.

Selections were made of two trees that appeared to be over thirty years of age and that had very little freeze damage. Both selections were reported to mature their fruit in June and early July. One tree had green fruit and the other black fruit; fruit of these selections showed no anthracnose although anthracnose was present on fruit of nearby trees.

Budwood was cut from these two trees in November and brought into the Valley. After fumigation by the Plant Quarantine Station at Brownsville, Texas, the budwood was grafted on West Indian rootstocks. These selections have been named "San Juaneno" and "Dr. Guerro" and the trees will be grown in the test plot at the Valley Experiment Station.

Sabinas-Hidalgo, Nuevo Leon, Mexico

The town of Sabinas-Hidalgo is about ninety miles south of Laredo, Texas, on the Pan American highway. Eliot Coit of Vista, California, has suggested that the Sabinas-Hidalgo district should be explored for promising avocado strains.

On August 1, 1955, William Cooper, Norman Maxwell and Edward Olson explored the Sabinas-Hidalgo region for avocado strains that might be adapted to the Valley.

After the group arrived in Sabinas-Hidalgo, they met Mr. Carlos Garza, a local avocado grower. Mr. Garza had previously surveyed the area for avocados and had grafted trees of many superior selections on his place. Mr. Garza said that there were about ten thousand avocado trees in the town and he spent a day showing the outstanding trees of the area to the group. Eleven selections were made of the most promising strains. The fruit of some are black skinned and others are green; the fruit matures from June through October. Many old trees survived the 1951 freeze with damage only to twigs and often were thirty feet or more in height.

The climate of this area is dry and there was no evidence of anthracnose; anthracnose susceptibility of the various selections will have to be determined in Valley test plots. The fruit size of the selections varied from three ounces to about ten ounces; most were in the five to seven ounce class.

Norman Maxwell and Everett Ballard returned to Sabinas-Hidalgo in late November to make budwood collections of the 11 selections. These selections are now successfully propagated on West Indian rootstock at the Experiment Station in Weslaco and will be planted in the test plot in 1956.

Rayones, Nuevo Leon, Mexico

The group left Sabinas-Hidalgo August 2 and drove to Montemorelos via Monterrey. They were met by representatives of the Patronato including Ing. Teodoro Rodriguez and Ing. Rafael Quintanilla and plans were completed by the Patronato, through the courtesy of Sr. Ing. Plutarco Elias Calles, for a trip into the mountains to the town of Rayones, Nuevo Leon. Many fine avocado trees of the Mexican race had been reported as growing near Rayones.

On August 3 the group left Montemorelos for Rayones in several Land Rover cars. The road to Rayones was along the bed of the Rio Pelon and the expedition forded this mountain stream 65 times en route into the mountains.

The expedition arrived at Rayones about noon. The group was met by a delegation, including the Alcalde, Don Galimo Salinas, who guided the mission to some of the avocado plantings. There was very little fruit set on the trees because of a late spring freeze that had destroyed most of the bloom. Several promising selections of Mexican strains were found.

Most of the fruit showed severe damage from anthracnose, and this was associated with the high humidity in the area. Also, several trees were found with a large amount of fruit damaged by an unidentified seed weevil. The damage consisted of a hole in the flesh extending into the seed where one or more adult weevils were found feeding within the seed. Later the group inspected avocado seedlings on the farm of Sr. M. M. De La Fuente.

On August 4 Ing. Teodoro Rodriguez took the Valley group to the town of Hualahuises which is on the Pan American highway south of Montemorelos. Mexican and Mexican—West Indian hybrid avocados were found in the town. It seemed that Hualahuises should be re-visited and several days allotted to searching the area for promising avocados.

Literature Cited

Cooper, William C. and N. P. Maxwell. 1956. The search for avocado varieties adapted to the Rio Grande Valley. Jour. Rio Grande Valley Hort. Soc. 10:

Avocado Varieties For Commercial Trial In The Rio Grande Valley

J. B. Chambers, Jr., *Vice President for Avocados, Rio Grande Valley Horticultural Society*

In the first yearbook of the Texas Avocado Society, published back in 1948, we quoted Wilson Popenoe as follows: "I believe that it can be safely said that the most important problem which the avocado growers in California are facing at the present time is the question of varieties." That was said in 1915 and published in the first yearbook of the California Avocado Society. California growers are, after forty years, still facing that important problem. It is needless to say that variety is also the most important unsolved problem in avocados for Texas.

The variety problem in the Rio Grande Valley is a complicated one; much more so than under Florida or California conditions. We are confronted with a soil salinity problem, an anthracnose problem and a cold hardiness problem. The cold hardy Mexican and Mexican hybrid varieties that are grown commercially in California, lack salt and anthracnose tolerance. Consequently, they are not too well adapted to our saline soils and our moist summer weather. The salt and anthracnose tolerant varieties grown in Florida, although quite adapted to our soils and summer climate, are tender to cold.

The poor adaptability to Valley conditions of most of the named avocado varieties grown in California or Florida has focused the attention of the Avocado Variety Committee on new and better varieties for Texas originating from seedlings found in the Valley and Mexico (Cooper and Maxwell, 1956). Once an outstanding seedling was found, the superior qualities of the specimen was perpetuated by grafting onto West Indian rootstock. These selections were planted in test plots in the Valley, along with trees of many named commercial varieties from California and Florida. The Variety Committee has evaluated both the old and new varieties from the standpoint of salt and cold tolerance of the tree, production of fruit and anthracnose tolerance of the fruit. Those varieties which appear the most promising for limited commercial trial in Texas are the Castro, Pancho and Lula. Varieties that are suitable for dooryard use include Dias, Santa Eugracia, Paz and Amidon.

The *Castro* was selected from the Castro planting of avocado seedlings at Victoria, Tamps., Mexico. The tree is upright growing, vigorous, consistent bearer of fruit, cold hardy and has moderate salt tolerance when grown on West Indian rootstock. The foliage has a strong anise odor which indicates the Mexican race of avocado. The tree blooms in late January and matures its fruit in June and early July. The fruit is pear shaped, purple colored, thin skinned and weighs 5 to 8 ounces. It has a medium sized seed and a rich nutty flavored flesh with no fiber. It has the disadvantage of developing anthracnose on the fruit during wet years but it is the best early summer variety presently available.

The *Pancho* originated as a seedling at Stuart Place, Texas. The tree, when grown on West Indian rootstock, is a heavy and consistent bearer of fruit and has good cold hardiness and moderate salt tolerance. The foliage is dense, leathery and has a strong anise odor which indicates the Mexican race of avocado. The blooming period begins in January and the fruit matures in July and early August. The fruit is oval to slightly pear shaped, 3-6 ounces in weight, light green colored and thin skinned. The seed is medium sized, and the flesh is greenish-white, with a rich nutty flavor. The fruit develops a small amount of anthracnose during wet years or years when the skin of the fruit has been injured by blowing sand. The Pancho is the best mid-summer variety presently available.

The *Lula* is a named variety from Florida. It is considered to be a Guatemalan-West Indian hybrid (Cintron, 1952). The variety was introduced into Texas about 1935. A planting of Lulas, located at the Kennedy place in La Feria, produced excellent crops of fine quality fruit consistently until the freeze of 1949 when the trees were severely injured. The trees are thrifty, vigorous growing and have good salt tolerance. The Lula variety blooms in March and the fruit ripens in September but will hang on the trees through January. The fruit weighs from 8 to 24 ounces and continues to increase in size if left on the tree during the fall and winter. It is a green fruit with a medium thick, slightly pebbled, rough skin and is tolerant to anthracnose under all weather conditions. The seed is medium large and the flesh has a creamy green color and good flavor. The fruit is well accepted by the trade and holds up well under shipment. The Lula tree, however, is more tender to cold than the Castro or Pancho varieties. Temperatures of 27° F for several hours will cause some injury. This variety is well adapted to our soil and summer climate and produces such excellent crops of fruit that it is worthy of commercial trial if the grower will provide wind breaks and use orchard heaters on cold nights.

The *Diaz* was found as a seedling at the Rogelio Diaz place in Victoria, Tamps., Mexico. It is probably a Mexican-West Indian hybrid. It is cold hardy and consistently produces a good crop of 6 to 10 ounce fruit which ripens in August. The fruit is purple, oval shaped and has a thin skin. The flesh is free of fiber and has a rich nutty flavor. The seed coat has a tendency to stick to the flesh which is undesirable in a commercial fruit. Also, on ripening, a fair percentage of the fruit develop splits in the skin that usually head over leaving scars on the fruit. The variety is of value mainly because of its extra heavy fruit production, excellent flavor and anthracnose resistance. It should be suitable for dooryard plantings in all parts of the Valley.

Other varieties that are suitable for dooryard plantings include the *Amidon, Paz* and *Santa Eugracia*. There are many other promising selections from Mexico now growing in the test plots but they have not been

under test long enough to make a proper evaluation of the variety. The search for even better varieties will continue for many years.

Literature Cited

Cintron, R. H. 1952. Raising a question as to the probable parentage of the Lula avocado. Yearbook Tex. Avo. Soc. for 1952:37-38.

Cooper, W. C. and N. P. Maxwell. 1956. The search for adaptable avocado varieties for the Rio Grande Valley. Proc. Rio Grande Valley Hort. Soc. for 1956.

Cotton Leafworm Moth Injury To Guavas

George P. Wene
Texas Agricultural Experiment Station

On August 16, 1955, the cotton leafworm moth, *Alabama argillace* (Hbn.), was observed feeding on guava fruits near McAllen, Texas. The adult moth would select a soft guava fruit, pierce the rind and suck the juices out of the fruit. In a short time these pierced spots would decay. As many as five moths were seen on a single fruit.

It was observed that the cotton leafworm moth would only attack fruit that had started to soften. Fruit that had started to turn yellow but was still hard, was not attacked. Therefore, this injury could be prevented by picking the guavas at the time "yellowing" commences.

This injury on guavas has been noticed for the past 3 or 4 years. It always occurs during August, when cotton stalks are being destroyed, indicating that the guava fruit is an alternate source of food.

The cotton leafworm moth has only been observed injuring the fruits of the common guava, *Psidium guajava.*

GRAPE SECTION

Elmer Linnard—*Section Chairman*

Problems and Possibilities of Table Grape Production For South Texas

H. B. Richardson, *University of California*

Trying to predict the future of any industry, particularly in an area that has had little or no experience with grapes, is very difficult. I am not unmindful of the problems involved, and it is often said that "Fools rush in where angels fear to tread." Nevertheless, I shall try and present to you some of California's problems and if I may be so bold, I'll try and interpret these in the light of possible production here in the South Texas area.

Economics

First, I'd like to comment on the economic picture. Many of you in this audience may be familiar with the situation in the grape industry in California. To be precise, there are too many grapes. The 1955 crop is 3,000,000 tons, ½ million tons above the 10 year average, with nearly 700,000 tons in the fresh channel in 1955. In the first place, California produces about 92 per cent of the grapes of the United States; most of the other production, other than California, is centered in a few other states, notably Washington, New York, Michigan, and Ohio. This production of other states is of little importance to us as table grape producers. The current California industry is approximately 456,000 acres in extent. 11,000 are classed as non-bearing. The area of production extends from the Mexican border to Mendocina county, over a distance of some 700 miles.

Table Grape Areas of Production

These areas extend from the Imperial desert in the south to Lodi, in San Joaquin county, in the north. This latter is the center of the Tokay industry and our northernmost table grape production district. Within California there are several distinct areas of production. There is the Coachella, Imperial and Borrego Valley area. This is strictly a desert industry, where early table grapes are produced under extreme conditions; the crops (tonnage-wise) are small, but the climate is such that here is produced the very earliest table fruit. The crops mature along late May and the first part of June. Shipping is over by mid-July. This area represents some 1500 cars in total production, from some 10,000 acres. It's a new, fast developing area. Much of this early development has been brought about by an increase in water supplies and by the actual and continued anticipated high returns for the early grape crops produced. This is the region of greatest non-bearing acreage.

The next area following the desert sections is near Bakersfield. There, shipping starts just before Coachella finishes. Usually, they are going by July 20th. The production pattern swings steadily northward, with the next large center being the Delano-Tulare areas, where we produce large amounts of table fruit. Here, both Thompson Seedless and Emperors and Ribiers are the main crop. The Thompson Seedless are produced for storage purposes and for volume movement. This movement occurs during August and September. The Emperors that are produced in the Exeter area are our main storage grape. These are harvested in October and November and are shipped to the markets out of cold storage plants up as late as the first part of May. Two years ago was the first year in which we had storage fruit and fresh grapes on the market at the same time. Early fall rains limit our table production in many sections. There are still many undeveloped areas that could be planted to grapes, economic conditions permitting.

Crop Utilization

One point in connection with production that should be well understood is crop utilization patterns. There are one-way grapes, that is, the grapes that can only be used for wine; we have two-way grapes, grapes that can be used for table fruit and for wine purposes; and we have three-way grapes, that is, grapes that can be used either for table fruit, for wine purposes, or for raisins. Texas production could only be directed into fresh channels on account of weather for drying and lack of winery outlets. The government, during the last several years, has undertaken a surplus removal program of raisins, which has served to somewhat stabilize the prices for wine grapes and also the volume movement through fresh shipping channels. Withdrawal of government support would considerably change the economic picture. This is the best guess from competent observers.

Climate

Climate is most important to us in the production of table grapes, and much of the production is centered in those areas where the varieties so planted reach their optimum of perfection, or for some other reason of earliness or volume. Varieties adapted to these areas have come about through long selection by the trial and error method. Many of the variety limitations are now pretty well understood.

California grapes mature and ripen during a period of little or no rainfall. The humidity is also very low at this time of year. Low humidity and lack of rainfall means we are free from a large group of diseases of vine and bunch, such as experienced in the humid production areas of the Northeast.

The following table gives the rainfall at four centers in South Texas and four in California for comparison.

Data from U. S. Weather Summaries

TEXAS RAINFALL AVERAGES*

	Year's Total Rainfall	*May*	*June*	*Two Month Total*
Laredo	20.47	3.46	1.77	5.23
Rio Grande	17.10	2.60	1.84	4.44
Mission	21.28	2.51	2.22	4.73
Harlingen	27.49	3.24	2.74	5.98

CALIFORNIA RAINFALL AVERAGES*

	Year's Total Rainfall	*May*	*June*	*Two Month Total*
Lodi	17.10	.65	.20	.85
Fresno	9.43	.39	.08	.47
Bakersfield	6.12	.42	.07	.49
Indio	3.25	.05	.02	.07

* All data from U. S. Weather Bureau summaries.

There was no month in the records examined that did not give at least an inch. August was the lightest rainfall month. May and June would be the critical months when the early fruit was ripening.

The California rainfall is low during the main ripening season. Humidity is also low. What rainfall does occur comes in flash storms, the effects of which are not lasting, at least weather-wise.

The temperature picture between California and Texas is more nearly alike, at least during the blooming and ripening season.

The tables below bring out the variations between the two areas. California has a lower average minimum during the winter months than Texas. This lower temperature is a help in making and keeping the vines dormant when freezing weather is sometimes encountered.

MEAN AVERAGE TEXAS TEMPERATURES*

	Dec.	*Jan.*	*April*	*May*	*June*	*July*
Laredo	56.6	55.7	75.2	82.3	85.4	87.3
Rio Grande	59.6	58.1	76.1	81.2	82.8	86.2
Mission	60.6	59.9	75.9	80.4	84.1	85.3
Harlingen	61.4	60.7	74.4	79.2	82.7	84.1

MEAN AVERAGE CALIFORNIA TEMPERATURES*

	Dec.	*Jan.*	*April*	*May*	*June*	*July*
Lodi	46.6	46.2	57.9	63.2	69.2	73.3
Fresno	46.4	46.1	60.6	67.0	75.3	81.9
Bakersfield	47.6	47.2	62.6	69.8	77.6	83.9
Indio	55.4	63.7	72.1	79.0	87.8	93.3

* From U. S. Weather Bureau summaries.

Soils

Soils we consider of great importance. The most desirable soil for grape production is a medium loam of considerable depth. Since all of the table acreages is irrigated, a large reservoir for water accumulation during the winter months, and to hold moisture from summer irrigations is necessary. Vineyards are planted in California on wide ranges of soils, from the heavy clays to the light sands. Most of our desert grapes are planted on the sandy type soils. Vineyards on these sands are giving difficulty, particularly with nematodes, and in the retention of moisture. Here frequently irrigations are very necessary and oftentime difficult or impractical to accomplish. The finale has not been written in the desert, but if I were selecting a soil for early vines I would want a medium soil, with some water-holding capacity and good drainage. Salines are a problem in some areas on both heavy and light soils.

In striking contrast are the soils which produce the Emperor grape in Tulare county. This crop is located on our red San Joaquin series of hard-pan soils. These soils are shallow—three or four feet—to an impervious hard pan layer. Emperor grapes respond well when planted on this particular soil type. Climate and soil of foothill Tulare county brings out the red color of the Emperor grape to perfection. Slope and row location are not important for most of our table production. They are more important in raisin production as the rows should run east and west if the maximum amount of sunshine is going to fall on drying raisins when these are laid in the vine crop rows.

Irrigation

In the matter of irrigation, plenty of good water is essential. We need good drainage on top of this. There are areas where severe burn of vine leaves occurs during the late parts of the summer. This burn usually occurs when insufficient amounts of water are available to the vines, or excess salines are present.

In all of the desert areas where there are limited amounts of rainfall, leaching should be undertaken. To accomplish this the vineyard should be laid out in such a way that row flooding can be done. We know that in many of our low rainfall areas leaching is not carried on to the extent that it should be. More attention will need to be paid to salt elimination as our vineyards reach greater maturity. The amount of wa-

ter that is necessary to produce a crop of grapes varies in the desert, usually 5 to 6 acre feet is applied annually. In the coastal areas from 15 to 20 inches is sufficient. Some supplemental irrigation through sprinklers is growing in importance. Sprinklers are adapted to old established vineyards in hilly country, where one or two supplemental applications of water will double the yields. Few table grape vineyards are irrigated by sprinklers.

Varieties

Table grape production in the state of California is limited to a small number of varieties. Varieties for early table production are Thompson Seedless, Cardinal, Beauty Seedless, Perlette and Delight. The Thompson Seedless is the old standard that has been grown for many years, and up to recently has been our leading early grape variety. The Thompson grape is being largely replaced by two new ones, the Perlette and Delight. These are University developments. Of the two, the Perlette seems to have moved the fartherest—at least in the market. The Eastern Market trade know the Perlette variety and have accepted it as one of the early varieties. The Perlette is a grape very similar to Thompson Seedless. The bunches are high in color and the flesh firm. The table production per vine is about equal to Thompson Seedless. The vine needs to be trained on the cordon system. Grower experience today indicates that Perlette takes a large amount of hand thinning, which is costly. So far to date the Perlette has taken over the early market from Thompson Seedless. The Perlette is 10 days earlier than Thompson in the Coachella Valley.

The Delight is a grape similar to Perlette, but has not caught on in the desert quite to the extent that the Perlette variety has. Beauty Seedless is a black grape developed by the University of California, and is just now showing up in commercial quantities in the eastern markets. The prices anticipated by growers who planted this new Black Seedless have not been as satisfactory as they had hoped. The variety has several problems very similar to those of Perlette. By this I mean that it takes a large amount of thinning to produce a good table bunch. There is this much to be said of these new varieties: *For early table grape production many are being planted.* It is my belief that the Perlette has established itself in the marketplace and that we will hear more from this variety as time goes along. The Perlette and Delight have some sunburn resistance, which may be a factor of importance for you in Texas.

One other early variety that might have a possibility is the Cardinal. This is a USDA development and has reached sizeable proportions in production in California. At the present time, somewhere in the neighborhood of 300 cars of Cardinal are produced and shipped annually. The variety is a colored grape; good flavor; has seeds; and has some weaknesses in the market. It has notably a short life and is not as widely accepted as it should be. Consumers seem to prefer the little white, seedless grapes over all others.

Our other varieties, which are mid-season, (the Thompson Seedless, Muscat, Tokay, Ribier, etc.) I don't believe have much possibilities as far as Texas production is concerned. Ribier and most of our colored varieties have difficulty producing acceptable market color; (outside of Cardinal), so these should hardly be considered in any program being undertaken. Certainly the late varieties, like Emperor, Almeria, and Calmeria are out, as far as anything in the areas of Texas are concerned. There are new developments coming along; we have under trial a large number of seedling varieties—the tetraploids, of the Concord type; some of the Lady Fingers with Muscat flavors; and others that will be released to the grape industry as time goes along. It takes many years to establish a variety. I suspect that anything that was planted here in Texas would have to undergo this same period of trial and error.

Rootstocks

I understand that Texas has a good deal of trouble with root diseases. We have the same difficulties in a minor way, with Armallaria root rot, crown rot, etc. Our major root difficulties, however, are with nematodes and phylloxera. We also have some virus diseases which are making inroads in our vineyards at the present time. The rootstocks are under constant study now and better ones are needed. At the present time, in most of our coastal and interior districts, where we have a phylloxera problem the standard is the St. George root. Some of the newer ones that are showing promise for the particular areas are the 99-R and AXR No. 1.

In the Coachella desert and San Joaquin areas, where nematodes are a problem, the 1613 stock is used. Performance has not been altogether good; acceptability by industry is slow; much needs to be done. There are two other stocks that have been under study in the Valley areas. They are known as Dogridge and Salt Creek. These are very vigorous growers and they have some resistance to nematodes and may find a place in our light sandy soils, particularly in the early table grape sections. The two rootstocks about which we know the most are the St. George and the 1613. Our recommendation to industry has been that if you don't need rootstocks, stay away from them. If they are a known necessity then select carefully your rootstock and scion materials for trueness to type and freedom from known virus diseases. Establishing a vineyard on rootstocks is a rather costly procedure and should only be done when necessary.

Vine Training

Pruning and Spacing

In all new vineyard plantings it is very important to do an adequate early job of vine training. This training program is not complicated, but a little timely vine management means earlier production. The Thompson Seedless variety is cane-pruned, with trunk and head being formed quickly and the canes taken up on the trellises as fast as possible. The Perlette variety is trained in cordon fashion, which is nothing more

than an elongated trunk. This trunk is strung along the wires and spur-pruned. Trellising should be done relatively high. By that I mean that the heads, or cordons, should be made up to the height of 36 to 48 inches. The reason for this is that it is easier to handle fruit as the vines mature. There are many variations of these two types of training, all of which have their places. With labor such as it is, anything that can be done at the start of a vineyard to facilitate laborers performing their bunch management and harvesting operation later on means the crop will be more properly handled and easier to harvest.

A vineyard planted in the spring of the year can be staked the following winter and the vines so pruned to take up and begin establishing the trunk. Cutting back to start the head or developing the cordon can be done early in next season's growth.

Most of the varieties that would be adaptable to Texas would either be cane-pruned or cordon-pruned. I doubt if the head or spur-pruned types would be of particular value. We will probably see more and more of a cordon-type training system being used, particularly in connection with mechanization. Thompson Seedless produces best as a 2 to 4 cane system, and with the Perlette we feel that the cordon system with 2 bud spurs, is going to be the most satisfactory. After all, a pruning system is one method of getting as much fruit as you can of a commercial quality with the least possible work, so our length of canes; the number of buds that we leave; the length of spurs that we leave on cordon; and the method of spacing are all born out of local experience. I suspect that here in Texas the local experience will be the best teacher for anybody who is going into commercial production. It would be well for anyone thinking of establishing a vineyard to hire somebody trained in the quickest and most practical methods of establishing a vineyard. A little training and experience on the part of farmers who are starting table grape production wlil save many headaches later on.

Some vineyardists cut the young vine back to the ground when making the first pruning. This is just a loss of time. It is better to form the trunk and the head at the earliest possible time.

I would caution anyone planting grape vineyards in the Texas area to be extremely cautious of the sources of their planting material. Take only wood from known varieties with a history of production. These wood sources should be selected during the producing season when the vines are in full crop. One can be sure then that woods to be used are not unfruitful, diseased, or off-type. A little care exercised at planting time can save a great many headaches a little later on.

Planting distances are standard and not much need be said. Most California plantings are either 8, 10, or 12 feet apart. More vigorous growing varieties are planted 10 feet apart in the row, the less vigorous producing varieties are planted 6 to 8 feet apart in the rows. We feel that 12 foot spacing between rows is about satisfactory for cultivation and normal vineyard management operation.

Bunch Management

Bunch management is very important. This is what gives us our quality. In any production program that Texas would undertake in order to meet California competition and competition from Arizona with early fruit, adequate bunch management would have to be performed. This means that the Thompson Seedless vines should not only be properly pruned, but that they should be properly thinned and girdled. Along with proper bunch management, of course, is this level of crop. Level of crop has a lot to do with time of maturity and the amount of sugar and acid balance that we get in that particular variety. With Thompson Seedless in the deserts, the shipping standard is the 17° Balling. In many cases, this fruit is, to my way of thinking, relatively sour, particularly because the acid is well over one, which gives a rather tart taste. Quality crop production on the desert will average somewhere between 150 and 250 boxes per acre annually. This is about as high as possible for early production. In the San Joaquin Valley Thompson Seedless can be made to produce heavier crops. It is not uncommon for vineyards around Delano, where early harvest is not desired, to vine-store the crop, which means that they over-crop the vines considerably from normal standards. By this method of over-cropping they are able to carry the grapes on the vineyard for a relatively long period. In this area production will reach from 500 to 700 lugs per acre, not to include strippings and others that they send to the winery. Much of the fruit that is vine-stored is flat tasting before harvest, but still looks good. In fruit of this character the acid will drop from a high palatability factor of from around .80 to down to .35, which can be considered low. Sugars will then be somewhere around 19 to 20° Balling. A crop of this type is rather insipid. It has pretty fair looks, and as long as it has been properly girdled and thinned it has high trade acceptance. There are the Thompsons that normally get into the market in late September and beyond. The methods of thinning the crop take the form of cutting off bunches to a given number. A normal crop in the desert should be somewhere around 18 to 20 bunches—not over 20 bunches maximum. These remaining bunches should be thinned out—that is, the tails dropped and the shoulders thinned, so that the bunch itself is somewhere in the range of ¾ lb. to 1½ lb. maximum weight. This is the acme, of course, and represents removal of 1/3 to 1/2 the berries on each bunch. The better growers approach this point, but some of the farmers never quite have courage to reduce the crop to this level. Where this is done, the ground is covered with green fruit from the thinning. With insufficient thinning and poor girdling, seedless bunches will be very tight. Tight bunches bruise easily and are very unattractive when displayed on the retail stands. The girdling procdure, for berry size enlargement, works only with the seedless varieties. Also, in connection with hormone treatments to enlarge berry size, we have only found this possible when used on seedless types. The seeded types, like Cardinal, Emperor, Ribier, and Tokay show little effect from the use of hormones for berry size increases.

Diseases

Diseases are very important to the industry in California. Research people and others are just beginning to understand something of the disease picture. For years we have had a number of diseases, some of which have not been well understood, particularly viruses and their transmitability. A rather large program has been going on for sometime in this sphere, and the outgrowth of this is a grapevine certification program, which is now operating. Under this grapevine certification program mother vines at the University will be certified as free from disease, and planting material from these vines, both for rootstocks and varietis, will be available to the industry in the future. The first releases are being made this year. The wood is not very plentiful as yet and the operation is necessarily small. This indexing procedure, in order to eliminate any possibility of the diseases present in the wood, is a rather tedious one; and one man and some helpers are constantly at work on the general program. Virus diseases are widespread through many table and wine varieties. This certification program is an attempt to eliminate, as far as we can, these virus, by commencing to supply to the industry foundation material from which to propagate future plantings —a long needed effort!

I have briefly commented on grape diseases with the California Grape Certification program for disease control. One of the virus diseases which this certification program is aimed at eliminating is *Fanleaf*, which is one of the viruses that has shown up in many grape distrcts. Not much is known about it. We do know that it has been largely spread by propagating material and has a severe effect on grape yields. There are some indications that this disease is soil born. Another disease which has been with us for a long time is *Pierce's disease*. There have been times when Pierce's disease has caused great difficulty. Years ago it eliminated the grape industry from southern California and later had made serious inroads into the vineyards of the San Joaquin Valley. With the dry years of the late 30's and 40's Pierce's disease had subsided to a considerable extent. It is known in a good many areas throughout the state. It has not been a major problem with us for several years. Pathologists tell us that with the advent of another series of wet seasons, we can expect new outbreaks. The disease is carried by a number of insects known as "sharpshooters." The disease is found in native California plants. One of the commercial plants that is known to carry the Pierce's Disease virus is alfalfa—the so-called alfalfa dwarf—and Pierce's disease in grapevines is the same disease. In many cases, occasional diseased vines can be eliminated in the vineyard, but this is not always feasible when the percentage is relatively high. Careful selection of grape planting materials can go a long ways in controlling this disease. Other known virus diseases are *Yellow Mosaic* and *White Emperor*. Clean propagating wood is the best method of controlling.

Powdery Mildew gives some trouble in California. Our weather conditions are such that downy mildew does not survive. Powdery mildew is easily controlled by the early and continued application of sulfur. In some areas it is necessary to put on a large amount of sulfur, starting when the vine foliage is out from about 6 to 10 inches, and continuing at 10 day to 2 week intervals. In other areas the condition is not so severe and the number of applications are limited. The Coachella Valley gets along with a limited number of applications. Sulfur can cause much fruit damage if used just before a severe heat wave. *Black-knot* shows up in some of the vineyards, but this is not a great problem. *Dead-arm* and *Black Measles* are both more or less controlled by the use of sodium-arsenite sprays. Growers sometimes are a little slow in treating for this disease. Weather conditions seem to influence the amount that shows up in any one year. When a large outbreak occurs, treating is very general the following year. Treatment is usually done about 2 weeks after pruning.

Insects

Insect control is ever important in grape and all plant culture. There are many insects attacking grapes. The most important are: red spider, vine-leaf hopper, thrips, bud beetles, skeletonizer, mealy-bug, and so forth. Methods new and old are known for control. Grape growers have been relatively slow to change over from the old dusting procedure for insect control to the more effective wet sprays. The entomologists constantly tell us that in order to secure adequate control, particularly with many of our new materials, it is necessary to make more use of wet spray programs, and to do a good thorough job of coverage. Many of the growers feel that the economic situation is such that they cannot afford to use adequate pest control measures. Right now the industry is at the turn of the road where more mechanization and the application of wet sprays for insect control is in order. From dust to wet sprays is the historical pattern of control measures for many other crops. Grapes have been a little slower in using the newer application approaches.

Nutrition

General recommendation for grape vineyards, as far as fertilizers are concerned, have been limited. Many of our vineyards are not using fertilizers of any kind. There is some evidence that the use of fertilizers is necessary—and beneficial in local situations. Young vineyards require little or no fertilization for successful growth. When fertilizers are needed the use of Nitrate forms give the most responses. There are a few spots in California where vineyards will respond to potash, but these are of a minor nature, and largely of academic interest at the present time. Phosphate applications have little value in grape production. It is possible to stimulate high vegetative growth in the grapevine at the expense of crop by unwise use of fertilizers. The role of minor elements is important, particularly zinc. The problem of getting zinc into the grapevine has been difficult. With cane-pruned types it has been almost impossible. Foliar sprays have assisted some, but with the new chelates evidence is coming in that we have a new tool that may help in the application of zinc to

the grapevine in a successful manner. Daubing of pruning cuts immediately after pruning has been successfully used in spur-pruned varieties.

Hormones are still experimental. A good deal of research has been done on the use of different materials. They have not found widespread use in the industry at the present time. We have been able to enlarge the Thompson Seedless berry-size about 50 per cent by the use of the hormone material. Where the vines are girdled, as is Thompson Seedless, for forming of large berries, the hormone, together with the girdle, will again increase the size of berries. The level of crop is most important in the production of satisfactory table fruit. If the growers fail to remove enough of the crop when they apply both hormones and girdling treatments the effect of these treatments will be minimized. The University is testing some new hormones that cause a delay in maturity. This may be important for producers of late shipping grapes. All work is still experimental.

Mechanization

More mechanization of vineyard operations is helping the industry cut down the costs of handling grapes. The grape industry in California has been slow in working out mechanization and labor saving shifts and changes. Compared to the California vegetable industry the grape growers are a long ways behind. Currently, there is under development by the University of California a mechanical grape picker. A production model has been made and demonstrated at the last two University Grape Days. We believe that the industry will be harvesting grapes mechanically within the not too distant future. As for table grapes, we may never harvest our table varieties by mechanical means. The mechanical harvester, however, is going to be a big help in the raisin grapes harvest and in the harvest of our wine grapes. There is one thing that is very important to the progress made in mechanization and that is the re-training of vines, which must be done. Some radical shifts in vine training have been done in the University plantings and this year new experimental plots are being established in commercial plantings. Much is yet to be done, but other more complicated mechanization procedures have been worked out, so why not with grapes?

Harvesting

I don't know what your local procedures would be. We have two general systems: one is our field packing, the other house packing system. Where adequate supervision is to be had for crews that are working in the field, the field pack is much to be preferred. There are some situations where the properties are small, and house packing is necessarily done. With the house packing, more handling is entailed as far as the fruit is concerned. It has been my view from the market side, that field packs are just as good, or better, than most house packs, other things being equal. I have seen some very poor packs, both field and house, but field packing means less handling and consequently fresher looking produce when it is offered in the market. California uses the 28 lb.

lugs for most of its table fruit. Our *early* shipped fruit goes out in 24 lb. lugs, though some 26 lb. lugs are used; but the bulk of the grapes moving into the East, other than our wine grapes, are shipped in 28 lb. lugs. One other consideration at the harvesting level that is most important is the matter of pre-cooling the crop when it is harvested. We have found that quality loss is very heavy when there are delays in getting the fruit into the coolers after it has been harvested. All of the University's recent work in trying to eliminate some of the quality loss situations that show up in the Eastern market point up the need for rapidity in cooling the fruit, once this fruit has left the vine. Speed is paramount, and the packing operations, in many cases is being shifted to meet this new need.

Transportation

I suspect that most of your fruit would move by trucks. We have had some research experience with truck shipments from California. You are much closer to the major market centers than we are, but good truck equipment, adequate insulation, and sufficient refrigeration are important. Truckers are inclined to say they can do many things with their equipment, but in running checks there is much evidence to the contrary. The shipper should be very careful to see that his fruit is adequately cooled before it goes into the truck, and once into the truck, that it is a cold truck, with sufficient cooling capacity to hold the grape load at as near 40° or below as is possible for the duration of shipment.

Railroads have long moved the bulk of California grapes. They have been losing out to trucks of late. Truck shipments show up regularly in New York and Chicago markets. With better highways and equipment more and more perishable products will be moved by trucks.

Conclusion

There are a great many details to this business of grape growing that are important to anyone considering planting a grape vineyard. The new grower should consider well what he is faced with. The industry as a whole is in a period of surplus and has been for sometime. Our acreage has decreased slightly, but it is increasing on the desert, in the early shipping area. Arizona has ambitions to expand their industry, both in the Yuma and the Salt River valleys. These two areas would be the main competition to Texas production. The supplies of early fruit coming into the market will necessarily increase in the years ahead. Anyone considering producing for this early market should consider well his competition. Many of our old growers who felt that they had the edge on the market with Thompson Seedless, by virtue of location, are having to revise their production schedule. The advent of new early varieties is forcing a change. Some growers' adjustment is being made in the direction of taking a lower price, but trying to increase the volume and quality for later markets. There may be a place in South Texas for a limited early grape industry, perhaps for only local markets. To compete at auction requires fruit of highest quality.

I had the opportunity to see fruit from the first shipment of Texas Thompson Seedless that came into the Chicago market last June, and I suspect that this is the forerunner of more trials as the years go along. The plant breeders are at work, and no doubt they will be able to surmount some of the problems of diseases, insects and other pests that go along with the climate such as you have during the major part of your production season. I would reiterate again that the Vinifera grape does not produce fruit of acceptable commercial quality in areas of high rainfall or high humidity during the ripening season. One of our biggest problems in California is early or unseasonable rains on the maturing crop. Our current crop of Emperor grapes, which is now in storage, is showing much difficulty as a result of unseasonable early rains, particularly that portion of the crop harvested after the rain. Licking this disease problem is just one of the many problems, solutions of which are ahead.

A farmer is a born gambler and an adventurer, and Texas, like California, has its share of people who interest themselves in many new and untried things. This is highly commendable, as I feel it is the way in which we have made great progress. Experimentation is long and costly and the pioneers very seldom stick it out long enough to reap the rewards. Experience is a hard and lasting teacher. If what I have said in this talk today will help some prospective grape growers to seek new facts, and advice to avoid pitfalls, then what I have said will not have been in vain.

Propagating Vinifera Grapes in the Lower Rio Grande Valley of Texas

NORMAN P. MAXWELL, *Texas Agricultural Experiment Station*

Vinifera grapes, when grown on their own roots in South Texas, are highly susceptible to cotton root rot. Nurserymen and prospective grape growers have found it difficult to successfully graft vinifera grapes on cotton root rot tolerant rootstocks in this area. The results obtained from using the common California propagating technique of bench grafting are variable and generally the percentage of living grafted plants will not exceed thirty per cent.

One method of propagation that has been tested for two years with some success is as follows: Rootstock cuttings were planted twelve inches apart in nursery rows and allowed to grow for one year. The plants are dug in early January and stored in damp sawdust until the middle of February. The vines were then set in their permanent locations in the vineyard and cleft grafted sometime during the next seven days. In order to prevent the graft union from drying out, soil was banked around the graft with just the top bud of the scion outside the mound.

Usually by May 15 the stock and scion had united and the plant had begun to grow. The mounds of soil around the grafted plants were then removed and roots cut off the scion to prevent scion-rooting.

This method of grafting has been more successful than bench grafting. The relative success with various scion rootstock combinations is shown in Table 1. The plants with dead scions can be regrafted the next year or replaced with a grafted plant.

Table 1. Percentage of living grafts after eight months when grape vines are moved from nursery to field and grafted in place within one week.

Scion	*Rootstock*	*No. Plants Grafted*	*No. Living Grafts*	*% Living Grafts*
Thompson Seedless	Champanel	61	41	67.2
Thompson Seedless	Dog Ridge	64	47	73.4
Thompson Seedless	La Pryor	35	27	77.1
	TOTAL	160	115	69.2
Perlette	Champanel	46	34	73.9
Perlette	Dog Ridge	46	38	82.6
Perlette	La Pryor	37	25	67.5
	TOTAL	129	97	74.6

This technique can be used by a grower. A nurseryman wishing to sell plants would perhaps prefer other propagating methods or contract to propagate on the grower's land.

Research work is being continued on vinifera grape propagation to find methods that will result in higher percentages of successful graft unions and the need for less replacements or regrafts in the vineyard.

ORNAMENTAL SECTION

Ray Goodwin – *Section Chairman*

Observations On Ornamental Horticulture in the Rio Grande Valley During the Past Five Years

D. E. Kornegay, *Harlingen*

For the purposes of this review, the "freeze" referred to is the memorable one of 1951. The "poor conditions" referred to have reference to conditions caused by lack of sufficient water for irrigation and conditions that resulted from the use of poor quality irrigation water that contained excessive amounts of elements that have harmful effects on plant growth. It is the opinion of this observer that the poor soil and water conditions that prevailed after the freeze, caused more problems of economic significance than did the actual freeze. After the freeze, and before the new Falcon Dam provided the Valley with ample water of good quality, ornamental plants suffered lack of vigor and a susceptability to insect and fungus attacks more than had ever been noted through previous growing seasons.

Ornamental propagation during this period was accomplished usually by starting with a greater inventory than was required, in order to finish the season with the small percentage of finished plants that were the results of the effort.

Although some problem conditions remain for ornamental culture to cope with as we enter the 1956 growing period, the outlook for the increased development of ornamental planting in the Valley is promising.

Plants have exhibited their individual tolerance or intolerance to the conditions afforded them during this unfavorable period, and as a result, valuable knowledge has been gained in the experience. Exceptional or peculiar characteristics are the basis of the following remarks and the discussion will not mention a large number of ornamental plants that are generally known to Valley residents. These remarks are based on personal observations and opinions, and are not intended to be authoritative.

Those plants selected for this review will be presented alphabetically and the remarks will be lacking in detail, but if questions are provoked, an elaborate and more detailed discussion will be attempted when desirable.

Allamanda—All existing varieties suffered heavy freeze mortality. Revived and newly planted Allamanda both experienced a painfully slow and chlorotic recovery.

Alternanthera—(Joseph's Coat) Is apparently tolerant to questionable soil conditions. This plant is a favorite of snails, and for that purpose, snail bait is a pest control requirement in its culture.

Arborvitae—(Of any of the known varieties, as well as the Junipers) Did not freeze in any particle, but can be expected to outgrow themselves in about ten years, and notably receive red spider burn each summer, unless preventative control is affected.

Arecastrum—(Cocus Plumosa Palm) Most of these palms were killed by the freeze, but within five years new plants have attained growth to from twenty to thirty feet in height.

Aristolochia—(Dutchman's Pipe) Is hardy, and its unusual bloom is almost continuous. It is a light weight vine that nevertheless is of full foliage. Its seed pods are as attractive as the bloom.

Bambusa—(Includes the known Bamboo varieties) Most plants returned new growth from below ground level. For some time they lacked the rapid growth that is their characteristic, but have now recovered satisfactorily after a period of ample irrigation.

Bauhinia—(Orchid Tree) Where excessive alkili or salt is prevalent, this plant does not transplant satisfactorily. Under slightly improved conditions this plant is a rapid growing, flowering shade tree.

Bigonia—In this plant family, the Yellow Esperanza has caused more recent concern than have others in its group. Although it recovers satisfactorily from freezes, and grows quite well for a while under questionable soil conditions, it appears to accumulate harmful salt and suffer from a subsequent rapid decline when rainfall in excess releases more harmful elements to the saturated root system.

Bougainvillea—White Madonna in most cases did not recover satisfactorily from the freeze, and it is highly intolerant to salt. Betty Hendry and Susan Hendry could be utilized more frequently because of their excellent habits of growth, and because of their inherited hardiness.

Buxus—(Japanese Boxwood is preferable) Imported liners of this plant have been found with nematode infested root systems. Precaution in that regard should be taken.

Caesalpinia—(the Poincianas) Attempts are being made to control the girdling beetle by applying insecticides around the base of plants at the time of year when the pest is in the grub stage.

Carissa—(Natal Plum) One of the hardiest shrubs in the Valley.

Cassia—(Fistula, the Golden Shower and Grandis, the Pink Shower) Both Showers respond satisfactorily if given wind protection and good soil practices are performed, but Splendida, the native plant is exceptionally hardy and furnishes a heavy adornment of yellow blooms.

Coccolobis uvifera—(Sea Grape) Because of its rapid recovery from the freeze and its tolerance to salty conditions, this plant is favored for more attention than it has received in the Valley.

Cortadaria—(Pampas Grass) Is hardy under most Valley-wide conditions.

Dasylirion—(Sotol) Should be considered for use in the Valley where extreme weather and soil conditions prevail.

Ehretia anacua—As a windbreak material, or as an individual shade tree, this plant merits attention because of its rugged hardiness and evergreen foliage.

Feijoa sellowiana—(Pineapple Guava) This plant is attractive, yet has been quite rugged and hardy under severe circumstances.

Fraxinus—(Ash) This is my personal choice of native trees, where large growth and rapid shade is required.

Gaillardia—Generally conceded to be an annual, this plant has been seen producing constant bloom for over a year, under poor soil conditions. Some of the double varieties are excellent for producing colors in flower beds where low-growth is imperative.

Gelsemium sempervirens—(Carolina Jasmine) This vine is cold hardy and tolerates a wide range of Valley conditions. Valley plantings should show more evidence of this particular plant.

Hibiscus rosasinensis—The selection of the hardier varieties of the Chinese Hibiscus has been greatly facilitated by the poor growing conditions that existed during the past five years.

Hibiscus tau—Where enormous size can be accommodated, this comparative new introduction to the Valley will provid a rapid and gigantic growing specimen to the landscape.

Hemerocallis (Day-lily)—This border plant should be included in Valley landscapes more frequently, because of its briliant blooms and its hardy growth under a wide range of conditions.

Ixora coccinea (Flame-of-the-Wood)—Where partial shade, wind protection and favorable soil conditions are provided, this plant affords a pleasant diversification in plant materials.

Jasminum—The Humile variety (Italian) has proven quite unsatisfactory because of salt tolerance. The Revolutum variety surpasses Primulinum in vigor and abundance of bloom, and because of similar size might be a favorite to replace the Primrose Jasmine that is notable for its shaggy inside limbs.

Lantana—The patented Gold Rush variety seems to do well under favorable soil conditions and in slightly protected areas.

Ligustrum—Though previously considered as cold hardy and tolerant to most Valley conditions, Ligustrum of most varieties has shown a surprising lack of vigor. Complete freeze mortality occurred in many instances, and older plants that are still existent appear to be generally unhealthy.

Murrae exotica (Orange Jasmine)—This plant has exhibited vigor in freeze recovery and a tolerance to slightly unfavorable conditions.

Passiflora—Several varieties display excellent qualities throughout a range of conditions in the Valley.

Penta carnea—Is of newly revived interest in the Valley and shows considerable promise where favorable circumstances are provided.

Petunia—Because there is a lack of perennial plant material that will maintain a dwarf habit of growth, and provide color, the annual Petunia deserves consideration for more extensive use than is the normal practice in the Valley at this time. Petunia transplants have shown continued vigor ,throughout the heat of our Summer and have continued to bloom into early fall.

Phoenix dactylifera (Date Palm)—Old, heavy-headed Date Palms received considerable and noticeable damage from being uprooted by tropical storms of the past two seasons. Shallow and weak root systems of this plant, do not seem to compare to the strength of its sister, the Ornamental Date Palm.

Pittosporum—Although impervious to cold, this plant has shown lack of vigor and intolerance to salt. Cottony cushion scale seems to be a constant companion of Pittosporum. Control of that pest is a constant problem with this plant.

Pyracantha—Shock from freezing, an absolute lack of salt tolerance, and a history of yearly infestation of aphids and bag-worms have caused increasing difficulty in the care of Pyracantha in the Valley.

Stenotaphrum secundatum—(St. Augustine or Carpet Grass) At the present time this lawn grass continues to be the favorite for Valley use, although various Zoysia and blue grasses are under trial in the Valley. The latter have not shown the rapid coverage and vigor that St. Augustine is noted for.

Viburnum suspensum—Under unfavorable conditions, this Viburnum has exhibited cold hardiness and general tolerance, while at the same time it has provided a pleasant broad-leafed evergreen growth that makes it a candidate to replace the ligustrums.

Tropical Foliage Plants For Use In Landscape

Richard Goodwin, *Mission*

The Rio Grande Valley, the sub-tropical show spot of southern Texas, has direly neglected the use of tropical foliage plants for the purpose of landscaping. These plants add such alluring colors and tropical effects to the modern home that no landscape job is complete without them.

Before outlining the use of any of these plants, we should first understand their culture; such aspects as soil conditions, planting, pruning ,and light requirements.

The natural habitat of foliage plants is an area of high rainfall and high humidity. Under these conditions there will be found a high rate of decomposition of those portions of the plants which have died and fallen to the ground. Where decomposition takes place, in conjunction with high humidity, an acid situation is set up in the soil. Consequently, such foliage plants, are accustomed to and even require acid soil conditions in which to grow.

Unfortunately, the Valley is not gifted with such soil conditions. The soil and the water are both of an alkaline nature. In addition, the annual rainfall for this area is low and not consistent to be able to set up an acid condition.

The soil condition necessary for growing tropical plants is a coarse loose soil which is acid in nature. The addition or the presence of humus in the soil is necessary to aid somewhat in having a lower alkaline condition plus aiding the soil structure. A soil with good humus condition benefits the plant from the standpoint of good root growth. This is accomplished due to good drainage and porous condition allowing good up take of oxygen.

Planting

When planting tropical foliage plants, give them a good home to live in. Since these plants are special plants, a high price is generally paid for them: As this is so, don't plant them in a cheap hole. Dig a hole at least four times the size of the ball on the plant. Mix the dug out dirt half and half with plenty of humus material, such as leaf mold, peat moss or black peat with the addition of some iron sulphate. This extra effort will show dividends in the future.

Pruning

Although gardeners seldom hesitate to trim and prune other ornamental plants, they find it hard to prune foliage plants. Such plants as Rubber plants, Fiddle Leaf Figs, Sheffleras, Crotons, Dracenas, and Jatrophas will develop into beautiful bushy plants with a limited amount of pruning. The development of these plants after pruning will be much more satisfactory.

Light

Certain foliage plants should be planted according to their light requirements. These simple rules may be an aid. Blooming plants and deeply colored leaved plants prefer high light intensities. Plants with pastel-colored leaves and those with dark green leaves, especially those larger-leaved varieties, prefer or withstand low light intensities.

Fertilizer

Nutrients for foliage plants are as essential as for other ornamentals if not more so. Fertilizer applied at the rate of one teaspoon per large plant two to three times per year or about one tablespoon dissolved in a gallon of water and applied as a normal watering at intervals of about six weeks seems best. One must remember to fertilize only into a moist soil, never a dry one.

Foliage Plants for This Area

Dracaena—Colors and growth habits vary with the varieties, and the beautiful foliage changes according to maturity and light intensity. It is generally found that they are most showy during the winter. Dracaenas may be planted in any good soil, but do require a situation where the humidity and moisture can be kept relatively high during the hot dry months. They do require freeze protection.

Crotons—Leaf habits vary from a screw-tail habit to narrow leaves to broad leaves with colors varying from dark greens, red and yellows to light pastels. The soil should be slightly acid. Most Crotons do best with a filtered light of 50% although some are shade loving. As with Dracaenas, Crotons like high humidity and moisture. During the growing season apply a fertilizer low in nitrogen and high in phosphorous and potassium. The narrow leaf and screw-tail varieties are the hardiest types for the Valley. Other types of Crotons require freeze protection.

P. Selloum—A relatively new introduction of Philodendron grows from a crown somewhat similar to an onion. After planting outside, it will obtain large leaves within two years. A slightly acid soil of good texture is best. Selloums require semi-shade and should be planted on the north or east side of the house. As this Philodendron will withstand temperatures of 20-22 degrees Fahrenheit, no protection is required in the Valley.

Ficus—The fig family is represented by two common foliage plants—the Rubber Plant and the Fiddle Leaf Fig. These two plants will reach tree size if not damaged by cold weather. Pruning is a must for them. They are able to withstand either sun or shade, but do best in a humid situation. Fertilization with Iron Sulphate will add color to the leaves.

Schefflera—In Australia these plants reach the size of a tree. Cold weather generally prevents that in the Valley. A shady location from the hot

afternoon sun is a must as the leaves will burn rather easily as a young plant. The planting location should be in a well-drained location as Scheffleras do not like wet feet but they will stand some dry conditions.

Bananas—There are several outstanding varieties of the bananas which will add to a tropical landscape effect. The Cavendish is low and thick bearing edible fruit; the Lady Finger, tall and bearing edible fruit; the Pink Bloom, of medium height and slender with a beautiful bloom; and the Red Spotted Leaf Banana which is of medium height and slender with beautifully mottled leaves.

Other foliage plants which should be mentioned but are somewhat more common are the Papayas, Jatrophas, Apidistra and last but not least, for all tropical areas, the Palms of which three should be mentioned, the Cocos Plumosa, the Chinese, and the Chamaedora.

Spreading Decline In Florida Citrus Groves And Ornamental Plantings

ED L. AYERS, *Plant Commissioner, Florida State Plant Board, Gainesville, Florida*

For more than thirty years there has existed in the citrus groves of Florida a condition variously known as decline, creeping decline, spreading decline, etc., and a great many observations and tests were made prior to 1953 by specialists of the Florida Citrus Experiment Station at Lake Alfred, Florida, to determine its cause. It was first thought to be caused by a mineral deficiency, but this was proved not to be true as were also deductions that it could be caused by fungus, bacterial, or virus diseases. Several workers were of the opinion that this decline could be caused by a nematode, but this was not determined to be a fact until late in 1953 when the burrowing nematode *Radopholus similis* (Cobb) Thorne was identified and a modified form of Koch's postulates was accomplished whereby the pest was isolated and used to reinfest plants reisolated, etc.

One of the principal reasons it had been so difficult to determine that this decline was caused by the burrowing nematode was that it was not often found in the top foot of Florida's warm sandy grove soil. A careful study of the root systems of grove trees disclosed that there were practically no feeder rootc below this top 12 inches of soil, which led to the deduction that the temperature and moisture of the subsoil (75° F.) were ideal for the development of the pest. Accordingly, most experimental work is now being done in pots placed in water tanks where the average soil temperature can be maintained at that level.

Early in 1954 the State Plant Board of Florida began a survey of the State which corroborated the findings of the Citrus Experiment Station, burrowing nematodes always being found where the peculiar symptoms which had become known as spreading decline were found.

Early in 1955 the State Plant Board was joined by the Pest Control Branch, Agricultural Research Service, United States Department of Agriculture, in its survey work. In addition to citrus and avocado trees, a large number of other plants, including ornamentals mostly of a subtropical nature, were found to be infested with the burrowing nematode. By the end of 1955 a fairly complete coverage of the State had been made.

Plants reported as host species in technical literature and those from which the burrowing nematode has been recovered in various stages of development or in considerable quantity by root dissection or maceration are considered here as host plants. Other plants have yielded burrowing nematodes by the incubation method and the Baermann funnel method. As it is probable that some of these will prove to be definite hosts, they are considered as suspected host plants and are marked on the list with an asterisk (*).

HOST AND SUSPECTED HOST PLANTS OF THE BURROWING NEMATODE, *Radopholus similis* (Cobb) Thorne

Acanthus montanus, T. Anders.	ACANTHACEAE	Acanthus
**Albizzia lebbeck*, Benth.	LEGUMINOSAE	Woman's Tongue Tree
Allamanda cathartica, L., var. *Williamsii*	APOCYNACEAE	Allamanda
A. neriifolia, Hook.		Allamanda
**Alpinia nutans*, Roscoe	ZINGIBERACEAE	Shell Lily
Ananas comosus, Merr.	BROMELIACEAE	Pineapple
Anthurium andraeanum, L.	ARACEAE	Flamingo Flower
* *A. chrystallianum*, L. & Andre.		
* *A.* sp.		
* *A. wrightii*		
Bambusa sp.	GRAMINEAE	Bamboo
**Beloperone guttata*, T. S. Brandeg	ACANTHACEAE	Shrimp Plant
Bradburya pubescens, Benth.	LEGUMINOSAE	Butterfly-pea
B. sp.		
Breynia nivosa, Small	EUPHORBIACEAE	Phylanthus; Snow-bush
Buxus microphylla var. *japonica*, Rehd. Wilson	BUXACEAE	Japanese Boxwood
Cajanus cajan, Mill	LEGUMINOSAE	Pigeon Pea
Calathea lietzei, E. Morr.	MARANTACEAE	Calathea
C. ornata, Koern.		Calathea
Callicarpa americana, L.	VERBENACEAE	French Mulberry
Calopogonium mucnoides, Desv.	LEGUMINOSAE	
Canna edulis, L.	CANNACEAE	Edible Canna
Capsicum frutescens, L.	SOLANACEAE	Bird Pepper
Celosia nitida, L.	AMARANTHACEAE	Wild Celosia

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Cestrum nocturnum, L.	SOLANACEAE	Night-blooming Jasmine
Chrysophyllum cainito, L.	SAPOTACEAE	Star Apple
**Cinnamomum camphora*, L.	LAURACEAE	Camphor
Citrus sp. (no species immune)	RUTACEAE	
Cocculus sp.	MENISPERMACEAE	Cocculus
Coffea arabica, L.	RUBIACEAE	Coffee
C. canephora, Cheval.		
C. excelsa, Cheval.		
C. quillou, L.		
C. robusta, L.		
C. sp.		
**Collinia elegans*, Liebm.	PALMACEAE	Chamadorea Palm; Neathe Bella Palm
Commelina sp.	COMMELINACEAE	Day Flower; Commelina
Cyperus rotundus, L.	CYPERACEAE	Nut Grass
**Datura* sp.	SOLANACEAE	Angel's Trumpet
**Delonix regia*, Raf.	LEGUMINOSAE	Royal Poinciana
Desmodium tortuosum, D. C.	LEGUMINOSAE	Meibomia; Florida Beggarweed
**Digitaria sanguinalis*, (L.) Scop.	GRAMINEAE	Crab Grass
Diospyros kaki, L.	EBENACEAE	Japanese Persimmon
D. virginiana, L.		Common (wild) Persimmon
**Eleagnus* sp.	ELEAGNACEAE	Eleagnus
Eriobotrya japonica, L.	ROSACEAE	Loquat
**Eugenia paniculata*, Banks	MYRTACEAE	Australian Brush Cherry; Eugenia Hookeriana

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**Feijoa sellowiana*, Berg.	MYRTACEAE	Feijoa
Ficus sp.	MORACEAE	Ficus Tree
**Gardenia jasminoides*, Ellis	RUBIACEAE	Gardenia; Cape Jasmine
Giganthochloa apus, Kurz.	GRAMINEAE	Bamboo
Hedychium coronatum, Koenig	ZINGIBERACEAE	Ginger Lily
Heliconia sp.	MUSACEAE	Heliconia
Hibiscus rosa-sinensis, L.	MALVACEAE	Hibiscus
**Ilex* sp.	AQUIFOLIACEAE	Holly
**Illicium anisatum*, L.	ILLICIACEAE	Anise
Indigofera endecaphylla, Jacq.	LEGUMINOSAE	Indigo
Indigofera hirsuta L.	LEGUMINOSAE	Hairy Indigo
Ipomoea batatas, Poir.	CONVOLVULACEAE	Sweet Potato
Ixora coccinea, L.	RUBIACEAE	Ixora
Jacaranda sp.	BIGNONIACEAE	Jacaranda
**Jasminum bahiense*	OLEACEAE	
J. dichotomum, Vahl.		Gold Coast Jasmine
* *J. illicifolium*		
J. primulinum, Hemsl.		Yellow Jasmine
J. pubescens, Willd.		Jasmine
J. sp.		
**Magnolia grandiflora*, L.	MAGNOLIACEAE	Magnolia
Malpighia glabra, L.	MALPIGHIACEAE	Barbados Cherry
Musa nana, Lour.	MUSACEAE	Cavendish Banana
M. paradisiaca, L.		Plantain
M. paradisiaca, L., var. *sapientum*, Kuntze		Common Banana
M. textilis		Manila Hemp; Abaca

**Nerium oleander*, L.	APOCYNACEAE	Oleander
Odontonema strictum, Kuntze	ACANTHACEAE	Jacobinia; Cardinal Guard; Pachystachys; Justicia
Pandanus veitchii, Dall.	PANDANACEAE	Pandanus
Panicum hemitomon, Schult	GRAMINEAE	Maiden Cane Grass
P. maximum, Jarg.		Guinea Grass
Peperomia obtusifolia (L.) A. Dietr.	PIPERACEAE	Peperomia
Persea americana, Mill.	LAURACEAE	Avocado
**Philodendron cordatum*	ARACEAE	Philodendron
* *P. dubium*		
P. hastatum		
P. Imbe, Schott		
* *P. mandaianum*		
* *P. melinoni*		
* *P. micans*		
P. panduriforme		
* *P. pittieri*		
* *P. rubrum*		
* *P. sagittatum*		
* *P. selloum*, C. Koch		
P. sp.		
* *P. sodiroi*		
* *P. wendimbe*		
* *P. wendlandii* hybrid		
P. wendlandii		
Pilea cadieri Cagn. & Guill.	URTICACEAE	Aluminum Plant; Pilea

Piper cubeba, L.	PIPERACEAE	Cubeb
P. nigrum, L.		Black Pepper
Podocarpus macrophylla, D. Don, var. *Maki*, Endl.	PODOCARPACEAE	Podocarpus
Poncirus trifoliata, Raf.	RUTHACEAE	Trifoliata Orange
Psidium cattleianum, Sabine	MYRTACEAE	Cattley Guava
P. guajava		Guava
Pyrostegia ignea, Presl.	BIGNONIACEAE	Flame Vine
**Rhynchelytrum roseum*, (Nees) Stapf & Hubb.	GRAMINEAE	
**Ricinus communis*, L.	EUPHORBIACEAE	Castor Bean
Rivina humilis, L.	PHYTOLACCACEAE	Bloodberry
Ruellia makoyana	ACANTHACEAE	Ruellia
Saccharum officinarum, L.	GRAMINEAE	Sugar Cane
Schinus terebinthifolius, Raddi.	ANACARDIACEAE	Brazilian Peppertree
Schiozostachyum sp.	GRAMINEAE	Bamboo
Scindapsus aureus, Engler	ARACEAE	Pothos
Severenia buxifolia	RUTACEAE	Box Thorn
Solanum nigrum, L.	SOLANACEAE	Black Nightshade
S. seaforthianum, Andr.		Brazilian Nightshade
Strelitzia reginae, Banks.	MUSACEAE	Bird-of-Paradise Flower
**Syngonium podophyllum*, Schott	ARACEAE	Nephthytis
Tephrosia candida, D. C.	LEGUMINOSAE	
Thea sinensis, L.	THEACEAE	Tea
**Thymus* sp.	THYMELAEA	Thyme
Urena lobata, L.	MALVACEAE	Caesar's Weed; French Cocklebur
Vigna hosei, Backer	LEGUMINOSAE	Cow Pea

There are some indications that there may be more than one species or strain of the burrowing nematode, as one that is consistently found on the banana plant does not seem to transfer to the citrus plants. There are also indications that some of the strains found on foliage plants will not attack citrus plants. A great deal of work is being done in Florida on this and other phases of the spreading decline program and many answers, no doubt, will be reached within the next few months. The United States Department of Agriculture has joined the State in burrowing nematode research work during the past few months and is preparing to do a great deal of experimental and testing work.

A typical spreading decline area consists of a group of trees all of which have the same non-thrifty appearance. The trees are stunted, have undersized leaves, sparse foliage, reduced terminal growth, lowered yields and extensive deterioration of the feeder root system below a depth of about 20 inches. Such trees remain in a non-thrifty condition indefinitely but are not killed by this disease. Because of their deficient root system, diseased trees always wilt more readily during periods of drought than the adjoining healthy trees and frequently show temporary improvement under favorable moisture conditions. The decline area is usually sharply separated from the healthy trees in the remainder of the grove and the area may occur at any point in a grove. What distinguishes it from other declines is the fact that the area spreads continuously and about equally in all directions regardless of elevation or direction of rows and cultivation.

This constant spread in all directions is one of the most characteristic features of the disease and led to its name, "spreading decline." For years the measurable annual rate of spread was the most reliable characteristic for diagnosing spreading decline in a grove. The rate of spread of the decline condition to new trees varies from grove to grove and from year to year in the same grove but the average rate of spread in 25 groves for 5 years has been 1.6 trees per year on the margin. From centers of infection, spreading decline moves out in all directions in a grove and crosses wide middles into other properties. So far, spreading decline has successfully crossed clay roads, asphalt roads with rights-of-way up to 100 feet wide and even railroad lines. Bridging these distances between groves is probably accomplished by root contact or near contact. At the edges of groves, the roots of rough lemon stocks have been traced outward for as much as 50 and 60 feet. The characteristics of spreading decline as outlines above are sufficient to differentiate it from other types of decline such as foot rot, water damage and psorosis, which in some cases may produce trees of the same appearance but which do not spread in the same way.

The burrowing nematode is a small plant parasitic worm about 1/50 of an inch long. It requires a source of living plant tissue for its food supply and feeds on the tender cortex tissues of rootlets, forming burrows and cavities. The females deposit eggs inside the rootlets where the young are hatched. The young feed on the rootlets until the available food supply is exhausted and then leave the deteriorated rootlet in search of sound roots suitable for food. The burrowing nematode spends most of its life within rootlets and is therefore classified as endoparasitic in contrast to parasitic nematodes that live outside the root in the soil and classified as ectoparasitic. When it leaves the deteriorated rootlet and moves about in the soil, it is in a migratory phase. The duration of the migratory period depends on the length of time required to find and enter another healthy rootlet. It is in this migratory stage that the nematodes, traveling in all directions in search of roots, extend the area of infestation and thus account for the "creeping" nature of spreading decline. The actual distance that an individual burrowing nematode may travel in the soil has not been determined, but it is probably not very far. Burrowing nematodes have been found invading citrus rootlets 12 feet deep. They have been found in soil and roots of trees two or three rows in advance of the visible disease margin. From the known average annual rate of spread of the disease and the lateral spread of these nematodes beyond the visible diseased area, it becomes apparent that trees are infested one to two years before showing symptoms of decay.

The dissemination of spreading decline becomes understandable when the knowledge that it is caused by the burrowing nematode becomes available. Infested nursery stock used for setting out new groves or for replants in previously noninfested groves accounts for establishment of new centers of infection. Often after a commercial grove has been planted with clean nursery stock, odd fruit trees and other plants are brought in from burrowing nematode infested areas, which explains why so often spreading decline has started adjacent to home sites and buildings in and about groves. There is no evidence to date that machinery is a factor in the transmission of burrowing nematodes, but infested roots could conceivably become entangled in machinery and subsequently be deposited in new locations where, if conditions were favorable, the nematode could become established. Therefore machinery used for working soil should be cleaned of all plant parts as a precautionary measure before moving such equipment from spreading decline infested groves.

Many hundreds of tests have been and are being made in the effort to find a nematocide that will kill nematodes on the trees in the soil without killing the trees. To date, all of these tests have shown negative results. Also, a vast amount of work has been done and observations made in an attempt to find a resistant rootstock. Although there are some hybrid rootstocks that offer some promise, many years will be required to prove them and to determine if they are satisfactory from a growth and production standpoint.

At the present time the only apparently effective control of the burrowing nematode in citrus and avocado groves is the "push-and-treat" method developed by the Citrus Experiment Station, Lake Alfred. This consists of either pushing out all visibly affected trees plus the first four trees past the last visibly affected tree, or two rows past the last

tree in the roots of which burrowing nematodes were found, whichever is the greater distance. The trees are stacked and burned on the infested property. The soil is raked by a bulldozer and the roots are picked up and burned. In final preparation for fumigation, the soil is leveled to permit efficient operation of the fumigation machine. The Plant Board then fumigates the property, injecting D-D soil fumigant at a depth of 12 to 14 inches at the rate of 600 pounds per acre. The growing of host plants on the treated property is not permitted for a 2-year period to force starvation of any burrowing nematodes that might have survived the fumigation.

The burrowing nematode does not form a cyst, and in addition to the large direct kill at the time of treatment undoubtedly any remaining nematodes die of starvation, as the fumigant does a good job of killing all citrus and other roots.

Due to the serious threat imposed on the citrus industry by the burrowing nematode, the Florida Sttae Legislature, during its last regular session, appropriated $1,756,300 for control or containment of this malady and empowered the State Plant Board to administer the program.

It is estimated that there are about 7,000 acres of citrus groves in Florida that are infested with the burrowing nematode. Our figures at present show that infested groves average about 6 or 7 acres of infested area per grove. With that average as an indication, there should be about 1,000-1,100 different groves suffering from spreading decline.

This nematode generally spreads naturally in all directions from an infested spot in a grove at the rate of about 50 feet in one year.

The work of pushing and treating infested areas of the State is now well under way. It is anticipated that approximately two years will be required to clean out all infested areas. Likewise, measures have been taken to clear all nurseries of the pest. Where infestation is found or suspected in citrus nursery stock, treatment of the roots with hot water for 10 minutes at 122° F. has proven effective in killing the burrowing nematode and it does little injury to the roots.

Apparently the burrowing nematode is doing little damage to plants other than citrus. There is some damage to avocado trees but it is not nearly as serious as on citrus, and there is little evident damage to susceptible ornamental plants.

The problem of the burrowing nematode and the vast amount of work that is being done on it in Florida has high-lighted the whole nematode field. Experimental work now under way will result in new control procedures and control methods which should prove beneficial to our entire agricultural industry. Certainly Florida has a problem in her citrus groves, and has and will come up with the answer.

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