PROCEEDINGS

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W. G. GODBEY, Business Manager
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Lower Rio Grande Valley Citrus and Vegetable Institute

Third Annual Meeting — Dec. 8 to 10, 1948

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Papers 23 to 26 inclusive were presented primarily for an audience interested in transit and storage losses in fruits and vegetables. They constituted what was organized as a supplementary "Valley Short Course" on that general theme, to be given in conjunction with the Institute. Paper 27 was not a part of the Institute proper. It is published herein by authority of the Rio Grande Horticultural Club as a matter of record, for its permanent value to the citrus industry.

Address of Welcome

D. J. McAlexander

Ladies and gentlemen, visitors from other states, friends and co-workers in the industry — it is my privilege this morning to extend to you a most warm and hearty welcome to this our third annual Horticulture Institute. Your presence here is an indication of your sincere interest. I trust that your attendance of these meetings will be both instructive and enjoyed.

It has been my observation and experience that, as the years roll by and as we surmount obstacles one by one, and solve the problem at hand, there in front of us is another challenging perplexity. This is probably as it should be. I think no one of us even expects to be able to attain here, that goal of perfection in which there are no more problems to face nor challenging issues to goad our spirits and energies into doing bigger and better things.

We must never let up. We must ever be alert. Why? — I believe it was Emerson who wrote: "Nature makes fifty poor melons for one that is good, and shakes down a tree full of gnarled, wormy, unripe crabs, before you can find a dozen dessert apples — Nature works very hard, and only hits the white once in a million throws."

We agree to that, but when hard times with low prices begin to confront us, we complain about the cost of research. Listen! — Bad times have a scientific value. These are occasions a good learner would not miss. We learn geology the morning after the earthquake, on ghastly diagrams of cloven mountains, upheaved plains, and the dry bed of the sea.

So we have once again assembled to exchange viewpoints, to weigh matter and theory, to see new developments, and to press onward together.

During this brief short course we will attempt to bring to your attention the present status of certain developments in scientific research, progress reports of agricultural projects, suggestions from men with "know-how," and timely tips from your fellow workers. The first two days are given over to the presentation of papers and subject matter. The third day is to be spent in the field where you may see and feel the thing you have heard about. You will especially enjoy the field day for it is planned for your pleasure.

But before we undertake the scheduled program I want to publicly express my appreciation to those busy men who have come from distant states to take part in this institute; and to those of the Valley who have so untiringly worked and made this program a reality. To the staff of the A & I Training Center, we are indebted for the use of their buildings and facilities. To Texas A & M College and its staff of agriculture workers we are thankful, for they are always interested and helpful and willing to serve when called upon. And to many others who have worked hard to make this short course a success.

Finally, may I again welcome each and every one of you, trusting that you will enjoy the time spent with us and that you may be enriched with knowledge and information.

General Aspects of Drainage and Irrigation in the Lower Rio Grande Valley of Texas

By

MORRIS E. BLOODWORTH

Agricultural Engineer

Texas Agricultural Experiment Station

Weslaco, Texas

M. E. Bloodworth, a native of Texas, was graduated from Texas A & M College in 1941. He has been Agricultural Engineer at Seguin, Raymondville, and Mission, Texas. At Mission he worked as Drainage and Irrigation Engineer. Since 1948 he has been the Drainage and Irrigation Engineer for the Lower Rio Grande Valley Experiment Station at Weslaco.

The historical beginning of irrigation agriculture dates back to the first days of Man and may be found in the Bible. It states as follows: "And a river went out of Eden to water the garden; and from thence it was parted, and became into four heads." (Genesis 2:10). From this it can be seen that irrigation has always had a place in agriculture, and is as old as history itself.

Many references may be found where irrigation was practiced by the ancient Babylonians, Egyptians, Indians, Chinese, Romans and early Spanish settlers in the New World. As early as 2300 B. C. found irrigation laws in effect and probably not too different from those of today in meaning.

The early Spanish explorers found Indians in New Mexico diverting water from the Rio Grande river for irrigation of corn. Even though irrigation practices are ancient in the Southwest, it has been only a short while ago, in time comparisons, that development started in this section.

The main development of the Lower Rio Grande Valley began in 1749, when Jose de Escandon founded Reynosa, Mexico. He and other early Spanish settlers foresaw the wonderful possibilities offered by the Rio Grande delta area, from the standpoint of soil fertility and irrigation, but were unable to utilize the land and water resources due to lack of means at their disposal. The early settlers had the problems of drouths, floods and distant markets for their products. In spite of these hardships, expansion of settlements was made toward the Gulf of Mexico on both sides of the river.

The Lower Rio Grande Valley is located at the southern tip of Texas. It is bordered on the East by the Gulf of Mexico, and on the South by the Rio Grande River, which forms the International Boundary between the United States and Mexico. It is composed of three counties, Willacy, Cameron, and Hidalgo, that covers an area of approximately 1,955,840 acres, or 3,056 square miles. The Valley boasted a population of 74,772 in 1920. The present population is estimated to exceed 268,000.

The topography is flat to undulating with elevations varying from approximately 30 feet at Raymondville and Brownsville, 75 feet in the Mid-Valley near Weslaco, to 140 feet at Mission. Higher elevations are

common west and north of Mission toward Starr County. However, much of the land is flat, with a large portion having slopes of 6 inches fall per mile. As a result, natural drainage channels are practically non-existent. This adds greatly to the drainage problem. Man-made floodways have been constructed during recent years and relieved many of the overflow hazards of the past.

The climate of the Valley may be classed as semi-tropical in nature with almost a year-long growing season. The rainfall is very erratic at times and varies from approximately 30 inches at Brownsville to 26 inches at Raymondville on the north, and 18 inches west of Mission. Evaporation for this same area averages 50 to 60 inches per year.

Our soils that are found on the gentle to steeper slopes may be classified as sandier types such as: Brennan, Delfina, Delmita, and Willacy series. The soils commonly found along the Rio Grande, Arroyo Colorado and low areas are clay loam to heavy clay types. The series commonly found are: Hidalgo, Harlingen, Cameron, Laredo, and Raymondville. In some localities the soil and sub-soil may be tight and impervious, causing a restricted flow of water laterally or downward. In other areas, the soils may allow a free movement of water downward for several feet until an impervious clay layer is reached. When this occurs, a drainage problem is usually found since water is added at a faster rate through irrigation and rainfall than will penetrate the impervious layers and percolate to lower strata.

For crop and citrus production, there are approximately 1,000,000 acres of land in the Valley. Of this area approximately 552,000 acres are irrigated. The principal agricultural enterprises in order of acres planted and returns received are: cotton (600,000 acres – 321,000 bales – $60,-000,000), vegetables (200,000 acres) and citrus (160,000 acres – 11,500,000 trees – 2 to 1 ratio for grapefruit over oranges).

Irrigation on any sizeable scale had its start in the Rio Grande Valley about 1876, when the first large scale plantings of sugar-cane were made around Brownsville and San Benito. Most of the plantings were made on the heavier soils and water was obtained from the Rio Grande River and resacas. This proved to be costly because the problems of salinity and water tables began to occur. In 1920, rice was started on a large scale but met the same fate as did sugar cane. In spite of these and other setbacks, the Valley has progressed rapidly in its irrigation enterprises. Today as mentioned previously, an acreage in excess of 552,000 acres is under irrigation.

Our water supply is obtained in most part from the Rio Grande River and is considered to be good water for irrigation purposes. By "good water" is meant that the total soluble salts are relatively low and are not too excessive for our soils. During the past few years, many wells have been drilled in the area north and northwest of Edinburg and east of this section to furnish water for lands that are not in irrigation districts. These areas have grown considerably and cannot be overlooked from the standpoint of additional problem areas. Some of these wells have water of good quality, but many are doubtful and may result in lowered crop production during the coming years.

Land use is a subject within itself, and only a small amount of time can be given to it now. It is believed that much of our Valley land has been mis-used from the standpoint of cropping. Many acres are cultivated, planted to citrus, and irrigated, that should actually be in pasture. Irrigation always introduces a hazard to maintenance of soil productivity and accelerates deterioration at a rapid rate. With the present shortage of water that is still facing us, it is necessary that we utilize every drop of available water and apply it to land that is best suited and adapted to the crops that are growing on it. In other words, let us plan to utilize our basic Valley resource – the soil – to the utmost by placing it in its proper classification and using it accordingly.

Even though we strive for and obtain proper land use for our irrigated lands, peak efficiency is not and cannot be obtained until the best methods and systems of irrigation and water distribution are installed on each area of land. All of our methods and systems of irrigation used in the Valley need to be studied from the standpoint of research, to determine which are best suited for certain soil types, slopes, crops to be irrigated, prevention of run-off, erosion, etc. This will involve many and varied personnel such as engineers, soil technicians, horticulturists, agronomists, and others who will be directly connected with the work involved. Probably the most important persons of all will be the people, like yourself, who are willing to cooperate in the improvement and advancement of a conservation and research program of this nature. Research along these lines is destined to play a very important role in the future prosperity of the Lower Rio Grande Valley.

The future of an economically sound irrigation program for the Valley will depend, to a great extent, upon the following:

1. Ample source and supply of irrigation water.
2. Proper land use.
3. Maintenance of soil productivity and fertility, by addition of organic matter.
4. Better planned cropping systems and rotations to fit available water allotment or supply.
5. Proper irrigation land preparation.
6. Proper amounts of water application and distribution on land.
7. Proper surface and sub-surface drainage system.

The drainage problem that is present now in the Valley is one of long standing. It has not arisen over night, nor will it leave over such a short period. From all the information that I have been able to obtain, the drainage problem started with or very shortly after, the installation of the first major irrigation project on sugar cane in the Brownsville area during 1876.

The alkali or salinity problems became rather serious around 1900. At this time, people from the lower end of the Valley requested assistance from the U. S. Department of Agriculture, and several drainage engineers were sent to this area. Surveys were made and several systems of subsurface tile were installed in 1910-12 that are functioning today.

Drainage work has been carried on from these dates to the present, but it has just been in recent years that such state and federal agencies as the State Board of Water Engineers, U. S. Geological Survey, U. S. Bureau of Reclamation and U. S. Soil Conservation Service have been able to initiate a program of operations in the Valley. Now, we of the Texas Agricultural Experiment Station and Soil Conservation Service Research, Division of Irrigation, will be in a position to cooperate and obtain basic and research information along the lines of irrigation and drainage that will be very useful to the action agencies in their work with the population of this section.

Drainage and irrigation problems are so closely related, that it is very difficult to even attempt to separate them for discussion purposes. In fact, they must be considered as inseparable companions and treated accordingly. There have been many discussions as to the cause of our present Valley drainage situation, but all seem to arrive at the same conclusions. They are generally as follows:

1. Excessive application of irrigation water and lack of land preparation for water distribution.
2. Heavy rainstorms and hurricanes.
3. Poor surface drainage system.
   a. Ditches too shallow.
   b. Heavy vegetative growth in ditches preventing flow of water.
4. Soils of low permeabilities.

From the above named causes, it may be seen that man has probably contributed more to the present Valley drainage problem than has nature. It has been a result, mainly, of the application of excessive amounts of irrigation water and lack of knowledge pertaining to our soils and their capabilities. If all of us can focus our attention on these two items alone, much will have been gained to remedy this problem.

Since these drainage and salinity problems are facing us and must be handled, we must decide what to do and how to do it as quickly as possible. The following suggestions are made as to possible relief measures for some of the local drainage and salinity problems.

1. Irrigation land preparation for a better distribution of water.
2. Apply a measured amount of water to fit crop needs and soil – get control of water.
3. Plan good crop rotations and add organic matter to retain and gain back soil structure – increase rate of infiltration and water holding capacity of soil.
4. Try to keep as much cover as possible on land at all times to keep down soil temperature and prevent evaporation during hot summer months.

5. Adequate surface drainage system.
6. Addition of tile drains—
    a. Size and type.
    b. Spacing.
    c. Outlets.
    d. Relief Pumping Wells.

From the above listed measures, it can be seen that a large part of the fight depends upon the farmer or landowner and his desires. In addition, it will probably be necessary on some of these problems, to request the assistance of certain technicians employed by the various state and federal agencies, in helping to install and maintain certain corrective measures. This assistance is available in all sections of the Rio Grande Valley.

In conclusion, the productivity, wealth and population of the Valley, have come about largely as a result of the application of irrigation water to our fertile Valley soils. It has been estimated that one-fourth of the food and clothing used in the world today is produced on irrigated land, although its area is only about five percent of the total cultivated land.

We have a good example of this locally, because on the basis of values of crops under irrigation in the Valley, approximately ten percent of the income and crops in Texas are produced in this area that contains about one percent of the cultivated land of the State. This is a good record for this section, but I firmly believe that the Valley has unlimited possibilities and will surpass these records of production and income in the future. With these points in mind, we of research, offer our knowledge, experience and full cooperation in helping solve the irrigation and drainage problems of the Lower Rio Grande Valley.

TOXIC EFFECT OF BORON ON PLANTS

By L. V. Wilcox

Soil Chemist, Division of Soil Management and Irrigation
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration

L. V. Wilcox, Soil Scientist, is in charge of the Rubidoux Laboratory unit of the combined U. S. Regional Salinity and Rubidoux Laboratories of Riverside, California. He has been in charge of the chemical work in connection with the investigation of the toxic effect of Boron on plants from the beginning, and developed the methods of analysis used for the determination of Boron; and also did most of the field work.

INTRODUCTION

Injury to crop plants, caused by toxic concentration of boron in the irrigation water, was first reported by Kelley and Brown[1] as a result of investigations in southern California in 1926 and 1927. Subsequent work by the Bureau of Plant Industry confirmed and amplified the findings of Kelley and Brown, and extended the observations to include most of the important irrigation supplies of the West. It is now known that boron occurs in injurious concentration in surface or ground waters in several areas in California and in Nevada. The areas are not extensive but, in some cases, the injury has been severe.

The purposes of this paper are: (1) To present certain facts regarding boron and its compounds; (2) To describe its effect on crop plants, and (3) To report the occurrence of boron in irrigation waters and soils.

PROPERTIES OF BORON

Boron is the chemical element that characterizes such familiar substances as boric acid and borax. Boron never occurs in nature in the elemental state but always in combination with other substances. The more important minerals are tineal and kernite, which are forms of borax, colemanite or calcium borate, and a large group of borosilicates. Borax and boric acid are quite soluble in water, and calcium borate to the extent of about 0.25 percent. The borosilicates are, in general, only very slightly soluble. Tourmaline, for example, is one of the borosilicate minerals found in soil that supplies boron to plants. Weathered tourmaline sand is very insoluble, but freshly ground tourmaline will cause severe boron injury to plants growing in it. This observation is reported to emphasize the fact that even the very insoluble boron minerals will, under certain circumstances, yield toxic quantities of boron.

EFFECT OF BORON ON PLANTS

Boron is essential to the normal growth of all plants, but the quantity required is very small as compared with other nutrients. A deficiency of boron produces striking symptoms on many plants that have a high boron requirement. On the other hand, boron is very toxic to certain

[1] *Kelley, W. P., and Brown, S. M. 1928. Boron in the Soils and Irrigation Waters of Southern California and Its Relation to Citrus and Walnut Culture. Hilgardia 3: (445-458).*

other plants and the concentration that will produce injury on these sensitive plants is often approximately that required for normal growth of very tolerant plants. For instance, lemons show definite and, at times, economically important injury when irrigated with water carrying 1 p.p.m. boron while alfalfa will make maximum growth with concentrations of from 1 to 2 p.p.m. boron.

The symptoms of boron injury vary among different plants, and some species show little or no evidence of injury on their leaves. Citrus, avocados and persimmons show the injury as a tip or marginal burning on mature leaves, accompanied by a yellowing of the tissue between the veins. Walnut leaves show a marginal burning with brown necrotic areas between the veins. The stone fruits as well as apples and pears are sensitive to boron but do not accumulate boron in their leaves or show typical injury on their leaves. Cotton, grapes, potatoes, beans, peas and several other plants show marginal burning and "cupping" of the leaf that results from a restriction of the growth of the margin.

Plants vary greatly in the quantity of boron that is accumulated in the mature leaves. Table 1 illustrates this.

TABLE 1.

Boron content of leaves in a mixed orchard planting in western Fresno County, California

(Samples collected Sept. 1, 1931. Boron expressed in parts per million on dry-weight basis)

Sample No.	Variety	Boron content	Sample No.	Variety	Boron content
		p.p.m.			p.p.m.
1059	Lemon	962	1067	Loquat	60
1060	Peach	132	1068	Plum	77
1061	Persimmon	913	1069	Nectarine	143
1062	Cherry	119	1070	Apple	86
1063	Quince	50	1071	Almond	82
1064	Grape	924	1072	Pomegranate	33
1065	Fig	2,222	1073	Olive	77
1066	Cottonwood	2,018			

From U. S. Dept. Agric. Tech. Bul. 448

This small planting was irrigated with water containing 1.39 p.p.m. boron, yet quince leaves contained only 50 p.p.m. boron, while fig leaves, in the same planting, showed over 2,200 p.p.m. boron. In the plants that accumulate boron, the highest concentration is found in the leaves, a lower concentration in the bark, and the lowest in the wood. This is shown for walnuts in Table 2.

Both the boron status of a soil and the intensity of the injury to the plants can often be judged by analysis of plant material. This is based on the fact that plants from low-boron soils contain normal or low concentrations of boron and conversely, high-boron soils produce plants of high boron content.

Table 3 shows, for nine species, the boron content of the plant material when grown in five sand-culture beds containing respectively: a trace, 5, 10, 15, and 25 p.p.m. boron. In every case, the boron content of the plant material increased with increasing boron in the culture solution. Alfalfa has been used successfully as an indicator plant for both deficiency and toxicity conditions. Normal concentrations of boron fall between the "0" and 5 p.p.m. boron values of Table 3. For citrus this is between 50 and 100 p.p.m. boron with injury indicated when the value is above 300 p.p.m. boron.

Leaf burning is only one of several symptoms of boron injury. With citrus, there is a premature drop of leaves that may be so severe that the trees become essentially deciduous. The fruit may be small with a large set or abnormally large with a very light set.

TABLE 2

WALNUTS

Boron in p.p.m. on Dry Weight

Leaves		*Twigs*	
Burned margins	2717	Bark	49
Green tissue	660	Wood	30
Midveins	118	*Nuts*	
Petioles	27	Husks	123
- - - - - - - -	- -	Shells	33
Entire	1302	Kernels	14

TABLE 3

Boron in entire plants grown in Experiment 11

	Sand culture beds				
Solution	"0"	5	10	15	25 p.p.m.
Acala cotton	16	79	156	279	383
Milo — less grain	17	102	208	292	427
Milo — grain	5	22	49	72	110
Wheat — less grain	15	237	339	401	598
Wheat — grain	tr.	23	59	57	108
Alfalfa	21	139	246	421	567
Cabbage	23	230	320	499	622
Pumpkin	17	291	601	1077	1671
Lima beans	17	319	757	1134	(1380)

PLANT TOLERANCE AND PERMISSIBLE LIMITS FOR BORON

The best information on plant tolerance is shown in Table 4. This was worked out at Rubidoux Laboratory and is essentially the same as reported by Eaton[3].

[3] Eaton, Frank M., McCallum, Roy D., and Mayhugh, Miles S. 1941. Quality of Irrigation Waters of the Hollister Area of California. 60 pp. illus.

Permissible limits for boron in irrigation water are indicated in Table 5.

OCCURRENCE OF BORON

Boron is widely distributed but in low concentrations except for a few, localized deposits. All natural waters thus far examined contain at least traces as do soils and plant materials.

Table 6 shows the boron content of water samples from a number of important irrigation supplies.

TABLE 4.

Relative tolerance of crop plants to boron

(In each group the plants first named are considered as being more sensitive and the last named more tolerant)

Sensitive to boron	*Semitolerant to boron*	*Tolerant to boron*
Lemon	Lima bean	Carrot
Grapefruit	Sweetpotato	Lettuce
Avocado	Bell pepper	Cabbage
Orange	Tomato	Turnip
Thornless blackberry	Pumpkin	Onion
Apricot	Zinnia	Broadbean
Peach	Oat	Gladiolus
Cherry	Milo	Alfalfa
Persimmon	Corn	Garden beet
Kadota fig	Wheat	Mangel
Grape (Sultanina and	Barley	Sugar beet
Malaga	Olive	Palm (Phoenix canariensis)
Apple	Ragged Robin rose	Date palm (P. dactylifera)
Pear	Field pea	Asparagus
Plum	Radish	Tamarix, or athel (Tamarix aphylla and T. gallica)
American elm	Sweet pea	
Navy Bean	Pima cotton	
Jerusalem-artichoke	Acala cotton	
Persian (English) walnut	Potato	
Black walnut	Sunflower (native)	
Pecan		

From U. S. Dept. Agric. Circ. 784

TABLE 5

Permissible limits for boron of several classes of irrigation water

Classes of water	*Crop Groups*		
	Sensitive	*Semitolerant*	*Tolerant*
	p.p.m.	*p.p.m.*	*p.p.m.*
Excellent	0.33	0.67	1.00
Good	0.33 to .67	0.67 to 1.33	1.00 to 2.00
Permissible	.67 to 1.00	1.33 to 2.00	2.00 to 3.00
Doubtful	1.00 to 1.25	2.00 to 2.50	3.00 to 3.75
Unsuitable	1.25	2.50	3.75

From U. S. Dept. Agr. Circ. 784

TABLE 6.

Boron in surface waters

No.	*Date*	*Stream*	*Boron p.p.m.*
1	11/25/35	Columbia at Wenatchee	.05
2	7/14/45	Sacramento at Tisdale	.05
3	8/1942	Colorado at Yuma	.16
4	3/1948	Rio Grande at Otowi Bridge	.08
5	3/1948	Rio Grande at El Paso	.19
6	3/1948	Rio Grande at Mercedes	.23
7	8/1941	Cache Creek at Capay Dam	1.78
8	8/30/40	Piru Creek at Piru	1.57
9	4/11/34	Sespe Hot Springs	10.2
10	8/30/40	Sespe Creek at Fillmore	2.11
11	3/9/32	Santa Clara River above Piru	.45
12	4/5/32	Santa Clara at Santa Paula	.78

The first 6 samples, listed in Table 6, are normal, uncontaminated waters. Cache Creek (No. 7) drains Clear Lake in the Coast Range west of Sacramento, California. The boron enters the stream from small geysers and hot springs. The water is used for irrigation and is satisfactory on the more tolerant crops such as alfalfa and beets, but produces severe injury on the sensitive crops. The last 5 samples (Nos. 8 - 12) are from streams in Ventura County where naturally occurring boron injury was first recognized in California. Piru and Sespe Creeks are tributaries of Santa Clara River. Sespe Creek above Sespe Hot Springs is very pure water with a boron content of approximately 0.3 p.p.m. boron. The Hot Springs (No. 9) carry about 10 p.p.m. boron. These springs discharge into Sespe Creek and raise the boron content of the water to 2 p.p.m. boron or over at the point of diversion near Fillmore (No. 10). No. 11 is from the Santa Clara River above both the Piru and Sespe Creeks. Here, the water is of good quality. The last sample represents the water below these two creeks. The boron content of .78 p.p.m. boron is sufficient to produce easily recognized injury on lemons.

Ground waters are highly variable in boron content. Adjacent wells may show very different values for boron, and not infrequently there are large differences between water-bearing strata in the same well. Usually the water from hot springs is contaminated, and often the saline water from very deep wells is high in boron.

REMEDIAL MEASURES

Where boron injury has resulted from boron in the irrigation water, there are usually two courses of action that may tend to improve the situation: (1) obtain a new supply of irrigation water of low boron content; or (2) change the planting to more tolerant crops.

At present, there is no way to remove boron economically from a water or to render it harmless.

SUMMARY

1. Boron, the characteristic element of boric acid and borax, is essential in low concentration to normal plant growth and in slightly higher concentrations is toxic to many plants.

2. Concentrations as low as 1 p.p.m. boron will cause easily recognized injury to many sensitive plants, while concentrations of 4 p.p.m. boron are about the maximum for any crop.

3. The more sensitive crops are citrus, nuts and deciduous fruits; the semitolerant are truck crops, cereals and cotton, while the more tolerant are alfalfa, beets, asparagus and palms.

4. There is no economical method for removing boron from a water or rendering it harmless. Relief can be had only by securing a better water or substituting more tolerant crops.

The Research Program of the Texas Agricultural Experiment Station

By

R. D. Lewis

Director, Texas Agricultural Experiment Station

Dr. R. D. Lewis, agronomist, was born in Wyalusing, Bradford County, Pa. He obtained his B. S. Degree from Penn. State College in 1919 and his Ph. D. from Cornell in 1926. He received his degrees in Agronomy and Plant Breeding. After his graduation from Cornell, he became assistant professor, remaining there until 1930. He was professor of Agronomy at Ohio State University becoming chairman of the department of Agronomy in 1939, as well as cooperative Agent of Ohio Agriculture Experiment Station and U. S. Department of Agriculture. In 1946 he was appointed Director of The Texas Experiment Station.

There are persons, often in high places in public life, who are apt to suggest that research should take a vacation until education of the common man "catches up." These persons apparently do not understand research, nor its relation to education. Without research that truly leads, education would become stale and without incentive. Research and education march forward together.

I represent one of the great public agricultural research institutions of this country, the Texas Agricultural Experiment Station, a part of the Texas Agricultural and Mechanical College System. Our research workers are literally seekers of the truth about the *what, why, where, when* and *how* of hundreds of agricultural problems. They apply to problems the scientific method of controlled, objective observations and measurements. They check and test their findings in various conditions and relations before they rely upon solutions or develop new principles; or before they can release new and better plants or animals for our use, profit, nourishment and enjoyment. Productive research workers in agriculture are men and women of conviction that object truth is worth discovering, and they have faith that the truth can be discovered.

The foundations for our state public educational and research institutions for service to agriculture were laid in 1862 in the Morrill or so-caled "Land-Grant" Act of Congress establishing our new great State colleges and universities.

In 1887, Congress formally recognized the need for research in problems of the soil, plants and livestock, and passed the Hatch Act to encourage the individual states to found agricultural experiment stations in connection with the previously established land-grant state colleges. So that same year, the Legislature of Texas accepted the Hatch Act and authorized the establishment of the Texas Agricultural Experiment Station in connection with the A. & M. College of Texas. That was done the next year, 1888.

Since that time, the Station has been charged by both the Texas

Legislature and the Congress in numerous acts with the conduct of research on problems concerning all phases of agriculture in this state, and, in cooperation wih Federal agencies and the experiment stations of other states, with investigations of problems of interstate significance. These relationships and responsibilities were greatly enlarged by the passage by Congress, in August, 1946, of the Research and Marketing Act, under which considerable expansion of research in agriculture is gradually taking place.

The great size of our state, its wide diversity of soil, climate, native vegetation, types of farming and associated industrial developments, have made it necessary for the Texas Station to establish many substations and field laboratories to work on problems peculiar to well-defined areas of the state. We now have 22 substations and 10 field laboratories, and we are cooperating at 10 other fixed locations with various bureaus of the United States Department of Agriculture. Research at many of these locations also has the active support of other public and private agencies. At the Main Station there are 16 subject matter departments and three service groups.

In 1923, the Legislature authorized the establishment of a station in the developing citrus belt of Cameron or Hidalgo County. That act in part reads as follows:

> "The Board (of Directors of A. & M. College) is authorized to establish and maintain a horticultural and agricultural experiment station in the citrus belt of Cameron or Hidalgo County for the purpose of making scientific investigations and experiments in the production of citrus fruits and in determining the best methods of eradicating insect pests and dangerous diseases that affect citrus trees, and for the purpose of studying the other horticultural and agricultural problems of that region. For such purposes, the Board is empowered to secure a suitable site for the location of said station, in either of said counties containing a sufficient amount of land not exceeding one hundred acres, well adapted to the growing of citrus fruits and supplied with water for irrigation purposes".

The Valley Citrus Station established east of Weslaco, in 1923, has served the Valley well even though it has been woefully under-financed throughout its history. When I survey its accomplishments and its contributions to the agricultural and industrial development of the Lower Rio Grande Valley, I am repeatedly amazed that so much has been done with so little.

On my first visit to this station in 1946, there were four professional research positions at the station, of which actually only three were filled. As of December of 1948, there are 10 professional positions, only one of which is not filled.

In the fall of 1946, I asked three individuals and a composite com-

mittee of our research staff, in consultation with growers, processors and shippers, to outline the research needs of the Valley.

All of these reports were consolidated into one entitled, "Proposal for Expanding Agricultural Research, Extension, and Graduate Training in the Lower Rio Grande Valley." This report was distributed among Valley leaders in January, 1947. It indicated that an annual budget of $360,000 would be required for a truly adequate program. Prior to the last session of the Legislature the maximum annual appropriation had been $19,037.

To conduct any research program at the Weslaco Station, the staff had to devote too much time to the production of crops for sale so as to increase available funds. Small supplements of funds were made from time to time by grants by companies, associations and from Main Station funds.

In 1946, the A. & M. College asked for a legislative appropriation for research in the Valley five times that of the previous biennium, or $100,000 per year. Despite the fact that the A. & M. College administration again and again placed this item among these of top priority, and actually raised this request by $25,000 during the legislative hearings, there was finally granted an amount equal to $47,664 per year for the present two-year period. The larger part of this appropriation is being used in the current fiscal year.

Again we are asking the Legislature of 1949 for a considerable increase in the appropriation for the Valley station: $120,000 for the next fiscal year beginning September 1, 1948, and $152,000 for the following year. These total roughly three times the current sums. Whether these funds, admittedly not yet adequate, are made available depends to a great extent on the support of the agricultural leadership of this great Valley.

The administration of the Texas A. & M. College System is fully "sold" on the needs and will do all they can to get these funds. But the determining factor is the active, unified support of these requests by those in the Valley who are convinced that a still greater research program is urgently needed.

A brief summary of the present research program of the Lower Rio Grande Valley Station indicates real progress during this past year, and with still more to be expected during the present season. Many of the details of current research findings are being reported by our staff members, residents at Weslaco, College Station, and other locations during this Institute, so I will only indicate certain major developments.

The increase in the professional staff from 4 in 1946 to 10 now is truly a big accomplishment. In addition, at least four men of our Main Station Staff give a major portion of their efforts to research affecting the Valley.

The work of the station has been greatly extended through the initiation of outlying experiments on the farms of several interested co-operators in Hidalgo, Cameron and Willacy Counties. During this past season, five systematic replicated tests were conducted at outlying locations with cabbage, two with tomatoes, two with potatoes, and three with cotton. Others with lima beans and citrus are being initiated. The fertilizer experiments with cabbage indicate that yields may be doubled by judicious use of fertilizers combined with other management practices.

Variety tests are being conducted with lettuce, lima beans, cabbage, tomatoes, sweet corn, potatoes, and special breeding programs for better tomatoes are underway in cooperation with the workers at five other experimental locations in Texas.

The influence of basic soil conditions on root distributions, health and longevity of citrus trees is underway. In this program, two men from the Main Station are actively cooperating with the local staff.

Irrigation, drainage and soil management come to the forefront of nearly every discussion of Valley agricultural problems. So we are happy to report that during the past year, four men have been added to the local staff to give major attention to basic problems in soil chemistry, drainage and irrigation. The last of these men, Emil Stuter, was placed with us in September by the cooperating Research Division of the Soil Conservation Service. Already significant advances in irrigation and drainage research are evident.

Citrus rootstock investigations, under the direction of W. C. Cooper of the U. S. Bureau of Plant Industry, Soils and Agricultural Engineering, have been greatly enlarged on the station property and at four other locations in the Valley. The Texas Station is now able to give more aid to this project and is providing technical assistance for Dr. Cooper.

The station sponsored in October an inter-agency conference on boron problems in the Valley. A boron research committee was organized and yesterday L. V. Wilcox of the U. S. Salinity and Rubidoux Laboratories in California arrived in the Valley to take part in and initiate basic studies on the boron situation and its possible solutions. The Bureau of Reclamation has made funds available for this purpose, and the Weslaco Station is making equipment and cooperating personnel available.

Insects and plant diseases are always here to plague us and upset previous calculations. Up-to-date studies and recommendations come from the work of the entomologists and pathologists at this station. We are about to make assistance available in each of these important activities. Many of the new insecticides control insects well, but may be disastrous to taste or to health of human beings – so the entomologists has to measure both the effects on humans as well as on insects!

Disease-resistant varieties of vegetables and losses of fruits and vegetables in storage and transportation are also under study.

Already then, the research program has been significantly expanded – it will be further expanded. From the Main Station we are gradually assigning a greater amount of funds for research in the Valley. The soils work here was initiated on State Chemist funds made available from the Main Station.

A considerable proportion of our new federal funds used in marketing investigations relate to Valley enterprises; specifically to costs of marketing green wrap tomatoes, margins in marketing citrus fruits and marketing of cotton.

One of the most significant recent developments in the A. & M. program for the Valley, is the closer integration of research and extension. We are pleased that the regional extension headquarters are on the station farm. Research and extension are complementary. The outlying work of the station has been greatly facilitated by the co-operation of the county agents and subject-matter specialists.

Funds are so important a determining factor in conducting adequate research programs, that I venture to mention them again: This time in terms of State-wide support of research by legislative appropriations. The Valley is by no means alone in having inadequate support for research. To bring home this point, may I cite the annual funds appropriated by a few state legislatures for research by their agricultural experiment stations in the past fiscal year of 1947-48. These are given in the following table in terms of farm and ranch, 100 acres in farms and ranches, person living on farm, or $1,000 of farm income.

APPROPRIATIONS BY STATE LEGISLATURES TO STATE AGRICULTURAL EXPERIMENT STATIONS
1947-48

State	*Total state appropriations*	*Per farm or ranch*	*Per 100 acres in farms*	*Per person on farms*	*Per $1,000 of farm income*
Texas	$ 994,156	$ 2.58	$ 0.70	$ 0.67	$0.75
Louisiana	661,323	5.11	6.59	1.11	2.24
Florida	2,303,889	37.67	17.61	9.43	5.65
New Jersey	1,783,016	67.99	98.07	16.12	8.01
California	3,250,805	23.40	9.27	6.03	1.74

In none of these states are the funds considered by agricultural interests to be fully adequate to meet the research needs!

In closing, may I assure you that we desire to serve you through a truly outstanding research and graduate training program in the Lower Rio Grande Valley, that our ability to serve depends to a major extent on the active, unified support that you request in a convincing manner through your legislative representatives.

California Citrus Production Methods Contrasted With Valley Methods

By

P. W. ROHRBAUGH

Dr. P. W. Rohrbaugh grew up on a farm in southern Nebraska. He did some undergraduate work at Nebraska Wesleyan University at Lincoln Nebraska. He received his Masters Degree at Iowa State College and his Ph. D. at the University of California. For four years he worked at the University of California Citrus Experiment Station, eleven years at the California Fruit Growers Exchange, and two years at the California State Polytechnic College, Citrus Dept. He came to Texas July 1, 1948 to become the Director of the A & I Citrus and Vegetable Training Center.

Six months in the Valley is not enough time to have become fully acquainted with all of the details of all of the production methods. Some noticeable differences are in evidence and the purpose of this paper is to point out some of these differences and to comment on some of the reasons for, or the advantages or disadvantages of, these different methods.

In general, the California grower uses much more intensive methods rather than the extensive methods used here in the Valley. The average holding of citrus acreage is between 15 and 20 acres, whereas, here in the Valley the average holding is around 30 to 40 acres.

The California grower does much more of the work in his orchard than does the Texas grower. Many of the California growers do their own irrigating, tractor work, pruning, etc., where the Texas grower depends upon the Latin laborer while he drinks coffee.

The California orange crop consists of only two commercial varieties, the Navel and the Valencia, while in Texas there are Hamlin, Navel, Valencia, Parson Brown, Temple, Joppa and Marrs.

Texas also has five or six different grapefruit, whereas, California has only one.

There is considerable marketing advantage in having only a few different fruits to sell. The housewife buys Texas grapefruit and she gets a nice Ruby Red seedless fruit. Next time when she buys, she asks for Texas grapefruit and gets a seedy white Duncan. Can one blame her if she wonders what it is all about?

About 90 to 95% of California citrus is marketed by two marketing organizations. These organizations are grower owned and controlled. They have sales representatives in nearly all major market centers. They know what and where the market is. Texas has a very large number of marketing organizations, no one of which markets more than 30% of the Valley fruit and there is no organization of shippers large

enough to keep in touch with and know what is going on in many markets.

CITRUS TREE PRODUCTION

The type of marketing and grading which is used in California makes it very unprofitable to produce low grades of fruit. It tends to make the grower do everything possible to grow the best grade of fruit and to keep it free from scale insects or other factors which lower the grade. This is especially true of lemons. All citrus fruit in California is hand picked with clippers.

In Texas a large portion of the fruit is sold by the ton before grading. The grower does not see the need or value in having clean, high quality, nice looking fruit.

In the production of trees in Texas, the nurseryman has not had the advantage of as much research and scientific information as the nurseryman in California. It is only now that the Texas nurseryman has begun to produce trees which have any assurance of being free of scaly bark or psorosis. Not nearly enough work has been done in selecting good fruiting strains. The grower in California has, for a number of years, been able to buy trees the parents of which have known records of production and freedom from psorosis.

DISEASE OF CITRUS

California has a number of serious diseases which seriously affect citrus production. They have the virus disease, psorosis, which is also a major problem in Texas. California has gone farther in its efforts to eliminate this disease by using certified disease free buds.

Texas is fortunate in not having the brown rot gummosis which destroys many trees in California. The fungus organism which causes this disease is undoubtedly killed by the higher temperatures of the Valley. The brown rot organism thrives under cool wet conditions and kills the bark of the trunk and roots. It would be quite impossible to grow citrus in California with the flood type of irrigation and the prevalence of water around the tree trunk as is commonly found in Texas. The only exception to this is, possibly, in the Imperial Valley where very high temperatures prevail and here most of the citrus has disappeared.

NO QUICK DECLINE HERE

Texas is fortunate in still being free of the disease known in California as quick decline. This disease is believed by some, to be the same as the Tristeza disease, and certainly has many characteristics in common.

While quick decline has apparently not affected grapefruit trees in California, very few California grapefruit trees are grown on sour orange rootstock and, therefore, would not be expected to be affected, as it is only trees on sour rootstock which are affected.

If the Tristeza disease, or quick decline if they are the same, does get into the Valley, it is reasonable to assume that most of the citrus trees, both orange and grapefruit, will have to be replaced. It is estimated that somewhere between 50 and 85% of the orange trees of California are on sour orange rootstock and are, therefore, susceptible to this disease.

The so-called Rio Grande gummosis which is so destructive to the grapefruit trees here in the Valley, is not a problem in California. This is probably due to low humidity in California. The presence and destructiveness of this disease which enters the tissues through breaks in the bark, makes it necessary to avoid any unnecesary breaks in the bark and to use a disinfectant and seal on any cuts or break in the bark. The prevalence of this disease makes the job of pruning a very important one. If the tree is not pruned and the cuts cared for, this disease apparently often enters the active tissues of the tree through the place where a limb has been cut off or where one has died.

INSECT PESTS

Texas is much more fortunate than California when it comes to insect pests. California has to spend far more in the control of insect pests such as red scale, purple scale, red spider, aphids, thrips, bud mite, orange tortrix and others. It is not unusual for the California grower to spend an average of $70.00 to $80.00 per acre per year on pest control. He has to resort to the use of dusts, sprays, fumigation and the propagation of parasites in insectaries.

The Valley grower occasionally finds it necessary to spray a few trees for scale, but usually gets by very well with four or five sulfur dusts per year which cost in the neighborhood of $15.00 to $20.00 per acre per year.

CULTIVATION

Most California growers continue to practice growing a cover crop during the winter and clean cultivation during the summer. There is a definite increasing tendency toward less cultivation and quite a few growers are now using oil sprays or other weed killers and doing no cultivation. Oranges usually tend to ripen a little earlier under this practice, probably due to a higher soil temperature since there is no shading of the soil.

In Texas there is a definite trend toward less cultivation, but the tendency here is to mow or chop the weeds and let them lay. This practice would seem to be definitely beneficial in that it keeps the soil cooler. It is somewhat of a fire hazard, but if the weeds are mowed often this need not be too great here in the Valley where the humidity is high.

The soils of the Valley in general tend to need organic matter and the practice of mowing the weeds and letting them lay appears to be a good way of supplying it.

Citrus trees in most parts of the Valley are shallow rooted, due to the high water table, and deep cultivation cuts off a large number of valuable roots.

FERTILIZATION

The application of nitrogen fertilizers has become more or less standardized at about 3 to 4 pounds of nitrogen per tree in most parts of California. In some places, such as Ventura County and where soil analyses are used to determine the nitrogen needs, they use as little as one pound per tree. Many growers in California follow the recommendation of the Citrus Experiment Station in not applying phosphate or potash fertilizers. Considerable manures, such as dairy manure and chicken manure, which carry a considerable content of phosphate and potash, are used.

There does not seem to be any very well established fertilizer policy for citrus fertilization in the Rio Grande Valley, but the tendency seems to be some combination of nitrogen and phosphate.

IRRIGATION

Irrigation in the Rio Grande Valley is largely by means of flood irrigation. There has apparently been considerable over-irrigation of citrus here due to several factors. It is difficult to flood irrigate and put on less than about 5 or 6 acre inches of water. Where we are troubled with high water table and high salt content and our water having a high salt content, it is important to use no more water than is necessary. Some Valley growers are now putting sprinkler systems so that they can better control the amount of water applied. Water is not metered or measured and this fact tends to encourage the use of too much water.

Nearly all citrus irrigation in California is by means of furrows, usually one or two furrows on each side of each row of trees. The water comes largely from wells and for the most part is excellent water. A few growers are using sprinkler systems. The advantages of a sprinkler system in California are not believed to be as great as in the Rio Grande Valley. Practically all irrigation water in California is metered and is paid for according to the amount of water used. Usually 2 or 3 acre inches per irrigation is used.

DRAINAGE

The problem of drainage in the Rio Grande Valley is a major one. Little of the Valley has an elevation of over 70 feet and it is a gradual slope seventy miles or more back from the ocean. This gives an average slope of only about 1 foot of fall per mile. This slope is not enough to furnish sufficient drainage, through the heavier types of subsoil, to keep the water table from rising too near the surface. Since the irrigation water, which comes from the Rio Grande river is rather high in salts, the subsurface water has a high salt content due to continual concentration. When this water table rises into the top four feet of soil, it brings this concentrated salt up with it. When this water table gets into the top four feet, it becomes very detrimenal to citrus trees. The California citrus groves are not bothered with drainage problems, except in a few places where the soil is extremely heavy. This is being overcome, to some extent, by non-cultivation practices.

PRUNING

Pruning of lemons in California is a big and expensive job. These trees tend to sucker much more than oranges or grapefruit trees do. A pruning job is necessary nearly every year on most lemon orchards. Pruning a lemon orchard costs anywhere up to $50.00 or $60.00 per acre. Oranges do not require a great deal of pruning. Very little treatment of wounds is done, except where very large limbs are removed, or where surgery work is done on the trunk. In Texas it is very important to treat all wounds or cuts in the bark of citrus trees, especially those in grapefruit trees in order to prevent the disease which is referred to as Rio Grande gummosis. This disease is one of the most important and derimental diseases of grapefruit in the Valley. The causal organism has not been adequately described but it apparently enters the tree through any opening or injury in the bark. For this reason, it is very important that every cut made with pruning shears or saw is treated with some compound to disinfect and seal the wound. The job of pruning citrus would be very small were it not for this gummosis disease. The trees in the Valley have much less tendency to produce water sprouts or suckers than those in California.

LABOR COSTS

In the Rio Grande Valley, orchard labor costs the grower about 25 to 35 cents per hour, while in California the grower pays 90 cents to $1.00 per hour to get the same type of work done.

OVER-ALL PRODUCTION COSTS

Few growers spend more than $100.00 per acre per year for the care of their orchards in the Rio Grande Valley. The range is probably about $75.00 to $110.00 per acre per year for what is considered good care.

In California the cost of good care is given as about $200.00 per acre for lemons. This additional cost for lemon is due to more frost protection, more pest control, and more pruning. Grapefruit (Desert Valley, Arizona) costs about $96.00; grapefruit (exclusive of Imperial and Coachella Valleys) costs about $195.00 per acre per year.

PRODUCTION RATE

It is very difficult to get any adequate figures as to the rate of production in fruit per acre or per tree, which would be comparable for California and Texas. There are many more young trees in Texas than there are in California. The trees in Texas are usually set farther apart than in California. The average orchard in California is set about 85 to 100 trees per acre, while in Texas the rate is about 60 trees per acre. The average production in tons of fruit per acre is probably not very far different from that in California.

FRUIT SIZES

The size of oranges in Texas is in general larger than in California. California has been hard hit in some areas around Los Angeles by small sizes of oranges. These small sizes have prevailed over a period of several years, and it is thought by many that the prevalence of industrial gases from plants developed during and since the war, is at least a contributing factor to this difficulty.

The Utilization of By-Products In Valley Agriculture

By Victor Schoffelmayer
Consultant, Southwest Research Institute

Victor H. Schoffelmayer is dean of Texas agricultural news editors. For many years he has been editor of the agricultural section of the Dallas Morning News. He has been a leader in the chemurgic movement in the Southwest, and is currently president of the Texas Chemurgic Council, and Consultant for the Southwest Research Institute, San Antonio, Texas.

The Valley's processing industries are gradually turning towards greater utilization of by-product and waste materials.

Just as the meat-packing industry finally learned to use all its waste materials so the great citrus and vegetable industries of the Valley must develop a program which includes full utilization of such raw materials as grapefruit, oranges, lemons, the wide range of market vegetables, and many others.

Every industry should look at its problem as a whole—not merely a phase of it. Complete utilization of fruits and vegetables—peel, juices, rag, butts, tops, residues, surplus crops in fields—all should become salable products through the application of chemistry, physics, biology, engineering and other applied sciences.

The Lower Rio Grande Valley is the Southwest's garden spot. It has the climate, soils, water and crop possibilities to give it a unique place in the economy of the Southwestern Region. Too, it has the right kind of people who are ready and willing to learn from other successful areas where processing has been established longer and where the latest successful methods are paying large dividends to growers, processors and shippers.

All of nature's fruits and vegetables, in the last analysis, are chemical raw materials. These materials—largely sugar, starch, protein, pectin, resins, gums, waxes, cellulose and lignin—are used by our modern industries in steadily increasing quantities. Some of these chemical raw materials are actually imported into this country from far-off regions. It is only reasonable to call the attention of our growers, land owners, manufacturers and the "Man on Main Street", to the appalling waste of most of our byproduct and waste materials because we pay too little attention to adding supplemental industries to process them.

We must remember above everything else, however, that before waste materials can be profitably processed they must be concentrated in sufficient abundance, and at a low enough cost, to assure materials.

No man in his sane mind would encourage an industry which can not possibly make a profit on its utilization of a byproduct or waste material. All that this writer is asking, however, is for our leading Valley processors of citrus fruits, carrots, beets, blackeyed peas, broccoli, pineapple, bananas and what have you to look carefully into the possibility of setting up, say, small supplementary plants alongside their larger main units.

The Valley is in need of more research chemists, physicists, biologists, chemical engineers and other scientists who will be assigned to definite tasks at finding uses for what now may be expensive wastes. These wastes are expensive when, say, several thousand tons have to be hauled away each season when they might be converted into livestock feed, into pectin, molasses, protein yeast, ethyl alcohol, acetic acid, furfural and many other needed chemicals.

Some Valley industries have upwards of 30,000 to 60,000 tons of such waste materials a year. Some managers actully pay $1 a load to rid their premises of these cumbersome wastes. But it might be far more profitable to work out an efficient chemical utilization of such wastes.

Ask Quaker Oats Company how it came to turn to rice hulls and cotton hulls as a source of furfural instead of relying exclusively on oat hulls, as the company had done for the past quarter century.

Why has Dow Chemical Company planted its own rapid-growing poplar forests to obtain cheaper and more rapidly grown cellulose for its chemical needs? Go to any of the large paper companies and see what they are doing, or visit the large California and other West Coast fruit processing plants and see what they are doing with fruit and vegetable wastes.

Those big western operators do not let their so-called waste apricots, prunes, apples, pears, grapes, peaches, berries clutter up their plants. Out of such over-ripe fruits the finest natural flavoring materials are made to be sold to candy and ice cream makers or to housewives for home use.

Do those Western processors waste thousands of tons of pectin as are now wasted in our Magic Valey? No, emphatically No! They have taken advantage (just as our Valley processors and growers can) of the newest scientific research. An entirely new wholesome product has appeared on the markets known as Velva-Fruit—a puree made from fully ripe fruits which could not be shipped. At that stage of their development they contain the highest quality of vitamins, protein, sugars, flavors and everything that makes for good eating and healthful living. Some of this type of research and effort would possibly pay Valley producers greatly. It should be investigated. All one needs to do to obtain the needed information as to these practical processes is to write to Western Regional Research Laboratory, Albany, California. The Valley has a great friend stationed there in the person of Dr. Francis P. Griffiths, formerly of Valley Vitamins, Inc., at McAllen. He will supply the needed information gladly and quickly to those needing it.

The new fruit puree is frozen into bricks and shipped all over the country as flavoring material to replace a lot of synthetic flavors. It

can be stored under refrigeration indefinitely. It is much sought by users of flavoring materials who prefer natural flavors to substitutes.

The answer to the Valley's processing problems is scientific research. No industry can long remain in the black without research—either its own staff of fact-finding scientists or availing itself of such nearby scientific research agencies as Southwest Research Institute at San Antonio, or Texas A. & M. Research Foundation, at College Station, or Texas Research Foundation at Renner, Texas, and many others ready to help.

The mere fact that so large a plant as Universal Colloid Company at McAllen now stands idle, after leading the way for many years in the field of commercial production of metallic pectinates and other pectin materials, calls for explanation. Of course, the Valley is young compared with the long history of California's fruit and vegetable processing industries. But the Valley is rapidly attaining maturity and idle processing plants should not be part of the expanding processing industries there.

What do we know about alfalfa and grass as sources of vitamins and high protein? Not too much. We are in the swaddling clothes era of such processing methods. We need to employ more technicians who can work out cheaper methods of processing carotene into pro-Vitamin A, and we need to know a lot more about extracting Chlorophyll and Xanthophyll. Chlorophyll at present constitutes one of the most profitable chemical materials derived from vegetable wastes or raw materials. Its uses are literally dozens.

The reader may wonder about some of these uses of vegetable materials other than food. Well, take pectin as an example. It can be substituted for synthetic resins as a covering for sausages, hams, bacon, candies, pills and other pharmaceuticals. It can be combined with, say, nickel, to effectually combat dysentery and diarrhea in children or adults. If we leave pectin in our citrus peel which we convert into cattlefeed we are wasting it because it adds nothing to the food value. It, therefore, should be removed and be sold as an important chemical raw material of industry. We need tens of millions of pounds of pectin and chlorophyll alone for their steadily growing uses in food and other manufacturing processes.

If, for instance, our Valley industries would discover a way to take the bitter taste out of citrus molasses (now made from peels and waste juice of canning industries in small quantities) we would produce our own important source of syrup which could be used either for animal or human food. There is a certain bitterness in that molasses which keeps it from competing successfully with corn syrup and other syrups.

There is a much larger chemical possibility in these Valley waste fruit juices and peel and vegetable tops etc. They could be fermented into ethyl alcohol and acetic acid, but another still more intriguing opportunity may be that of fermentation by feed-yeasts, such as *Torula* *utilis*, which builds up protein yeast colonies into a material that contains more than 50 per cent pure, eatable protein. A ton of, say, rag and waste juices are said to yield around 35 to 50 pounds of highgrade protein. A continuous process of fermentation has been developed at the Winter Haven, Fla., U. S. Citrus Products Station. Detailed information may be had from there by those interested. This may offer a new opportunity for one of the Valley's outstanding waste materials.

Such processing may supply livestock feed producers and mixers with a high quality protein raw material which would greatly add to the salability of their dehydrated stockfeed.

The foregoing examples are merely chosen to arouse the Valley to its latent, vast possibilities by giving wastes and byproducts of industry the research they deserve. Such research is likely to pay off handsomely.

The Valley needs new crops to round its economy. Why stop largely with citrus fruits and such staples as cotton, alfalfa and feed crops? Why not extend the papaya grove acreage and learn how to market and process this interesting fruit which is so high in papain (vegetable pepsin)?

Why not try mangoes, cherimoyas, oilseed palms, cucurbits for their oil in the seed capsules? Why not ramie as an important new fiber crop, stronger than cotton?

These are just a few suggestions for growers and land owners to think about.

The Valley needs more Chemurgic Committees, such as the one at McAllen headed by Conrad Roitsch and "Red" Salmon, before he left the Valley for the High Texas Plains. Chemurgic thinking will do a lot for Valley people. It is easy to get in a rut and to be apt to stay in it.

VEGETABLE PEST CONTROL PROBLEMS

By
George P. Wene, Texas Agricultural Experiment Station, Weslaco.

George P. Wene studied at Park College. He received his masters degree from Ohio State University and his Ph. D. from Cornell University. He has worked on tobacco insect investigation in Virginia and on the control of potato insects in New York. Since 1946 he has worked on the control of vegetable insects at the Texas Agricultural Experiment Station at Weslaco.

The most important point about any insect control program is to know the insects and the insecticides which will control those insects. Both darkling beetles and cut worms cut young tomato plants off at the ground level. Cutworms are controlled by dusting with a mixture of 40 per cent cryolite and 60 per cent citrus meal. Darkling beetles can only be controlled with a 5.0 per cent chlordan dust. So if a farmer finds his young plants cut off at the ground level, he should dig in the plant row and look for either a black beetle one-quarter of an inch in length or the greyish-black curled cutworms and then apply the proper insecticide.

Timing is a very important factor in the insect control program. In the control of tomato fruitworm injury the tomato plants should be free of worms at the time the earliest fruit start setting. So at fruit setting time begin applying weekly applications of 5.0 per cent DDT for 3 or 4 weeks.

The cowpea curculio, *Chalcodermis aenus* Boheman, is the most serious insect pest of blackeye peas. This insect causes more injury to the spring planting than to those peas planted in the fall. The female adult lays its eggs inside pea pods one-half inch or more in length. The young larvae or worms develop inside the individual peas on the pod. Since egg laying is spread over a long period of time many peas will contain partially developed larvae at harvest time. It is these partially developed larvae which have caused the rejection of many fields of blackeye peas as far as the canners are concerned. As it is impossible and also impractical to kill these young curculio inside the pod, one must apply an insecticide treatment which will kill the adult before it lays its eggs. Experiments have shown that three weekly applications, starting when the first pods are one-half inch in length, of a 5.0 per cent DDT dust will control this insect. The recommended rates are 15 pounds per acre by ground machine and 25 pounds per acre by airplane. The data in table I show the effectiveness of the various insecticides used in the control of the cowpea curculio.

The turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis), has been the principal reason that fresh market buyers and canners have rejected many acres of greens. Greens to be sold must be free from aphids and the low returns from turnip or mustard greens do not justify any extensive aphid control program. Table 2 gives a good representation of the results obtained during the past year on the aphid control experiments. All the insecticides were applied with rotary hand dusters at approximately 25 pounds per acre.

As can be seen by the data, a 1.0 per cent gamma benzene hexachloride dust was very effective in controlling this insect. This material, however, should not be used because the benzene hexachloride odor was picked up in canned turnip greens which had been dusted with 1.0 per cent pure isomer of benzene hexachloride nine days before canning.

A 1.0 per cent parathion dust was very effective in controlling turnip aphids. Parathion is a highly poisonous material. A laboratory test showed that turnip greens canned 9 days after dusting with 1.0 per cent parathion contained 4.5 part of parathion per million parts of turnip greens. This amount is considered very dangerous to warm-blooded animals. So do not use any parathion on edible portions of plants until more is known about its toxicity to warm-blooded animals.

Nicotine is used as an aphicide in many parts of the country. As shown by the data in table 2, nicotine is only effective for a short period of time. The effectiveness of nicotine varies with the mean daily temperature. The maximum effectiveness of this material is obtained when the mean daily temperature is above 70° F. During the regular growing season the mean daily is usually below 70° F. Nicotine can be used because it leaves no poisonous residue.

The mixture of 0.1 per cent pyrethrins with 1.0 per cent DDT is about as effective as the 3.0 per cent nicotine dust. This material also does not leave a poisonous residue.

Melon aphids, *Aphis gossypii* Glov., is the most important insect problem on fall cucurbits. The data in table 3 compare the effectiveness of various insecticides in controlling this insect. Parathion dusts were very effective but cannot be used because of the poisonous residues left on the melons. A 1.0 per cent pure gamma isomer of benzene hexachloride dust was very effective. This dust did not burn cucurbits but ordinary benzene hexachloride dust will kill cucurbits. So far we have been unable to detect benzene hexachloride contamination of melon when the pure isomer was used. This material is promising and could be used by growers on a limited scale until they are certain that there is no danger of contamination and plant injury.

A 3.0 per cent nicotine dust reduced the aphid population for a short period after application. However, the aphid population built up rapidly on the cantaloupes within nine days after application. Because of the short period of effectiveness, control of aphids on cucurbits with nicotine dust would be very expensive.

Since the work of Hibbs and Ewert (1946) onion thrip research work consists mainly of comparing the new insecticides with the recommended 5.0 per cent DDT dust. The results of the past 2 years are illustrated by table 4. The data in the table show that a combination of 2.5 per cent DDT and 0.5 per cent gamma benzene hexachloride is

superior to the recommended 5.0 per cent DDT. This mixture has the quick kill of the benzene hexachloride and a greater residual effectiveness than either 5.0 per cent DDT or 1.0 percent gamma benzene hexachloride. The 5.0 per cent chlordan was not as effective as the DDT-benzene hexachloride dust but may have a place in the control of thrips on spring cucurbits which are injured by both DDT and benzene hexachloride. A 1.0 per cent parathion dust was as effective as the DDT-benzene hexachloride mixture but should not be used as it leaves a very poisonous deposit on the plant.

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TABLE 1

Effectiveness of insecticides in reducing cowpea curculio injury

Treatments	Percent Pods Infested After 2 Applications	Percent Pods Infested After 3 Applications
5.0% DDT	3.3	0.7
40.0% Cryolite	5.3	1.7
5.0% Chlordan	4.0	2.0
Untreated	15.3	15.6

TABLE 2

Effectiveness of various insecticides in the field against the turnip aphid

Treatments	Aphid Population per Leaflet at following days after dusting					
	1		3		7	
	Number	Per cent Control	Number	Per cent Control	Number	Per cent Control
0.5 % Gamma benzene hexachloride	56.0	60.1	40.5	63.8	53.8	67.3
1.0 % Gamma benzene hexachloride	21.3	91.2	3.4	97.0	5.3	96.7
0.25% Parathion	22.9	83.7	6.0	94.6	35.2	79.4
1.0 % Parathion	0.1	99.6	0.0	100.0	0.0	100.0
0.1 % Pyrethrins plus 1.0% DDT (impregnated)	86.3	40.5	37.3	66.8	95.5	40.8
3.0 % Nicotine	11.9	91.5	18.4	83.6	72.7	54.9
Untreated	140.5	—	111.9	—	161.4	—

TABLE 3

Effectiveness of various insecticides in controlling melon aphids

Treatments	Ave. No. Aphids per leaf at following days after dusting		
	1	3	9
0.5% Parathion	2.1	4.0	23.9
1.0% Parathion	0.2	0.9	15.8
1.0% pure gamma isomer of benzene hexachloride	153.3	50.9	89.2
3.0% Nicotine	118.0	65.5	227.8
Untreated	295.0	257.2	312.4

TABLE 4

Effectiveness of various insecticides in controlling onion thrips

Treatments	Average number of thrips per basal 4 inches of plant after treatment applications.	
	1 Day	5-7 Days
5.0% DDT	5.5	15.5
5.0% DDT with 50.0% Sulfur	4.0	13.9
1.0% gamma benzene hexachloride	1.2	17.7
2.5% DDT plus 0.5% gamma benzene hexachloride	1.2	10.0
3.0% Chlordan	2.6	20.6
5.0% Chlordan	1.4	18.5
1.0% Parathion	0.4	10.0
10.0% Chlorinated camphene	3.8	15.4
Untreated	31.7	37.4

The Use of Anhydrous Ammonia as a Fertilizer

M. K. Thornton

Extension Agricultural Chemist

M. K. Thornton graduated from Columbia University in 1914 receiving a degree in Chemical Engineering. He has worked in Agricultural Chemistry at A & M College and has been Texas Extension Agricultural Chemist since 1938.

The topic assigned me for discussion is of great interest and has captured the imagination of the people throughout the entire country, particularly in those areas of mechanized farming.

The use of ammonia compounds as a fertilizer is an old art. During the recent war a large number of synthetic nitrogen plants were built in order to meet the military demands. At the conclusion of the war these plants became surplus. They offered the possibility of furnishing large quantities of fixed nitrogen for industrial and agricultural use. Under the unprecedented demand for nitrogen for fertilizer and the availability of these war plants, it is natural that the scientists would turn to ammonia as a possible source of fertilizer material.

Experimental work dealing with the use of ammonia in irrigation water was begun in California in 1932. In 1939, research by agricultural workers in California and more recently in Mississippi was undertaken for the purpose of determining the adaptability of ammonia in the gaseous form to our farm requirements. These investigators found that anhydrous ammonia may be used as a source of nitrogen without detrimental effects to most crops. It may be applied directly to the soil or in irrigation water. Nitrogen from ammonia is as effective in increasing the yield of crops as nitrogen in other forms, particularly when the soil is well supplied with calcium.

Yields of Crops From Fertilizing with Anhydrous Ammonia and Ammonium Nitrate. (*Delta Branch - Miss. Agri. Exp. Sta.*)

	Corn	*Cotton*	*Oats*
Check	38.6	1454 lbs. seed cotton	27.1 bu.
Anhydrous ammonia	51.1 bu.	1971 lbs. seed cotton	46.4 bu.
Ammonium nitrate	50 bu.	1974 lbs. seed cotton	43.6 bu.

Anhydrous ammonia is a gas at ordinary temperatures and pressures. It is transported under pressure in the liquid form. In the liquid form at ordinary temperatures ammonia exerts considerable pressure and is an explosive and chemical hazard. For this reason it is necessary that it be stored in high pressure containers and handled carefully. This means that storage tanks will have to be available and capable of handling large quantities of this material under high pressures. It might be handled locally in propane storage tanks, if they are equipped with proper fittings. Butane tanks are not strong enough. In addition, it will be necessary for the ammonia container mounted on the tractor or cultivator to be a high pressure tank, equipped with suitable reducing valves and applicators that will place the ammonia in the soil at predetermined depths and immediately cover it. Fittings must not be brass, copper or bronze. They should be made of high grade steel.

Since anhydrous ammonia requires such heavy equipment for storage and handling it is not likely to be practicable for the small farmer until contractors in the neighborhood are equipped to handle and distribute the material. If the acreage being treated with anhydrous ammonia is of sufficient size, the cost of application may be somewhat less than the cost of application of other forms of nitrogen fertilizer.

In applying anhydrous ammonia to the soil, the soil should be moist enough to break well. If the soil is too wet, the applicator nozzles will freeze up. If the soil is excessively dry, ammonia will be lost in the air.

Ammonia applicator nozzles should be at least three inches in the soil. If large amounts of nitrogen are being applied these nozzles should be deeper in the soil than this. Under good conditions, the soil will retain about ten pounds of nitrogen per acre per inch depth of application.

Anhydrous ammonia may be applied during land preparation before seeding, or at the time of seeding by putting it into the soil some distance from the seed. It can be applied also as a side dressing to growing crops. When applied as a side dressing the anhydrous ammonia must be drilled into the ground to about a depth of 4 inches. It can be applied to either row crops or drilled crops. When applied to drilled crops as a top dressing the distributor would normally be run across the drill furrows at right angles. In this way, it will injure relatively little of the crop.

The use of anhydrous ammonia, and liquid ammonia, is still in the development stage. As research and development work proceeds it is possible and probable that this material will be used to an increasingly greater extent.

In the preceding section of this paper, we dealt with the use of anhydrous ammonia. Perhaps it would be well to consider the use of ammonia in solution. Gaseous ammonia can be released through a suitable orifice into irrigation water and used for fertilizing crops in the same way as other liquid fertilizers.

Ammonia in solution will give excellent results although the losses will be somewhat higher than from some of the ammonium salts.

The rate of application of ammonia gas into the water should not exceed 100 parts per million. This corresponds to approximately 250 pounds per acre foot. Low concentrations of ammonia are less likely to damage sensitive crops, will lose less by volatilization and will give more uniform distribution of the fertilizer.

The use of ammonia in solution is not adapted to sprinkler irrigation because the extreme volatility of the material would result in high losses.

In irrigation water there will be some loss of ammonia into the air even though it is rather dilute. Data taken from the paper by Chapman and published in the proceedings of the 19th Annual Meeting of the National Joint Committee on Fertilizer Application, June 1944 indicates the following losses from ammonia on an acre basis. It may be observed that under ordinary methods of handling the amount of loss is relatively small.

TABLE I

Calculated Ammonia Losses From
Irrigation Waters at 25° C.

Concentration of NH3 in water: 50 p. p. m. nitrogen [1]

Length Exposure of Acre Water Surface [2]	Solution Quiet	Solution in Motion [3]
Hours	Percent Loss	Percent Loss
0.25	0.7	1.5
0.50	1.4	3.3
1.00	2.9	6.6
2.00	5.8	13.2
4.00	10.6	26.4

[1] 45.3 pounds nitrogen applied in 4 acre inches of water will give a concentration of 50 p. p. m. N.

[2] The time required for 4 acre inches of water to disappear in soil.

[3] Induced by continuous stirring at a rate to simulate the most rapid movement likely to occur in flow under field conditions.

Owing to the difference in cost between ammonia and its compounds, a small loss by volatilization may not be objectionable.

From the above, I believe that we can see that the use of both anhydrous ammonia and aqueous ammonia will find increasing application throughout certain of the sections of the country.

VEGETABLE SEED PRODUCTION

By Walter H. Baxter Jr.

Walter Baxter Seed Co., Weslaco, Texas

Walter Baxter, a native Texan, received his degree from Texas A & M College in 1923. He has lived in the Rio Grande Valley for the past 29 years, being actively engaged in Vegetable Seed Production for the past 20 years. He is President of the Texas Seedmen's Association.

The production of vegetable seed in this country started with the harvest of the first crop after the white man settled here. These seed, however, were far from the type used today. They consisted of the few known vegetables that the Pilgrims brought over with them and those they saw the Indians using. The Indians, however, used a type of maize or corn as their main crop rather than vegetables. Nevertheless, these early efforts by our forefathers marked the beginning of the industry in this country. Since that early beginning great strides have been made and today the seed industry is one of great importance. After all, to produce food we must first plant. There will always be seeding time and harvest on this globe if human life is to exist.

From an early beginning in the New England States the seed producing areas have spread until they reach the West Coast. As the lands of the East lost some of their fertility the seed growers moved westward. However, there are still some vegetable seeds produced in the East on land that has been in cultivation over 200 years.

The East can still grow some seed as good or better than any other area. Much of the trial ground or breeding work is still done there. It is no wonder that for many years Philadelphia was considered the seed headquarters of the New World. This held true until the turn of the century when the West was opened up to the plow and the people established themselves as farmers.

As the railroads extended their lines West and farming increased, the use of seed increased. Soon the farmers realized the necessity for the development of new varieties of vegetables that could stand the longer haul to market. This was the job of the seed grower. Much research was required and many years of hard work were put into the development of these new varieties of vegetables.

There are always a great many things to consider in the development of a new vegetable. For instance, its edibility, its carrying qualities, its appearance, its adaptability to the area of production must all be considered by the seed grower. Many plant breeders have worked for years on one single variety of vegetable only to see it go to pieces before it was considered desirable. One such case was that of a plant breeder who had worked for five years trying to produce a tomato which contained more vitamin E than any other – only to find at the end of his fifth year that it was impossible to get his tomato off the plant without pulling the core of the fruit out too. Thus many hours of hard work came to nought.

We must not look too long at the failures, but think of the many fine vegetables we enjoy today that we just take for granted, not realizing how many years have been spent in their breeding and growing. Many men have spent their lives producing better varieties of vegetables for all of us to enjoy.

Since this country was settled by people from all over the world, there was a demand for the vegetables each nationality had enjoyed in their native lands. This gave vent to the importing of seed from the older seed growing areas. Therefore, for many years most of the seed used in the United States came from foreign countries. It was not until the advent of World War I that this country realized that we had to produce vegetable seed for ourselves.

Our first attempts at seed production were like most early ventures, but by the second harvest time we found the proper locations to grow certain crops and the crops were good. Within a few years after the war we found that we could grow most seed as well or better than anyone else. With hard work and American ingenuity our new found industry grew to great proportions. For example: whereas before World War I we got most of our carrot seed from Belgium and France, now the United States produces most of the world's supply of this seed. This is true not only of carrot, but also of many other vegetables.

Corn being a native of this continent has probably shown the greatest development of any cultivated crop. Sweet corn is the only corn classified as a vegetable rather than a cereal grain, nevertheless great strides have been made in increasing the production of all kinds of corn.

The greatest development made in increased corn production came with the scientific crossing of different varieties. This method of crossing produced hybrids and today most varieties of seed corn planted are hybrid varieties.

To produce any kind of hybrid seed requires a great deal of scientific work which is done by experts in their own field. That is why the seed produced by this method is higher in price and always will be. The crosses must be made each year as the cross cannot be reproduced from the completed cross or hybrid. With this hybridizing method fully developed wonderful results have been attained. This year's mammoth yields of corn are an example of plant improvement methods.

The fine results obtained with corn encouraged the growers to try the same idea for commercial vegetable seed production. This has also produced some amazing results, but not so outstanding as that of hybrid corn. Today there are many known vegetable hybrid seeds offered by seed firms and their value is still in the experimental stage.

There are two trends of thought among seed breeders. Some are of the opinion that single plant selection, as to type and purity, is the best method, whereas others think that the hybrids are the answer. Of course, the old way of single plant selection has been the tried and proven method for many years and it is hard to make radical changes very suddenly, but we do have something to look forward to as work goes on in the hybridizing of vegetables.

It might be of interest to you to know how some of the single plant selection work is done. As an example, suppose we find a very desirable radish in our trial plat. This particular radish has all the qualities desired as to trueness to type and color; in other words, it is what we would like for all that stock of radish to be, so we take this one radish and replant it off to itself and watch it grow. When the plant starts to bolt or shoot a seed stem we place a bag over the whole plant. This is done to keep insects and pollen from any other radish from coming in contact with the seed flowers. After the seed pods are formed they are allowed to dry and are harvested and stored until the next planting season.

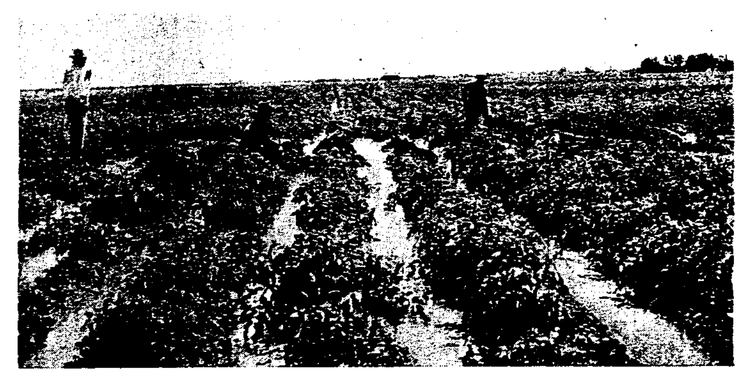
When the proper time comes, this stock seed from this single plant is planted in a small plat. This plat is covered with a wood frame about six feed high and of necessary width on which a light canvas is placed to make it absolutely insect proof. This is done in order that no insect may bring in outside pollen and cause the desirability of the plant to be changed. As the plants continue to grow and the seed stems form, the plant breeder places a piece of raw meat in the inclosure that has been allowed to become alive with green maggots. These maggots soon hatch out and become adult green flies and begin their attempt to escape the inclosure. In their attempt they crawl all over the plants, their blooms and the inside of the inclosure. This gives the blooms the necessary pollination and the seed pods form without any chance of outside crossing. Therefore, we have multiplied this one single radish into what is known as "Stock Seed from a Single Plant Selection."

This is told merely to give you an idea of the work done by the plant breeder to develop better seed and to keep the known varieties as pure as possible. There are many other ways that the plant breeder works in our behalf to develop vegetables, that have more food value as well as market appeal. Their job is endless and many times their efforts are short lived because of market changes and new varieties that replace the old.

It has often been asked why we cannot produce seed in this area. The answer is we *can* on some things, but on others it is impossible because of our warm climate, the high price of our land and the cost of production. In other areas where seed is produced the land is cheaper and production costs are not so high. Then, too, it takes two years for some vegetables like beet, carrot and cabbage to produce seed and it is impossible for us to store these through our warm weather. Another factor that is most serious is the high humidity we have. This moisture in the seed is very detrimental and causes the seed to soon lose its germination and vitality. It is even necessary that we keep all planting seed in cold storage in order to preserve its value;

so you can readily see the task we would encounter if we undertook to save seed on a large scale. Nature has endowed certain spots on earth with certain qualities that make them excel in producing certain things and we have learned that it is best to get our supply of vegetable seed from areas that have the climates that tend to produce seed with the highest germination and the strongest vitality. You may rest assured that most reliable firms will supply you with stock that should be from proven seed producing areas.

It has been my privilege to have covered most of the seed growing areas in this country and in almost every instance I have found the seed grower trying to produce the finest seed possible. There is still a great deal to do to get better stocks and to keep them clean after we get them, but it is a big job and may never reach perfection.



IRRIGATING FIELD CROPS IN THE RIO GRANDE VALLEY

Recommended Vegetable Varieties For the Lower Rio Grande Valley of Texas

By
J. B. CORNS

Joseph B. Corns received his B. S. degree from Texas A & M College in 1927, majoring in Horticulture. He received his M. S. degree from the University of California in 1930 with a major in Citriculture. He received his Ph. D from Cornell University in 1937 with a Vegetable crops major and Pomology and Plant Physics minors.

He was assistant professor of Vegetable Crops at the University of Illinois from 1937-1941. He served in the U. S. Army as officer in charge quartermaster market centers from 1941-1946. He was director of the Citrus and Vegetable Training Center of Texas A. and I. College from 1946-1947 and is now head of the Department of Agriculture of Edinburg Junior College.

There is a larger number of varieties found in the vegetable crops than in any other field of crop production. Many of these varieties are duplications. Some varieties have only slight differences and should be known as strains instead of varieties. Leading seed companies are working to reduce the number of varieties and to eliminate varieties which are of minor importance or which are practically the same as some other named variety.

Here in the Rio Grande Valley there has been the trend toward standardization on a few of the best adapted varieties rather than to grow a large number of varieties. An example of this is shown with tomatoes. Several seed catalogues list 50 or more varieties of tomatoes, but of these 50, there are only about 6 that are commercially grown here in the Valley and more than 95% of the tomato crop is grown from 4 leading varieties: Rutgers, Stokesdale, Valiant, and Grothen's Globe.

The varieties of seed offered for sale are constantly changing. Each year some varieties are dropped from the offerings of the seed companies, while other newer and improved varieties are added. It is significant to note the very large amount of breeding work which is being carried on by the U. S. Dept. of Agriculture, the State Experiment Stations, and the seed companies in introducing varieties which not only produce more, but also have better shipping qualities, and have certain resistance to insect and disease damage. Most of the varieties of today will within the next five years be discarded in favor of newer and more productive varieties.

It would be beyond the scope of this paper to discuss the leading varieties of all vegetable crops produced in South Texas, so only the crops of major importance will be considered.

TOMATOES

The tomato crop is the No. 1 vegetable crop of the Valley based

upon carlot shipments and upon acreage planted. There is a fall crop and a spring crop, but the fall crop is small by comparison.

Gothen's Globe: For the fall crop the leading variety is Gothen's Globe, which is used for the green-wrap shipping and is an early maturing variety. This is considered to be the earliest of all varieties suited for our conditions. This variety resembles the Break O' Day, but has a bright red color with the fruits medium large, globular, firm, and solid.

Valiant: Another variety which is a first early and is so used both for the fall and the spring crop. This is a short-season early variety requiring about the same time for maturity as the Grothen's Globe. The fruits are large for an early variety and are globe shaped with a bright scarlet color. An objectionable feature of this variety is the sparse open growth of the plants, which exposes the fruit to sunscald. In addition it does not hold up well in green wrap shipment.

Rutgers: For the main or spring crop the Rutgers is the number one variety and far exceeds all others in acreage grown. This is an excellent variety for all purpose use and has wide adaptation, but is 2 to 3 weeks later maturing than Grothen's Globe or Valiant. The variety is partially resistant to Fusarium wilt which is a distinct advantage. It is an excellent shipping variety and is definitely preferred by the shipping trade.

Stokesdale: This is a fairly early maturing variety, though a few days later than the two early maturing varieties. It is rather extensively used for the early spring crop.

CABBAGE

Cabbage varieties are continually changing and the trend is toward smaller headed varieties, since that is the preference shown by the consumer. Some of the present varieties are passing out and are bein·· replaced by smaller headed sorts. At present, the Texas Experiment Station is carrying on some trials using as many as 43,000 cabbage plants per acre in an effort to secure a variety with a high yield, but with small heads.

Glory of Enkhuizen: This is the No. 1 cabbage variety of the Valley and produces large, round, solid heads with large gray-green outer leaves. It is of excellent quality. This variety is a popular, medium-early cabbage and is a very good shipper. The principal objection to the variety is that the heads are larger than desired, especially when produced on land of high fertility. Closer planting may be the solution to this problem of large sized heads.

Marion Market: This variety is the No. 2 cabbage variety of the Valley and has about the same season of maturity as Glory of Enkhuizen. The heads are round, firm; the leaves blue-green; and it is well received on the market. It is a development from the Copenhagen Market, but the heads are a little larger and later maturing.

Midseason Market: This variety is the same season of maturity as the Marion Market, but the heads are larger and are globe-shaped on short stems, with medium yellowish green leaves, and of good texture and quality.

Green Acre: This is one of the newer varieties and is an improved strain of the Golden Acre. An increasing acreage is being grown and it is showing up very well. It is an earlier variety than any of the other described varieties and has the advantage of holding its green color longer, which is a distinct advantage for shipping.

CARROTS

Imperator (Long Strain): This is the No. 1 bunching and shipping carrot variety of the Rio Grande Valley, and is probably the most extensively grown variety in the country. The tops are medium length, but are sufficiently strong for good bunching. The roots have rounded shoulders, smooth, deep rich orange color extending to the core, and are of excellent quality.

Chantenay (Long Type): This is a second carrot variety here in the Valley that serves both for bunching and for canning. It is nearly a week earlier than the Imperator. It has roots that are smooth, tapered, stump-rooted; and a very good deep orange flesh with an indistinct core.

Red Core Chantenay (Canner): This is a strain of the Chantenay variety especially bred for the development of interior color, which is a quality demanded by the canning trade. The roots are somewhat shorter than the Improved Chantenay; the flesh is reddish orange with indistinct core of nearly the same color.

POTATOES

Bliss Triumph: This is the principal variety grown in the Rio Grande Valley. It is very early, round, red-skinned, with reddish violet sprouts. The vines are small and compact and the yields are not large. Its prime advantage is its earliness and its good adaptation to the soil and weather conditions of South Texas.

GREEN CORN

Green corn is a very important spring crop for the Rio Grande Valley. No variety has yet been developed which is ideally suited for the Valley. The corn earworm is the major problem in sweet corn production, therefore much breeding work is being done, both in South Texas and in the North to secure hybrids that are less susceptible to earworm damage. Mr. E. V. Walter of the U. S. Dept. of Agriculture has carried on extensive breeding trials here in the Valley for a number of years, and from these trials some promising hybrids are being produced which have resistance to earworm injury coupled with high-yielding qualities.

Ioana: This is the leading yellow sweet corn hybrid now grown in the Valley. This hybrid was originated by Iowa State College, and was commercially developed by the Associated Seed Growers and was awarded the Bronze Medal in the All-America Trials in 1939. It is an attractive

hybrid which is very resistant to wilt. The ears are 7½ to 8 inches long, 12-14 rowed, and well filled with medium-narrow light yellow kernels.

Erie: There is a limited acreage of this new hybrid being grown, and it is probable that more will be grown in the future. This hybrid was awarded Honorable Mention in the All-America Selections for 1947. It has about the same season of maturity as Ioana or about 88 days. The ear is 12-14 rowed, cylindrical and slightly tapering. This is a promising variety for the Rio Grande Valley.

Bantam Hybrid No. 57: This is a new introduction which has considerable earworm resistance. This variety has shown promise in the trials and will likely be used in increasing amounts when more seed is available.

ONIONS

The production of green and dry onions is an important industry in the Valley. Green onion production, however, is small as compared to that of dry onions. The four leading varieties in order of their importance are: Excel, Yellow Bermuda, Crystal Wax, and Texas Grano.

Excel: This is the leading variety of South Texas. It is a heavy yielding variety of the Bermuda type which was developed by the U. S. Department of Agriculture in cooperation with the Texas and California Experiment Stations. It is approximately 10 days earlier than other Bermuda varieties and is more resistant to splitting and bolting, which makes Excel a preferred variety. It produces bulbs that are uniformly thick-flat; with small tops and necks. The variety Excel received the All-America 1948 sectional award for the Bermuda onion growing areas of the South and Southwest.

Yellow Bermuda: This variety produces medium sized flat type bulbs. The skin is light straw color, thin, and loose; flesh nearly white, sweet and mild. This variety is of second importance for the Lower Rio Grande Valley.

Crystal Wax: Sometimes called White Bermuda, this variety is essentially the same as the Yellow Bermuda previously described, except for color. This is the variety to supply the trade that prefers the early white onion.

Texas Grano: This variety is a selection from the Babosa (Early Grano) made at the Texas Winter Haven Experiment Station. It was selected for greater uniformity of maturity and earliness. It is a desirable strain for Texas and may well increase in popularity with the trade.

BEETS

The beet production for the Rio Grande Valley is primarily a shipping deal, so the principal varieties are those for bunching.

Green Top Bunching: This is the leading variety and is by far the most important. It is characterized by the green tops which are erect, uniform in size and color, and it bunches very attractively for the market. The roots are round when young, becoming flattened globe later, deep red, smooth, with small tap root. The flesh is a deep dark red, tender, and of excellent quality.

Detroit Dark Red: There is some acreage of this variety which is particularly adapted for canning, although some are used for bunching. This has long been a favorite with the canning trade due to the dark red color of the flesh with only indistinct lighter red zones, which produces an excellent canned product. It is about 10 days later maturing than the Green Top Bunching.

Perfected Detroit (Canner): This is an improved strain of Detroit which is well adapted for canning and is of second importance only to the Green Top Bunching here in the Rio Grande Valley. Its general characteristics are the same as those described for the Detroit Dark Red.

PEPPER

The pepper crop has been of lesser importance to the Lower Rio Grande Valley, but has shown a steady increase in production during the last 5 years.

California Wonder: This is the leading variety grown. The fruits are mostly 4-lobed, very attractive, smooth, uniform and deep green, changing to bright crimson; the flesh is very thick, sweet and mild. The plants are vigorous, upright, and yield well. The season of maturity is about 75 days from the time of setting the plants in the field.

BEANS

A large acreage of beans is grown here in the Valley. Some of this acreage is for canning, but it is mostly for shipping.

Stringless Black Valentine: This variety is of first importance for the shipping trade, and is well adapted for long distance shipping, since it retains its color and texture very well. The plants are erect, prolific, and bear very attractive oval pods, nearly straight, dark green, strictly stringless and of fine quality and flavor. It matures in about 50 days, so is classified as an early variety.

Stringless Green Pod or Tendergreen: This is a variety of first importance for the canning trade. The plants are of medium size, bear well, and the pods are nearly straight, dark green, round, meaty, and succulent. It has the same maturity as the Stringless Black Valentine.

U. S. No. 5 Refugee: This is of second importance as a canning variety, and is grown extensively. It is highly resistant to common bean mosaic and the plants are similar to the regular Refugee except the pods are slightly smaller in diameter and are longer.

Ranger: This variety, an improved Refugee, is a new introduction which won the All-America Bronze Medal in 1947. The variety is characterized by its pecuilar habit of growth, disease resistance, and high yield. It is a canning variety. At this time a very small acreage has

been grown here in the Valley, but unquestionably, a greater acreage will be grown in the future.

Cowpeas: Cowpeas are more properly grouped with beans than peas. This is coming to be a very important crop for canning and will likely continue to increase since cowpeas can be used as a soil-building crop that also produces some revenue. The Purple Hull (Brown Eye) and the Black Eye, Half-runner are the principal varieties used.

EGGPLANT

This is a crop of secondary importance that is shipped mostly by truck or loaded in mixed cars.

Black Beauty: This is the No. 1 variety of the Valley, constituting practically all of the plantings. The fruits are large oval shaped, smooth, very dark purple, and will hold color well after picking.

Fort Myers Market: This is the only other commercial variety, but the plantings are very light as compared with the Black Beauty. Fort Myers Market is characterized by producing tall plants that are vigorous and very resistant to blight and other diseases. The fruits are long, oval, with no neck at the stem-end; a characteristic that distinguishes them from the globe to oval-shaped fruits of the Black Beauty.

LETTUCE

Lettuce is the crop which has shown the greatest increase in acreage during the last three years, and will likely continue to increase since the varieties that have been introduced are adapted especially for South Texas. This subject will be discussed at length in another paper on the Institute program, therefore little will be given here about the recommended varieties. The two leading varieties are Great Lakes and Cornell No. 456.

Great Lakes: A sure heading variety which is slow-bolting, shows considerable resistance to tipburn, and matures in about 83 days.

Cornell No. 456: A variety developed by the U. S. Dept. of Agriculture and Cornell Experiment Station as a summer lettuce for New York, it has proved to be one of the best varieties for South Texas. The heads are a little smaller than Great Lakes and mature a few days earlier.

BROCCOLI

There are only two main varieties grown here in the Valley: DeCicco and Medium Sprouting.

DeCicco: This is the more important of the two varieties and is about 10 days to 2 weeks earlier than the Medium Sprouting. It is equally good for bunching or for freezing and is very productive. The plants are medium tall, light green in color and will mature in about 60 days.

Medium Sprouting: This variety is later maturing than the variety DeCicco, but the plants are larger, more vigorous, and will produce sprouts over a longer period.

Lettuce Production in the Rio Grande Valley

By

J. R. Padgett

Manager Demonstration Farm

Rio Farms, Inc., Edcouch, Texas

Mr. Padgett spent 6 years with the Forest Service, starting when it was a part of the Department of the Interior and transferring with it to the Department of Agriculture. The next 25 years were spent in operating farms and ranches in various sections of the United States, from Wyoming to Texas and in the Republic of Mexico. He returned to the Department of Agriculture to work for the next 10 years on farm management and crop production programs. Mr. Padgett was assigned to this section of Texas when Rio Farms was started and helped in its organization. He remained with this organization and for the past 7 years has been the Farm Demonstration Manager of Rio Farms, Inc., Edcouch, Texas.

The production of head lettuce on a commercial basis, is new in the Valley. It is so new, in fact, that is is yet on an experimental basis and will probably remain there for several years to come.

Many growers have attempted to establish this crop in the Valley since it became an agricultural area, but have failed – primarily because the crop bolted, or went to seed, before a firm head was established. Only within the last two or three years has this tendency to bolt been overcome and that was accomplished by the introduction of new, heat resistant varieties of lettuce into the area.

Apparently, many breeders have been coping with the problem of fortifying their new lettuce varieties with the ability to reach a normal development in areas previously thought too hot for lettuce growing. Several varieties have lately demonstrated their ability to produce excellent crops in the Valley with little or no bolting. The first of these that came to the attention of Valley growers, are Great Lakes and a variety known locally as Stewarts Special.

In November 1946, these two varieties were planted on the test plots of the Demonstration farm operated by Rio Farms, Inc. at Monte Alto. The two varieties were planted side by side on the same day and given identical treatment. The planting was made on a rather light sandy loam that sloped into a lagoon area where the soil was dark in color and considerably heavier. In ninety days, the Great Lakes variety growing on the heavier land was ready to cut and the Stewarts Special was ready on the ninety-seventh day. On the sandier areas of the two varieties, maturity came some 8 to 10 days later, by which time all the crop had been harvested from the heavier soil. Both varieties produced an excellent crop of firm heads that graded largely No. 4 U. S. Fancy. There were about 30% No. 5 and probably 5% No. 3. The larger heads were produced on the heavier soils. The Great Lakes cut 300 boxes per acre and the Stewarts Special, 350 boxes per acre. There was very little difference in quality. The following year, in the

fall of 1947, both Great Lakes and Stewarts Special were again planted on Rio Farms' test plots and a third variety – Cornell 456 – was added. The planting date was moved back some thirty days – to October 11 – and the same type of soil was used as on the previous year. This year, due to an unseasonably hot December, we were harvesting lettuce in sixty-five days, and both the quality and yield were far below the previous year. Of the three varieties, Great Lakes, Stewarts Special and Cornell 456, the latter variety yielded a higher percentage of merchantable heads of a uniform size, than either of the other varieties. Again with all three varieties, the earliest and best production was on the heavier soils. Our average production for this season was 186 packed out crates.

It has been necessary to refer to the work done by Rio Farms on its demonstration plots, because I am familiar with their results. Consequently, I can report their findings with accuracy.

The third year's work with lettuce, is now drawing to conclusion on these plots and many varieties new to the Valley, are approaching maturity. These include Ferry-Morse Strain of Great Lakes, also their Imperials No. 44 - 152 - 615 - 846 and a new Woodruff introduction known as A36. It is too early, at this time, to report on these varieties, but at this time (December 1st), they all seem happy in their Valley environment. It is reasonable to expect that among them, there are varieties that will equal or surpass those that have already made good under our conditions.

There is every indication that lettuce will become one of the major vegetable crops of the Valley. Many factors, at this time, point to this conclusion. Our sandy loams are ideal, especially where they are well supplied with organic matter. The 7.5 near average pH of our Valley soils, is satisfactory for the production of high quality lettuce. Our water situation during winter months is seldom an embarrassing factor and our labor situation is far better than any other lettuce producing area in the United States.

There are many things that we will have to learn and apply, before this becomes a major crop, such as, the selection of proper soils and fertilizers and the most efficient methods of applying these fertilizers. It has been demonstrated in the older lettuce growing areas, that the use of manure as a fertilizing agent is profitable. Tests over a five year period in California, demonstrated that a combination of manure and commercial fertilizer produced better yields and quality than either straight applications of manure or commercial fertilizer. This practice is followed consistently in that section where manure is available. It is also found desirable to place all fertilizers in an area as close as possible to lettuce plants. They have a relatively small root system and profit most from nutrients within easy reach. It may develop that a fertilizing practice that will further lower the pH of our soils, will be found desirable. This crop seems to thrive better on soils that seem to have a slight acid reaction; however, its performance is satisfactory in California soils, with a pH considerably higher than our Valley soils.

In the light of our experiences on Rio Farms, it is probable that the lettuce industry in the Valley will reach its most profitable levels on the heavier sandy soils, typical of the Santa Rosa, Rio Hondo or Raymondville areas, and where special effort is made to maintain a high organic content in the soils.

Apparently, there is not much to fear from disease or insect losses. Lettuce is subject to many diseases, but few losses have occurred in any of the areas where it is commonly grown. Its chief insect enemies are plant lice or aphis, and green loopers, both of which are easily controlled with insecticides now available.

The introduction of the Great Lakes variety of lettuce has revolutionized growing and marketing conditions on lettuce. Prior to the development of this variety, there were peaks and valleys in the marketing of lettuce, because old varieties would only produce under certain conditions and at certain times. Great Lakes has the ability to produce under most any condition and at most any time and consequently, has leveled off the valleys' in selling, so that now there are no periods when the grower does not have ample competition on the markets.

This situation reflects to the Valley's advantage, because of the factors previously mentioned, i.e. - land rentals far cheaper than competitive areas, ample water and a fair assurance of water at the critical period, and an inexhaustible supply of cheap labor. Competent authorities, who are familiar with the details of lettuce production, figure that the Valley can raise, pack and market a box of lettuce at a price of one dollar less than any competing area – which alone assures lettuce of a place in the picture of Valley activities in the future.

CHEMICAL WEED CONTROL

J. W. Gibson,

Technical Service and Development,
The Dow Chemical Company

J. W. Gibson is a native Texan, a graduate of the School of Agriculture of A & M College of Texas. For the past three years he has been employed by the Dow Chemical Company as a representative of their Technical Service and Development Division, devoting much of his time to solving vegetation control problems.

The control of weeds by chemical means is not a substitute for other methods of weed control such as tillage. In the case of row crops, weed killing chemicals make it possible to reduce the amount of hand weeding necessary. In drill crops and in pastures, they make possible the control of weeds which otherwise would not be controlled. Discoveries of new weed killing chemicals during the past few years, and an understanding of the special techniques necessary to apply them are the basis for the development of a new era in agriculture as revolutionary, perhaps, as the adaptation of the gasoline tractor to farming. In certain crops, chemical weed control has brought about greatly increased yields and net profits.

It is important for every grower to understand that there is no "shot-gun" chemical or method of controlling weeds. The right material must be used in the right way at the right time and in the right place. Of course this requires a certain amount of basic information regarding herbicides and how to use them.

We can divide chemical weedkillers into several general classes, based on the manner in which they act on the plant.

1. *Soil Sterilants.*

Soil sterilants kill by creating a toxic condition in the soil, the duration of which depends on the chemical used and the quantity applied, as well as soil and rainfall factors. Where a vegetation-free condition is desired, arsenicals, boron and chlorates may be used provided sufficiently heavy applications are made and repeat treatments put on as required in the event of plant recovery. Chemicals such as these as well as certain volatile gases such as carbon bisulfide have been used for treating localized areas for the eradication of perennials such as field bindweed and Johnson grass. To a large extent, 2,4-D has replaced the soil sterilants for the control of many perennial weeds. Certain chemicals that break down quickly have been used for killing weed seeds or preventing their emergence. Among these is calcium cyanamid, which has been used for treating tobacco plant beds and certain other areas.

2,4-D is being used to control grass seedlings as well as seedlings of broad-leafed weeds. As a pre-emergence spray, it controls weeds without damaging certain less susceptible crops such as corn. Soil type, rainfall, depth of planting, and crop are factors which influence the success of pre-emergence weed control with 2,4-D. On many crops, this development should be considered still in the experimental or trial stage.

Recently it has ben found that Dowfume MC-2 (Methyl Bromide containing 2% Chloropicrin) when properly applied. will give an excellent kill of weed seeds, underground bulbs, rhizomes, roots, as well as nematodes and other soil pests. Dowfume MC-2 gas must be confined in order to build up a concentration that will be toxic to weed seeds, Johnson grass and Bermuda grass rhizomes, and to nutgrass nuts. This is accomplished by placing a gas-proof cover over areas to be treated such as hot beds, cold frames, seed beds and flower beds. An attractive feature in the use of Methyl Bromide as a weed seed killer is the fact that 96 hours after the treatment is applied, the ground will be sufficiently free from gas to allow seeding or transplanting.

2. *Contact Herbicides*

Several different materials have been used from time to time to kill top growth by contact action. These materials are not absorbed, translocated and carried into the roots. Also, there is little likelihood of drift injuring other vegetation in the vicinity, if reasonable care is taken to prevent the spray from actually wetting the other vegetation. In fact. thorough wetting is necessary for these contact herbicides to be effective as weed killers. Small annuals are killed by a single treatment, but perennial plants are killed only by repeated application and gradual exhaustion of the root reserves. A common contact herbicide is petroleum oil. Recently, certain phenolic compounds applied in oil emulsions have come into use. These sprays give a contact action similar to that of straight oil and since they contain considerable water are in many instances less expensive for treating ditch banks, roadsides, orchards areas and fence rows.

Contact herbicides are sometimes used to eradicate annual weeds from such established perennial crops as alfalfa. Usually the spray is applied during the season when the alfalfa is relatively dormant. The alfalfa is harmed very little if at all but most small weeds are killed. In one sense this is a selective syraying technique, yet all exposed foliage is burned.

3. *Selective Herbicides*

When applied under proper conditions and at suitable concentrations, selective weedkillers control weeds without harming crops. There are four types of selective weedkillers, based on the way they affect the plant:

(1) Selectivity based on minimum wetting of the crop and limited absorption of the toxicant because of leaf wax protection. If foliage is treated while crop plants are quite small, grains, flax, peas, alfalfa, gladioli, and under some conditions onions, are difficult to wet by aqueous sprays because of their leaf shape and relatively thick and continuous leaf wax or cutin. That part of the toxicant which does adhere to the plant is not readily absorbed. In recent years, salts of certain phenolic derivatives have been widely used for the control of annual weeds, particularly in the United States and Canada. Among the commercial products which are used as selective herbicides in this category are Sinox-W and Dow Selective Weedkiller. Other materials which have been used as selective contact weedkillers include sulfuric acid and sodium pentachlorophenate.

(2) Selectivity based on the physiological resistance of carrots, parsley, parsnips and related plants to certain petroleum fractions. Since about 1942, Stoddard solvent, stove oil and other light petroleum fractions have been used for the selective spraying of carrots and related crops. Why most small weeds are killed by this treatment while the crops mentioned grow unharmed is not understood. It is my understanding that a petroleum fraction known as John Deere tractor fuel has been used successfully in the Rio Grande Valley for weeding small carrots. I would caution those who use this material to investigate the possibility that this oil may impart an oily flavor to the carrots. I am informed that one of the local refineries is to offer a carrot oil for sale which, if properly used, should be consistent in its weedkilling effectiveness and relatively free from the danger of imparting oil flavor to the carrots. If any petroleum fraction is used too near the time when carrots are harvested, it is possible that the oily flavor will be imparted to the carrots. Therefore, if petroleum selective sprays are used for carrots, they should be used while the carrots and weeds are small.

(3) Selectivity based on differential plasmolysis when sprayed with salt solutions. The use of saturated or near saturated solutions of various salts as selective sprays on beets is in the developmental stage. Just why garden beets, sugar beets and certain of their relatives are not killed by this method, while many weeds are killed, is not clearly understood.

(4) Selectivity based on physiological resistance to the herbicidal action of growth regulating substances or plant hormone type of selective weed killers, such as 2,4-D. 2,4-D and other similar materials so upset the growth of many plants that death occurs. 2,4-D is selective in that most members of the grass family and some other kinds of plants are not seriously affected by it when it is used in the right way and at the right dosage. It may now be used as a selective weedkiller on grain, rice, sugar cane, sorghum and corn. It looks extremely promising on strawberries, brambles, asparagus, potatoes and flax. It is very useful on lawns, pastures and rights-of-way to kill many kinds of herbaceous and woody weeds without destroying the grass. If 2,4-D is properly applied, its uses are legion. However, such sensitive plants as tomatoes, cotton, okra, cucumbers, sweet potatoes, blackeyed peas and snap beans can be adversely affected by very low dosages characteristic of spray drift. Even with liquid sprays, 2,4-D may drift dangerously if applied in winds or if too high pressures are used. When 2,4-D is applied by airplane, only qualified airplane operators should be employed who, by their past experience, have demonstrated that they know when and where and how to apply 2,4-D safely.

The use of chemical weedkillers as an aid in crop production has already proved very profitable in many parts of the country. The use of the newer chemicals and new ways of using some of the older materials should minimize the weed problem of the vegetable grower. Some of the ways in which herbicides are proving useful in various parts of the country will be reported here, not as recommendations for the Rio Grande Valley, but as suggestions for Experiment Station and farm trials. Because of differences in kinds of weeds, in climate and soil conditions, and varieties and cultural practices, the methods of using herbicides will necessarily vary from place to place.

Pre-emergence and Preplanting Weed Control

A new "wrinkle" in the rapidly expanding weed control field is the use of pre-emergence sprays to destroy weed seedlings prior to the emergence of crop plants. In addition to using these sprays after planting of crops, they can be used to a distinct advantage to clean out weeds immediately before the crop is planted.

Various shallow tillage methods have been used in attempts to kill these tiny weeds without hurting the germinating crops. Such methods have definite limitations, not only because the crop plants are injured but also because killing weeds during the wet weather by shallow scratching of the soil is often very difficult. Chemical spraying for killing tiny weeds that may be up before the crop, has been under experimentation during the past few years. Especially during moist weather this method is far more successful than pre-emergence tillage. If properly timed, risk to many kinds of crop plants is negligible.

Pre-emergence spraying has certain limitations, but it seems to have a definite place in the production of some crops as a practical method of reducing hand weeding and hoeing costs. Although pre-emergence spraying is not entirely past the experimental stage of development, it is ready for small scale trials under varied conditions and on various crops. It appears to have a place in home gardens, nurseries and outdoor flower culture, as well as in the production of certain market garden and field crops.

At the outset one should avoid the idea that pre-emergence spraying will eliminate the need for other control methods. Some weeds will always emerge too late to be killed by pre-emergence treatment, and these must be controlled by other means. Just how much good a pre-emergence treatment will do depends upon the length of time that elapses between seeding and crop emergence, on the species of weed seeds present, and on soil moisture and temperature conditions.

For example, pre-emergence spraying of onions might be successful on one field where pigweed (*Amaranthus retroflexus*) is prevalent because the seedlings of this weed would break the surface before the onions. On another field, where there were few seeds of quick-germinating weed species in the soil, pre-emergence spraying of onions would be of less value.

The weather also plays a part in deciding whether a pre-emergence treatment will prove of value. When a cool period happens to follow the seeding of a heat-loving crop such as beans or corn, many cool-weather weeds may emerge first. Pre-emergence spraying will often prove useful under such circumstances, but if the same crop is planted in the same soil during warm weather there may be so few weeds up first that the treatment would be far less valuable.

Not only does the potential value of pre-emergence spraying depend upon conditions, but proper timing of the application is very

important if one is to avoid risk to the crop itself. The sprays used will be just as deadly to tiny crop plants (once they break the surface) as they are to weeds. If rain interferes and the application is delayed, one may have to skip it entirely in order to avoid injury. Experiments have indicated some crop damage when heavy rains followed treatments. In spite of these limitations growers have saved a tremendous amount of hand labor by properly timed pre-emergence sprays.

Because the rate of germination and emergence varies so much with soil temperature and moisture, no absolute rule can be laid down for timing on application in relation to the time of seeding. Seedlings that may take two weeks to make their first appearance during cool spring weather may emerge in half that time when the soil is warm. Keen observation will be the primary key to successful spraying. One must observe the development of seedlings below the surface and decide for each planting just when the latest safe time for spraying has arrived. Of course the longer one can wait without risk to the crop, the more weeds will have had a chance to emerge.

Species that push a husky leaf through the ground first, such as potatoes, gladioli and the various flowering bulbs, can be seen readily and even if an occasional leaf tip should be "burned" by the spray, no permanent damage to the crop will result. With the small seeded crops, on the other hand, one must use diligence in observing the germination process and take great care not to injure the tiny plants by spraying after they first break the surface. Plants with two seed leaves are known as dicots and are especially vulnerable if the spray is applied a little too late. Their tiny stems break the surface first and any injury is disastrous. With monocots, such as onions, the growing point is protected below ground at the time the first leaf shows above the surface. Even so, spraying should not be done after emergence because injury to this seed-leaf will slow the growth of the seedling.

Many weeds of the dicot type may be just breaking the surface when the spray is applied and these will be killed even though the operator does not realize they are there. When at the stage where only the tiny bent stem has pushed through, small-seeded weeds can be seen only by very careful examination of the surface. Almost invariably, pre-emergence sprays kill more weed seedlings than one realizes at the time of application.

A delay in planting of several days after fitting the ground has been used successfully as a means of getting more weeds up before the crop. It is well known that weed seeds ordinarily germinate mostly in the top one or two inches of soil. If these surface weeds are allowed to get started and the soil disturbed as little as possible at the time of planting, pre-emergence spraying can be used successfully with quick-germinating crops such as beets. Even with plants that are slow to emerge, this scheme of fitting the soil a little in advance of planting may increase the value of pre-emergence treatment. A planter with a knife-like opening device and compression wheels for covering would tend to disturb the soil less than conventional planters now in use. If the ground becomes very compact from excessive rains after fitting this technique will not work.

Petroleum fractions such as stove oil and Stoddard solvent have been used on a limited scale for pre-emergence treatment. They are rather expensive and certain weed species such as wild carrot and ragweed are resistant to their action. Stoddard solvent has the distinct advantage of being volatile and there is practically no chance of a toxic residue injuring the crop as it comes through.

The phenolic contact sprays which are usually applied in an emulsion form are inexpensive and very effective on seedlings of all species of weeds. They do leave some residue but the quantity of toxicant actually applied is so very small the risk is negligible if the application is properly timed. As they undergo decomposition rather quickly in the soil, toxic residues are quite temporary.

Tests in 1947 and 1948 indicated rather clearly that for pre-emergence work the weed killer should be applied in a moderate volume of water as a fine spray. Tiny weeds will retain very little liquid, particularly when only the stem is pushing through the soil. If an emulsion is too dilute, insufficient toxicant will be in contract with the weed seedlings to kill them.

The phenolic contact sprays can be used economically for a preplanting treatment to kill small weeds. Ground that does not compact too badly can be fitted and fertilized some time in advance of plantings and weeds killed after they emerge. This type of treatment involves no risk to a subsequent crop and may prove highly profitable under some conditions. Reworking with tillage equipment destroys the weeds but stirring the soil tends to bring more seeds to the surface where they may germinate after seeding. Crop land that is fitted early in the season may be kept free from annual weeds for later planting by spraying with a contact weed killer. As perennial weeds and grasses quickly resprout after being burned to the ground with contact sprays, soil must be free of perennial species in order to make the best use of this preplanting weed control system. Where weed growth warrants, a combination of a preplanting spray followed by a pre-emergence spray may be used.

Selective Spraying of Carrots

Growers have found herbicides particularly useful on certain vegetable crops. In the recently released circular bulletin 136 from the California Experiment Station, Dr. A. S. Crafts sets down some precautions regarding the selective spraying of carrots with oil.

1. Use only stove oil or a special fraction having a gravity rating in A.P.I. units of 37 degrees or above for killing weeds in carrots.

2. Never use Diesel or similar heavy fuel oils to spray carrots. Diesel may be used only for pre-emergence spraying.

3. Apply just enough oil to wet the plants; more runs off and is lost.

4. Apply stove oil only to young carrots having 1 to 4 true leaves. A more refined oil, however, may be used up to within 6 weeks of harvest.

5. Move the sprayer through the field at constant speed. Adequate screens should be used in the suction line of the pump so that nozzles do not clog.

6. Shut off the spray before stopping in the field to clean nozzles.

7.If excess oil is accidentally applied in one spot, hoe out those plants, because a few heavily contaminated carrots may cause rejection of a whole shipment.

8. Do not harvest carrots until the oil flavor and odor have disappeared. This may be determined by preparing, cooking, and tasting random samples from the rows.

Onions

Selective spraying of onions in the Northwest and in California with the dinitro selective sprays, such as Sinox and Dow Selective Weed Killer have been used successfully. In other sections of the country, the use of these materials has not proven entirely predictable. At the present time, I understand that experimental work with a formulation containing potassium cyanate shows promise.

Peas

Canning peas in the northern states are often sprayed with a dinitro selective and this operation has proved very successful. A little leaf burn usually occurs but careful tests at the Michigan and Wisconsin Experiment Stations indicate that this does not affect the yield. Great benefits have often resulted from weed control, particularly on drilled peas where no cultivation is possible. We do not know whether the black-eyed peas that are grown under Valley conditions can be successfully treated with a dinitro selective weedkiller.

Sweet Corn

In many sections of the country, both field corn and sweet corn are being successfully treated with 2,4-D. Only carefully conducted field trials will determine whether 2,4-D can be successfully used on corn grown in the Rio Grande Valley. If proper precautions are observed, I feel that 2,4-D can be used without damage to adjoining crops. I would suggest that anyone planning to use 2,4-D in any form, should get a copy of Miscellaneous Publication No. 14 published by the Texas Agricultural Experiment Station, entitled "Warning To Those Planning To Use 2,4-D Weedkillers." I would strongly recommend that those planning to use 2,4-D Weedkillers pay particular attention to the precautions concerning drift, spray pressures, and the formulation of 2,4-D used.

Beets

Solutions of common salt as a selective spray for beets look promising in the northern and eastern states. On many soils in that area salt is a desirable fertilizer for the beet crop. This is not the case in your area and if the method is tried, as little salt as possible should be used. This can be done by using just one spray nozzle per row and covering only a four to six inch band over the row. Some weeds such as lambsquarters and purslane are also tolerant of salt, so the success of this method depends on the kinds of weeds present. The Michigan Agricultural Experiment Station suggests two pounds of salt per gallon or as much as can be dissolved. They also recommend the addition of a wetting agent to promote good wetting of certain weeds that are likely to shed the spray otherwise. Beets should be sprayed when they are in about two leaf stage. Later the weeds were large and more difficult to kill. Apply enough of the spray to thoroughly wet the weeds with as much liquid as they will hold. With one nozzle per row this is likely to be at least forty gallons per acre, depending of course, on row spacing and weed size.

Spinach

Certain growers of spinach have been very successful in using pre-emergence and pre-planting selective spraying of weeds in the spinach growing areas of Texas, using dinitro materials.

Perennial Weed Controls

There is no doubt that weedkillers are very useful for the control of local areas of perennial weeds on vegetable land. Even the soil sterilants may be useful where only a small patch becomes infested. The grower can well afford to have a small parcel of land out of cultivation for a couple of years in order to eradicate a new weed that he has not had before. I suggest that you follow the recommendations of the Experiment Station and the manufacturers of the various weedkillers, for perennial weed control.

Vegetation Control on Drainage and Irrigation Ditches and on other Rights-of-Way

The accumulation of debris in irrigation ditches, drainage ditches, and other non-cultivated areas is an ever present problem, particularly in areas with as long a growing season as the Rio Grande Valley. Just now, considerable research work is going on with chemicals to kill Johnson grass, Bermuda grass and Joint grass. However, until such time as a material which will eradicate these troublesome grasses is found, I suggest that serious consideration be given to the contact type weed killers. In areas where a power mower can be used, this machine will prove very useful. However, on most ditch banks it is not practical to try to use a mower. In this case, a contact weedkiller such as Dow Contact Weedkiller may be used to keep the vegetation under control.

Control of Aquatic Plants

2,4-D is recommended especially for control of many of the emergent aquatics such as water hyacinths. Cattails and tules are more resistant and experimental work with these aquatics is now under way in the Rio Grande Valley which shows considerable promise. However, because of the inherent hazards involved in the use of 2,4-D on irrigation canals, we cannot recommend its use where the water from the canals is to be used to irrigate susceptible crops. For treatment of moss and other submergent aquatics, trichlorbenzene and ortho-dichlorobenzene have been used. However, I have no information on this, and would advise that anyone interested consult the Experiment Station for information concerning their use. I understand that in certain instances these materials may kill fish.

In conclusion I would like to say that I have discussed some of the important fields in which chemical weedkillers may be used, and I would suggest that for further information concerning them you consult the Experiment Station, the County Agricultural Agent, and representatives of the concerns who manufacture and sell weedkilling chemicals.

Again I repeat that it is important for every grower to understand that there are no "shot-gun" chemicals or "shot-gun" methods of controlling weeds. The right material must be used in the right way at the right time and in the right place.

THE TOMATO IMPROVEMENT PROGRAM OF THE SOUTH

by

A. L. Harrison,
Plant Pathologist
Texas Agricultural Experiment Station
Tomato Disease Laboratory
Yoakum, Texas

Dr. A. L. Harrison obtained his Ph. D. in Plant Pathology at Cornell University in 1935. He has done work in Plant Pathology at the New York Experiment Station, Rogers Bros. Seed Co. of Idaho, Vegetable Crops Laboratory at Bradenton, Florida and in Arizona. He is actively engaged in tomato disease research at the Texas Experiment Station at Yoakum, Texas.

The problem of improving the varieties and strains of tomatoes for the South has not received the attention that it deserves. Although the tomato is one of the main vegetable crops it has received comparatively little attention on the part of the plant breeder until the past few years. Even yet the various projects of the workers in the South are only scratching the surface. No vegetable crop offers greater possibilities for improvement than the tomato.

This is especially true from the standpoint of developing varieties resistant to the various diseases that annually cause losses amounting to millions of dollars. Fusarium wilt, collar rot, grey spot, mosaic, root knot, late blight, septoria leaf spot, curly top, spotted wilt, bacterial canker, bacterial spot, bacterial wilt, and southern blight are among the most serious diseases with which the tomato grower has to contend. One or more of these diseases is serious in every tomato growing region of the United States, and all of them occur to some extent in one or more of the tomato growing areas of Texas. Fortunately only a few of these are major problems in the lower Rio Grande valley. Nevertheless the control of these diseases has always been a problem to the tomato grower. The control measures in some cases consist of long systems of crop rotation, costly application of sprays or dusts or planting the tomato crop in new soils. This picture will rapidly change as the years go by with the introduction of tomatoes resistant to more and more diseases. The ultimate goal of all tomato improvement programs is the development of varieties of tomatoes resistant to all the major diseases of tomatoes.

Years ago seedsmen and research workers in the State and Federal agencies crossed tomatoes, but their progress at best was extremely slow because their basic breeding material was little, if any, better than the stocks they were trying to improve. In order to change this picture entirely new basic breeding material was necessary. As a result of this need the Bureau of Plant Exploration and Introduction of the U. S. Department of Agriculture introduced, in the early 1930's, hundreds of samples of wild and cultivated tomatoes. Most of these introductions came from South America, the home of the tomato.

For the most part nothing was known about these numerous samples. A long tedious job remained to test them to see if they possessed any disease resistant characters or other desirable horticultural characters that could be incorporated into the gene complex of the common commercial tomato to improve existing varieties. It was a long, tedious, uphill pull but through the efforts of the workers in the various State and Federal experiment stations we are now beginning to see the results from these introductions of wild tomatoes.

The testing of these introductions has required some basic research in developing new techniques for checking on disease resistance. Some basic research facts have also been borrowed from other fields of endeavor to help the program along. The need of basic research in any field cannot be over emphasized. Just recently in a talk given by a public relations man for one of our large chemical manufacturing firms he stressed the importance of basic research in industry and stated that frequently millions of dollars were spent on a product before one penny was returned on the investment. Sometimes it took ten years, sometimes longer from the test tube to commercial production.

In the plant improvement field this process is just as tedious and just as long or longer. With tomatoes the minimum time is from 6-10 generations from the cross until the resulting selections can be tested under commercial conditions. If the original cross does not yield the desired types then additional crosses have to be made. This process may have to be repeated many times. It all depends on the type of breeding material the breeder is using and on the inheritance of the characters the plant breeder is trying to incorporate in the new tomato.

The major emphasis in any tomato improvement program should be on the development of tomatoes resistant to the various diseases that affect the crop. This is the aim of most of the research workers who are trying to improve the existing varieties of tomatoes. Of course, it is of paramount importance to give attention also to those horticultural characters that go to make up a good tomato, such as size, shape, yield, shipping quality, appearance and many other characters too numerous to mention.

No major development had occurred in the tomato breeding program of the South since the turn of the century until the U. S. Department of Agriculture introduced these hundreds of strains, varieties and species to which reference has already been made. The work of properly evaluating and classifying these possible breeding stocks has been a tremendous task. Certain lines are still being checked for resistance to various diseases. However, since their introduction the various State and Federal agencies have found within this large collection a high degree of resistance and in some cases immunity to most of the major diseases of the tomato. In many cases the resistance or immunity was found in types that were a long way from the commercial tomato. In fact, some of them look very much like ornamentals, especially when

in full bloom. At this stage of development the plants are a mass of yellow flowers. The fruits, when ripe, are small and green and frequently have a purplish coloring in the skin. They hang in clusters and look more like grapes than tomatoes.

One of these green grapelike tomatoes has been found by several workers to be resistant to the root knot nematode and to several of the other major diseases of the tomato. The question then arose: can the resistance of this wild, small, green grapelike tomato be transferred to our commercial types? Thousands of crosses were attempted (personally I made several hundred) but with very little success. Fruits would be formed, when the pollen of the wild green grapelike tomato was placed on the stigmas of the commercial varieties, but they would be seedless. Fortunately among the thousands of crosses attempted a few were successful. Then another problem arose. The hybrids were almost always self sterile. The plant breeder then borrowed some facts from basic research, facts that did not appear, at the time they were first discovered, ever to be useful to the tomato improvement program. The facts to which I refer are the techniques of embryo culture. These techniques greatly speeded up the development of root knot resistant tomatoes. To make a long story short the plant breeder now has at his disposal numerous lines that are highly resistant to root knot, that are self fertile and readily cross with the commercial types. The degree of resistance that is exhibited by some individual plants is illustrated in Figure 1. These plants were grown side by side in the same plot of soil. The fruits of this breeding stock range from ½ inch up to 1½ inches in diameter, so that it should be only a matter of time before there will be available commercial varieties of tomatoes resistant to root knot.

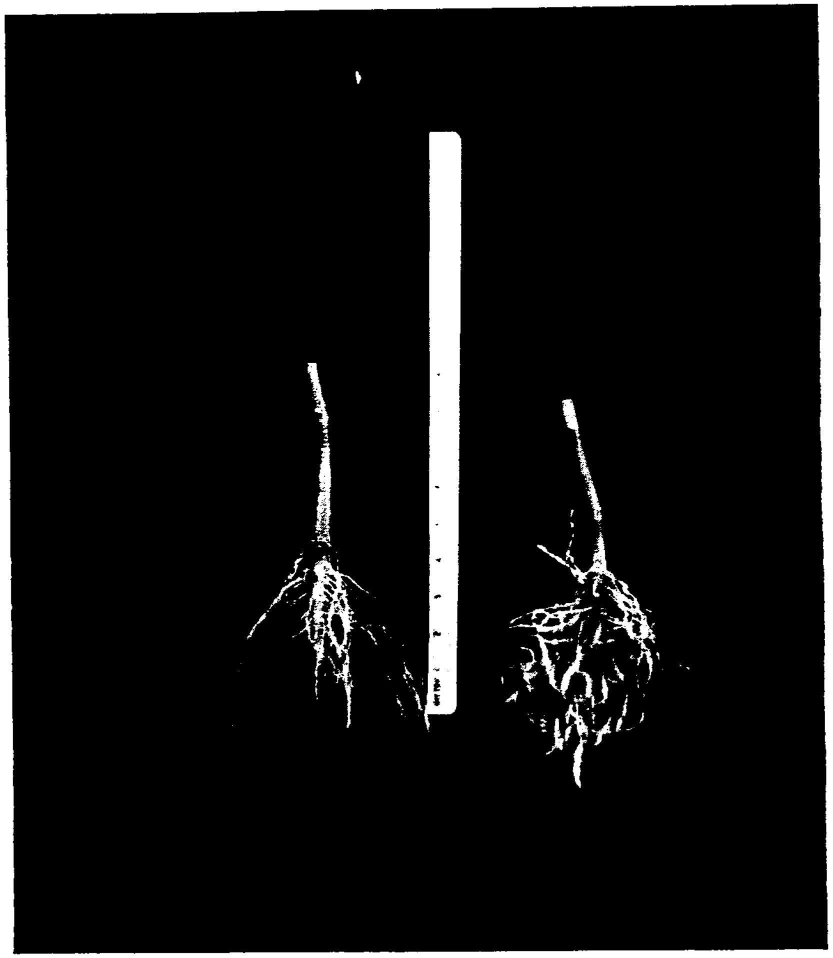


FIGURE 1.

Resistance of tomatoes to root knot. These plants were grown side by side in the same soil in the same tray. Not a single gall was observed on the plant at the left.

Root knot is only one of the many diseases with which the tomato plant breeder is working. The first major advancement for the tomato improvement program started back in the early 1930's when the workers in Missouri and the U. S. Department of Agriculture at Beltsville discovered a source of resistance to Fusarium wilt in the wild cherry tomato. As a result of their work we now have available untold quantities of foundation breeding material that has a high degree of resistance

to Fusarium wilt. This resistance amounts to "field immunity". By "field immunity" is meant that tomato lines known to be pure for this type of resistance will not die from or show symptoms of Fusarium wilt under ordinary field conditions. However, under extremely favorable greenhouse conditions, where seedlings are inoculated with a virulent strain of the causal fungus, from 10 to 15 per cent of the seedlings may die from wilt. Those that survive this rigid seedling inoculation test will develop normally without any symptoms of Fusarium wilt. Under the same conditions 100 per cent of the so called wilt resistant varieties like Rutgers and Marglobe will die before they are six inches high.

This phase of the tomato improvement program has progressed far enough so that several new varieties have been released with this type of resistance. The first variety to have this type of resistance was Pan America and for this reason this type of resistance has frequently been referred to as the Pan American type of resistance to Fusarium wilt. Pan America was released by the U. S. Department of Agriculture in 1941. However, it has never yielded as well as the existing varieties, under disease free conditions, and for this reason has never been popular. Nevertheless it has been used extensively as foundation breeding material by numerous workers.

The U. S. No. 24 is another release of the U. S. Department of Agriculture with this high degree of resistance to Fusarium wilt. It likewise has failed to become popular because of its tendency for low yields under wilt free conditions.

Since then several other varieties have been released that possess this Pan American type of resistance to Fusarium wilt. The Southland, just released this past year by the U. S. Vegetable Breeding Laboratory at Charleston, S. C., is a high yielding tomato and in addition to the the Pan American type of resistance to Fusarium wilt, has resistance to the stem canker phase of early blight and resistance to some of the late blight fungus.

Just recently the Vegetable Crops Laboratory of the Florida Agricultural Experiment Station at Bradenton, Florida has released two varieties, the Manahill and the Manasota, for commercial trials. Just what place, if any, these varieties will have in our Texas agriculture remains to be seen. They will have to be tried under various local conditions before they can be properly evaluated for our use in Texas.

The problem of combining resistance to more than one disease is also receiving considerable attention. In Figure 2 is illustrated the resistance of some of the tomato breeding lines to both Fusarium wilt and the collar rot phase of early blight. The seedlings at transplanting stage had been dipped in a mixed suspension of the fungi causing Fusarium wilt and early blight. Only those with a high degree of resistance to both fungi survived the drastic test. This technique has been used by the author for sometime with a marked degree of success in testing for the combined resistance to both Fusarium wilt and collar rot.

When the flood of new breeding material became available to research workers in the late 1930's many southern states gave renewed

FIGURE 2.

Resistance of some tomato hybrids to Fusarium wilt and the collar rot phase of early blight. The seedlings at transplanting time had been dipped in a mixed suspension of fungi causing Fusarium wilt and early blight. Most of the seedlings in the lower picture failed to develop symptoms of either disease, while those in the upper picture soon died from one or the other of these diseases.

emphasis to their tomato improvement program. These workers soon realized that unless some cooperative arrangement was made between the various agencies working on the improvement of tomatoes that the industry would soon be flooded with so many new varieties that it wouldn't know which way to turn. Consequently to overcome this possible confusion, a co-operative program was set up whereby each co-operating agency would test the promising hybrids of the other co-operating agencies. This arrangement was called the Southern Tomato Exchange Program or in short the STEP trials. In brief the program works as follows: Any cooperator who has a tomato which he thinks may have a place in Southern agriculture sends a sample of seed to the Vegetable Breeding Laboratory at Charleston, S.C. There the sample is subdivided and small samples sent to each co-operator in the south for observational trials under the various local conditions. Lines that appear the most promising are tried the next season in replicated yield trials. Thus it is possible by testing these new lines under these widely varying conditions to greatly increase the chances of getting a new tomato with wide adaptability. The wider the adaptability of a tomato, the easier it is for the seedsmen to produce seed and maintain sufficient stocks to meet the needs of the industry. A tomato with restricted adaptability, no matter how good it may be in a small area, is apt to fall by the wayside simply because of the difficulty of maintaining seed stocks.

The STEP program has just completed its third year of co-operative effort, and is being relied on more and more by the co-operative agencies to properly evaluate new promising lines. Southland, the new introduction by the U. S. Vegetable Breeding Laboratory at Charleston has gone through the STEP trials as STEP 22. It is highly probable that two or three more of these STEP lines will be released for commercial trials in the next year or so.

The extent of the tomato improvement program in the South was recently surveyed by Dr. V. M. Watts of the University of Arkansas in a mimeographed report in which he summarizes the answers to a questionaire to the various Federal and State experiment stations located in the South. His summary also includes reports received from the Hawaiian and Puerto Rican experiment stations. The following southern states are known to have active tomato improvement programs: Alabama, Arakansas, Florida, Georgia, Missouri, North Carolina, South Carolina, Mississippi, Oklahoma, Tennessee and Texas, as well as the Territories of Hawaii and Puerto Rico and the U. S. Department of Agriculture at Beltsville. Some 28 horticultural and 23 disease resistant characters are being considered by one or more of these agencies. This will give you some idea of the extent of the tomato improvement program in the South. In most cases the programs have been in progress long enough so that a constant succession of new and better varieties will be forthcoming in the near future for the betterment of the tomato industry. It will be only a matter of time until many of the diseases of tomatoes will no longer be a limiting factor between profit and loss in the production of tomatoes. Varieties with combined resistance to several diseases will be available to the industry.

A survey of the tomato breeding programs shows a wonderfully hopeful future to tomato growers. It is doubtful if any vegetable improvement program, with the possible exception of that of the potato, has a better record of achievement. Of course, the job isn't done. In fact, it has just begun. There is no end to problems in the field, for new ones arise each year, but we are gaining and consolidating our gains as we go along. It would be nice if we could combine resistance to all the important diseases along with the desirable horticultural characteristics that the industry wants in a tomato and release only one variety. But that is too Utopian. However, progress is being made and in the not too distant future high yielding desirable varieties with resistance to several diseases and adapted to the various growing sections of the South will be available.

GRADING GRAPEFRUUIT IN A VALLEY PACKING PLANT

CITRUS VARIETIES IN THE RIO GRANDE VALLEY OF TEXAS

By

NORMAN P. MAXWELL

Assistant Horticulturist,

Substation No. 15, Weslaco, Texas

N. P. Maxwell was born in Lancaster Pa. obtaining a B. S. degree from the University of Delaware. He obtained his M. S. degree in Citrus Propagation from Texas A. & M. in 1948. He has been actively engaged in a study of Citrus Varieties at the Lower Rio Grande Valley Experiment Station for the past 3 years.

Citrus varieties is a broad title, so I will limit my discussion to several topics that will be of interest to all of us.

The first topic I wish to discuss is the history of the development of the red grapefruit. A Walters grapefruit tree, which is a white seedy variety, growing in the Atwood grove at Manavista, Florida, had a bud sport that was discovered in 1906 bearing pink colored fruit. The variety was named Foster in honor of the man who discovered it. Since the fruit is only of average quality and seedy, it has never become a popular commercial variety. There are, however, limited plantings of it in Florida, Texas, and Arizona.

An interesting discovery concerning the Foster grapefruit in the Lower Rio Grande Valley was found recently by Joseph Hollerbach near Mission, Texas. He discovered a Foster tree that had a bud sport which was nearly seedless. Since this eliminates the main objection of Foster, it may in time develop into a worthwhile commercial variety. At least it presents interesting possibilities.

The Thompson or Pink Marsh variety originated as a bud sport on a White Marsh tree in the grove of W. B. Thompson at Oneco, Florida. It was discovered in 1913 by S. A. Collins of Oneco. The pink color is only apparent in the pulp of the fruit, and the color fades in March and April to amber. Although the Thompson is grown to a limited extent as a commercial variety in the Rio Grande Valley, it will probably never become a principal variety. This is due to the varieties or strains of red grapefruit in the Valley that show a red blush on the outside of the rind, and whose pulp is a deeper red color than the Thompson.

During the period from 1929 to 1935, numerous bud sports were discovered on many Thompson grapefruit trees in the Lower Rio Grande Valley. The fruit of these sporting branches showed a red pulp far deeper in color than the parent Thompson's fruit; also, many of the bud sports had fruit which exhibited a reddish blush on the rind.

It is not known as yet whether there are any distinct differences in the quality of one sport over another, although there are claims by a few of the bud sport owners that some of the sports hold their red pulp color longer, mature earlier in the fall, have larger fruit, and exhibit more blush on the rind than do the other sports. All of the aforementioned fruit characters are influenced to a great extent by soil and climatic conditions; therefore, until these various bud sports are all planted in the same grove and records taken on the trees and fruit, it will not be known whether there are differences between the sports.

At the present time, there are seven bud sports of red grapefruit being propagated in the Rio Grande Valley. These strains are: (1) The Ruby, discovered in 1929 by A. E. Henninger near McAllen, Texas, (2) The Ballard, discovered in 1929 by E. B. Ballard near Weslaco, Texas. (3). The Red Blush discovered in 1931 by Dr. J. B. Webb near Donna, Texas, (4) The Shary Red, discovered in 1929 near Mission, Texas in a grove belonging to H. P. Klatt, (5) The Red Gold, discovered in 1931 near Donna, Texas by H. W. Riddle, (6) The Red Radiance, discovered in 1933 near Edinburg, Texas by R. B. Curry and (7) The Langford Red Grapefruit, discovered by T. E. Langford in 1934 near McAllen, Texas.

A definite problem in the Valley is to find a good seedless early orange. At the present time the principal early orange variety is the Hamlin or Norris orange. The Hamlin orange was found in 1879 near Glenwood, Florida in a grove belonging to Mrs. Mary H. Payne. It is considered a seedless variety, and the season for maturity in Texas extends from October through November. Some of the bad features exhibited under Texas conditions are splitting of the fruit, drying out quickly after the fruit is mature, and small sized fruit. Until a better and earlier seedless orange variety is either found or bred, the Hamlin will probably remain the principal early orange.

The two mid-season varieties of oranges that comprise the major acreage in the Rio Grande Valley are the Joppa and the Pineapple varieties. The Joppa was brought into California from seed imported from Palestine by Chapman at San Gabriel, California. It is no longer grown commercially in California and Florida, but in Texas the Joppa is still extensively grown. Under Texas growing conditions, the Joppa variety is above average in quality and matures during late October and November. The trees do not bear quite as heavily as the Hamlin trees, but the fruit is superior to the Hamlin in flavor, size and keeping quality. This variety seems to be increasing in the commercial plantings and will probably be the leading mid-season variety in the future.

The pineapple orange is the other mid-season variety grown in the Rio Grande Valley to any appreciable extent. It originated near Citra, Florida and was first propagated in 1876 in the Bishop, Hoyt and Company groves. It has been found that the pineapple orange trees bear well under Texas growing conditions. The fruit has a very attractive appearance and the quality is excellent. The main disadvantage of the Pineapple orange is the seedy nature of the fruit.

The Valencia orange is the late variety of orange grown in the Rio Grande Valley. It was first introduced into California by A. B. Chapman and George H. Smith in 1876 from the Thomas Rivers Nursery, Sawbridgeworth, England. The exact origin of the Valencia is unknown, although there are varieties of oranges growing in China, Sicily, and Brazil that appear to be almost identical to the Valencia. The Valencia orange has a very high percentage of nucellar embryony, so it is quite possible that all of the good, late maturing, oval strains of nearly seedless fruit found in the forementioned countries have descended from the same source. The Valencia orange is grown in almost all of the citrus sections of the world, and is the most important late maturing variety of orange that is grown. Under Texas conditions the Valencia bears well, is considered a seedless fruit, has excellent quality, and with proper grove care, the fruit attains large sizes. The season of maturity is from January through March, but the fruit will remain on the tree without deteriorating to any great extent several months after it has reached maturity.

Another group of fruit grown commercially in the Rio Grande Valley are the Navel oranges. The Navel oranges mature from early November through December and are especially popular near Christmas with gift fruit shippers. The Texas Navel is probably the best adapted strain for Texas growing conditions. This variety was introduced into the United States from Bahia, Brazil in 1916 by Dorsett, Shamel, and Popenoe. It was introduced into the Rio Grande Valley in 1924 at the Experiment Station at Weslaco, Texas. Under Valley conditions, the tree is a vigorous grower and produces good yields of fruit that have a mild, pleasing flavor.

Gift fruit growers and shippers are becoming interested in several relatively new groups of citrus named Tangelos and Tangors that were developed by Webber, Swingle, Robinson and Savage.

Tangelos are hybrids developed by crossing a tangerine or mandarin orange with either a grapefruit or pummelo. Almost all of these crosses were made by Swingle at Eustis, Florida in 1897, or by Webber in 1898 in connection with investigations of the U. S. D. A.

Tangors are hybrids of tangerines or mandarin oranges crossed with the sweet orange. These crosses were made in 1931. Very few of the tangors have been given names, and since they resemble the tangelo in appearance, are often incorrectly called tangelos.

The tangelo and tangor hybrids usually are intermediate between the parent species, and the distinction is so apparent that they cannot be classified with either parent group. The fruit produced by many of these hybrid combinations is very attractive and of excellent quality. Probably many of them will become commercial varieties of citrus for the gift fruit growers in the future after the public has become acquainted with the fine quality of their fruit.

The Experiment Station at Weslaco, Texas has specimen trees in their variety block of Clement, Lake, Mineola, Sampson, Thornton, and several other varieties of tangelos that have not been grown long enough to make a statement upon their quality and adaptability under Texas conditions. The two principal tangors present on the Experiment Station are the Umatillo and the Temple.

The tangelos showing the greatest promise in the variety block are the Lake, Mineola, and Thornton. The Clement and Sampson fruit both seem to be of poor quality, although the Sampson tree appears to be well adapted to Valley conditions.

The Lake tangelo is a hybrid of the Bowen grapefruit pollinated with the Dancy tangerine. Under Valley growing conditions the fruit presents a very pleasing appearance, and has the shape and size of a large tangerine with a very smooth rind. When the fruit is fully mature, the rind and pulp are deep orange in color. Although it is classified as a seedy fruit, it does not have an excessive number of seeds. The fruit is low in acid and has a sweet but not insipid flavor. This variety of tangelo ripens in Texas during the period from the last of November until the first of January. This period of ripening makes it an excellent gift and Christmas trade fruit.

Another tangelo variety that shows promise under Valley conditions is the Mineola. The Mineola is of the same parentage as the Lake tangelo. The fruit is shaped like a medium large flattened orange with the base slightly raised but not distinctly necked. The rind of the mature fruit is deep reddish orange and the pulp is also orange colored. The fruit has an excellent flavor and attractive appearance. The season of maturity extends from the middle of January to nearly the end of February which is decidely later than the Lake tangelo.

The most commonly grown tangelo in the Valley is the Thornton. It is a hybrid of the grapefruit crossed with pollen of the tangerine. The fruit is shaped oblate to obovate and is medium large in size. The rind and pulp are a light orange color when fully mature. The flavor is mild sweet, and lacking in acid when the fruit is ready to harvest. The ripening period extends from the beginning of December through the middle of January which is practically synonymous with the Lake tangelo. The main disadvantage to the Thornton tangelo is the rough coarse appearance. It also becomes soft, puffy, and does not ship too well when ripe. It is extremely doubtful that this variety will ever develop into an extensively planted commercial variety for the gift fruit growers.

The Clement tangelo is a hybrid of the grapefruit crossed with pollen of the Clementine tangerine. Although the fruit has a pleasing flavor, the variety appears to be of little value under Valley conditions because of the coarse rough appearance of the rind and the irregular shape of the fruit.

A variety of tangelo that is showing value as a rootstock in California and Florida is the Sampson. It is supposedly resistant to foot

rot, and I believe Dr. Cooper is conducting tests on it in Texas in his various rootstock plantings. The Sampson is a hybrid of the grapefruit crossed with the Dancy tangerine. The fruit is rather pleasing in appearance due to its smooth rind which is orange yellow in color. The flavor is very acid and inclined to be slightly bitter, thereby limiting its use to either a juice fruit or for making marmalade.

Of the two tangor varieties on the Station, the Temple is probably the best known variety and is showing the most promise. The exact origin of the Temple tangor, or as it is commonly called Temple orange, is not known, but it is thought to be a hybrid of the tangerine crossed with the sweet orange. The fruit is a deep orange to reddish color and is very appealing to the eye. It ripens about Christmas time here in Texas and is used a great deal in gift packages. The main disadvantage of the Temple is its low cold resistance. At the present time there is a limited commercial acreage of Temple oranges in the Valley.

The other tangor present on the Experiment Station is the Umatillo. This tangor is a hybrid of the Satsuma mandarin pollinated with the Ruby orange. The fruit color is reddish orange with a smooth and glossy rind. The size of the fruit is large and it is shaped like a Satsuma mandarin. The flavor is pleasing to most people but it seems slightly inferior as compared with some of the tangelos. It ripens in late January and February in Texas. Until more is known about the Umatillo, it cannot be recommended as a gift fruit variety.

One of the characteristics of the tangelos and tangors seems to be the tendency toward alternate bearing. Perhaps with judicious use of fertilizer, orchard management, and irrigation practices this difficulty can be partially or wholly corrected.

At the present time, the Experiment Station at Weslaco, Texas is cooperating with the Horticultural Department of the Agricultural Experiment Station, located at the Agricultural and Mechanical College of Texas in planning a citrus variety, strain testing and breeding program. This program will be located on the Valley Experiment Station at Weslaco, Texas, and, when it gets underway, perhaps some of the problems concerning citrus varieties will be partially or completely answered for the Rio Grande Valley.

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Seasonal Changes in Relation to Consumer Acceptance of Oranges, Grapefruit, Temple Oranges, and Tangerines[1]

By

PAUL L. HARDING

Plant Physiologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

Dr. Paul L. Harding has been a staff member of the Bureau of Plant Industry, U. S. D. A., for the past eighteen years. He has been assigned to the investigation of seasonal changes in citrus fruits at the Orlando Florida Station since 1935. For five years prior to that time he was assigned to Washington D. C. to study the transportation and storage of fruits and vegetables. He obtained his Ph. D. from Iowa State College and was research assistant of the Iowa State Experiment Station before joining the Bureau of Plant Industry.

INTRODUCTION

The importance of citrus fruits in the diet of the nation is indicated by the rapid growth of the citrus industry. During the decade from 1935 to 1945 production of oranges in the United States increased from 52 million boxes to 105 million boxes and of grapefruit from 18 million to 63 million boxes. This tremendous rise in production has been accompanied by an ever-increasing demand for citrus fruits by consumers, from 39 pounds per capita in 1934 to 68 pounds in 1944. Rapid transportation to marketing centers, usually under refrigeration, has contributed to the increasingly wider use of citrus by the consuming public. The many improvements made in handling methods that have resulted in a better retention of vitamins, and the development of higher quality in processed and canned products have also been factors.

Orange and grapefruit juices are important in the diet since they are foods in which the alkaline element ultimately predominates. This is of interest because citrus juice contains organic acids, chiefly citric acid. But the juice is also rich in mineral salts which are predominantly alkaline. The organic acids are destroyed in the process of digestion, so that the final effect of the juice is determined by its mineral content.

It is important that all possible information bearing on those factors that make for higher quality in citrus fruits should be identified and evaluated. With this objective, investigations have been made on oranges, grapefruit, tangerines, and Temple oranges at the U. S. Department of Agriculture Horticultural Field Laboratory, Orlando, Florida.

These investigations have included detailed observations and measurements of the physical characteristics and also analyses of the chemical constituents of the principal varieties of fruits at definite intervals, beginning with immature fruit and continuing until the fruit was fully mature and ripe. The changes that occurred, step by step, were determined; and of more importance, methods for evaluation and establishing definite standards for comparison of these changes were devised.

The ripening process of oranges and grapefruit can take place only while the fruits are attached to the tree. It is therefore obvious that these fruits should not be harvested until they are mature and hence ripe. The following definitions are given in order to avoid possible confusion as to the meaning of the terms "maturity" and "ripening" as they are used here. *Maturity* refers to the stage of development of the fruit; *ripening* refers to the process by which a mature fruit becomes edible. A mature fruit is one that has attained such a stage of development that it will ripen with acceptable eating quality. Fruits with starch reserves, such as apples and pears, may be mature at harvest time, but many varieties do not become ripe and edible until sometime later, when they attain their soft, juicy, aromatic qualities. In contrast, oranges and grapefruit do not improve in their eating quality after harvest and owe their sweetness to the natural sugar contained when they are picked; they contain practically no starch and do not undergo such marked change in composition as do apples, pears, or bananas after being picked from the tree. Since the ripening processes in oranges and grapefruit occur only while they are on the tree, it can be readily understood that they should not be harvested until they are mature and hence of acceptable quality. Instead of improving in their eating quality after harvest, these fruits tend to lose quality, the rate of loss being correlated with the temperature at which they are held.

In storage studies made on Florida oranges the rate of respiration was determined at temperatures from 32° to 110° F. The material used up in respiration was ascertained from these data. At 32° F. sugar was broken down or "respired;" but at 50° to 70° more acid than sugar was used up, or if the sugar was incompletely oxidized, intermediate products such as ethylene or alcohol were formed. At 90° and above the CO^2-O^2 ratios indicated that considerable intramolecular respiration was taking place (that is, that the fruit was breaking down its own tissues to obtain required oxygen).

MATERIAL AND METHODS

The data presented in this article were obtained between 1935 and 1946, and these investigations are still in progress. Each type of citrus fruit usually was studied during four consecutive years. The experimental plots were located in several different commercial groves. Variety, rootstock, and soil type determined the selection and location of the plots. Samples were collected from all of the groves at intervals of 2 or 4 weeks, beginning about September 1 and continuing through the season until the fruit was overripe. This long period of sampling provided information on the changes in physical characters and chemical constituents of the fruit during the various stages of maturity and ripening. Differences among groves, as well as those occurring from year to year, were thus determined. The detailed information is presented elsewhere (1), (2), (3), (4), (5).

Market quality is associated with appearance, firmness, freedom

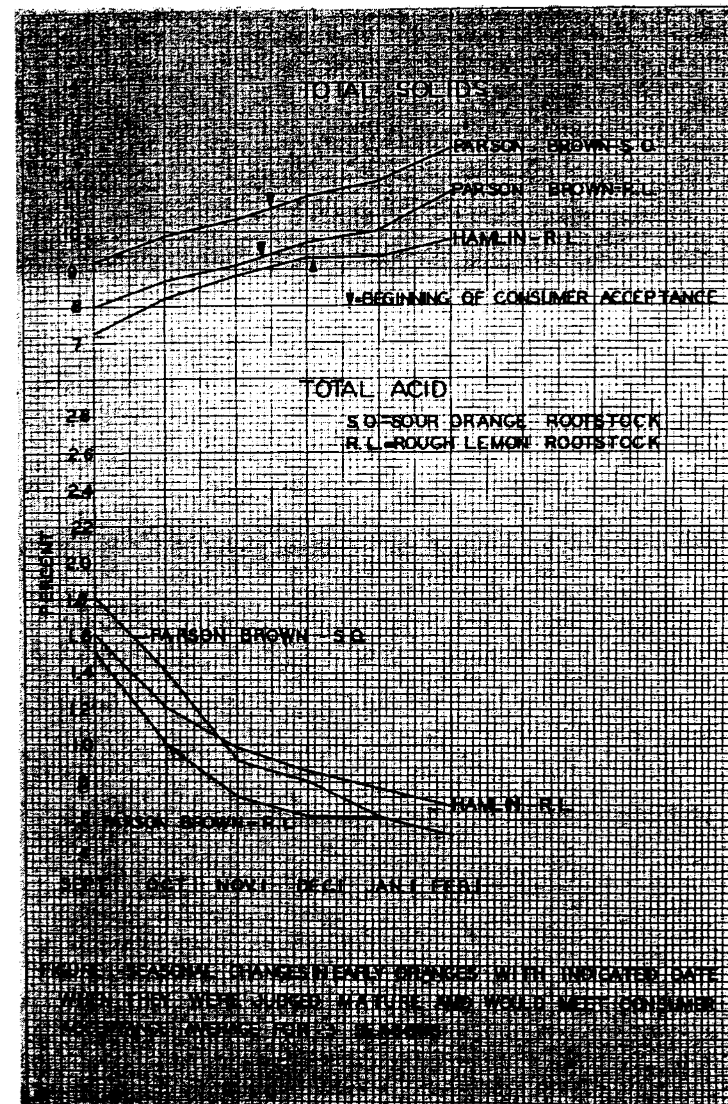
[1]Published in the Proceedings of the American Society for Horticultural Science, Vol. 49, 1947, pp. 107-115. See this for figure reference.

from blemishes, thickness and texture of rind, whereas eating quality is influenced by the texture of flesh, juiciness, content of total solids (principally sugars), total acid (citric), ratio of solids to acid, aromatic constituents, vitamins, and mineral content.

The eating quality of the fruit was determined soon after picking. In each test 30 to 50 or more fruits were used. The fruits were cut transversely and from each half was cut a wedge-shaped piece for tasting. The judging panel was made up of staff members of the Orlando station, and each judge was asked to taste several pieces before rating a sample according to the arbitrary scale. By use of this scale the fruit could be classified as very acid, acid, tart, pleasantly tart to sweet, or insipid. At the beginning of each season the arbitrary standard scale to be used and the method of evaluating internal quality were discussed. At that time it was pointed out that a score of 70 would be the minimum standard of acceptability, whereas good to excellent quality would be rated from 70 to 100. The scale also permitted the scoring of immature fruit (values 20 to 69) and of insipid fruit (values 50 to 100); but it was understood that any rated below 70 would not meet consumer approval and the sweet but insipid fruit would be so designated to differentiate it from better-quality fruit having a similar numerical rating. The judges were believed to represent fairly well the prospective consumers. Tastes showed differences in scoring but not large ones, and the numerical average thus obtained from 20 to 45 judges appears to be a satisfactory method of measuring quality.

Flavor as determined by taste is closely correlated with seasonal changes in weight and texture of the fruit, the color of its flesh, the percentage of the fruit that is juice, and the ratio of total solids to total acidity. These improve or increase with the maturity of the fruit. By recording the picking dates and plotting the total solids and the total acid in nomograph form, (a special chart showing the relation of more than 2 factors), it was possible to show the relation of these two factors to each other in fruit at its earliest stages of consumer acceptance, as judged by its flavor, and eventually to determine a minimum standard of acceptability for the different varieties.

An effort was made to give an over-all picture of the quality of oranges, grapefruit, Temples and tangerines that might be expected on the market at different times. The average values presented for total solids, total acid, and palatability (consumer acceptance) were obtained by averaging the results obtained at each picking period. The results should be regarded as approximate since they are based on average rather than minimum values. These findings are shown in figures 1 to 7.



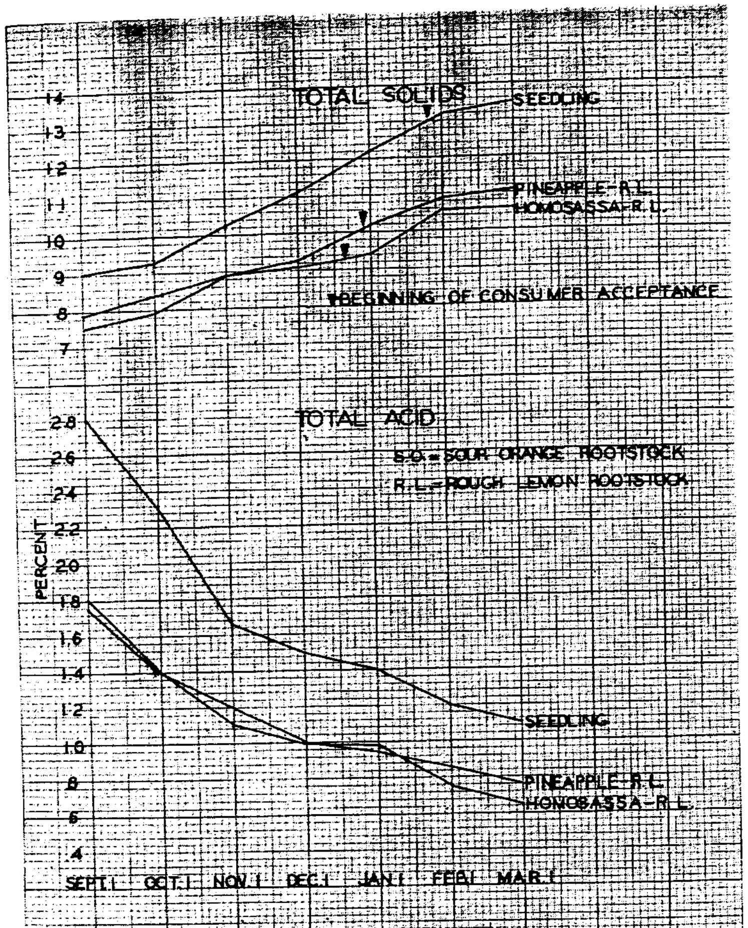


FIGURE 2.-SEASONAL CHANGES IN MIDSEASON ORANGES WITH INDICATED DATE WHEN THEY WERE JUDGED MATURE AND WOULD MEET CONSUMER ACCEPTANCE. AVERAGE FOR 3 YEARS.

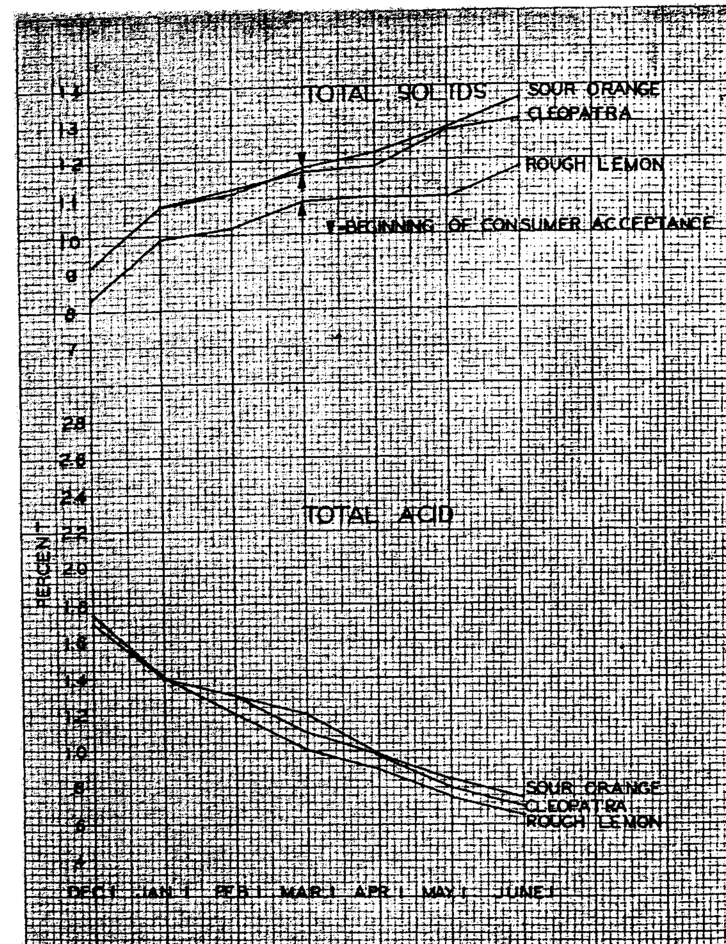


FIGURE [illegible] SEASONAL CHANGES IN LATE (VALENCIA) ORANGES WITH INDICATED DATE WHEN THEY WERE JUDGED MATURE AND WOULD MEET CONSUMER ACCEPTANCE AVERAGE FOR 3 SEASONS.

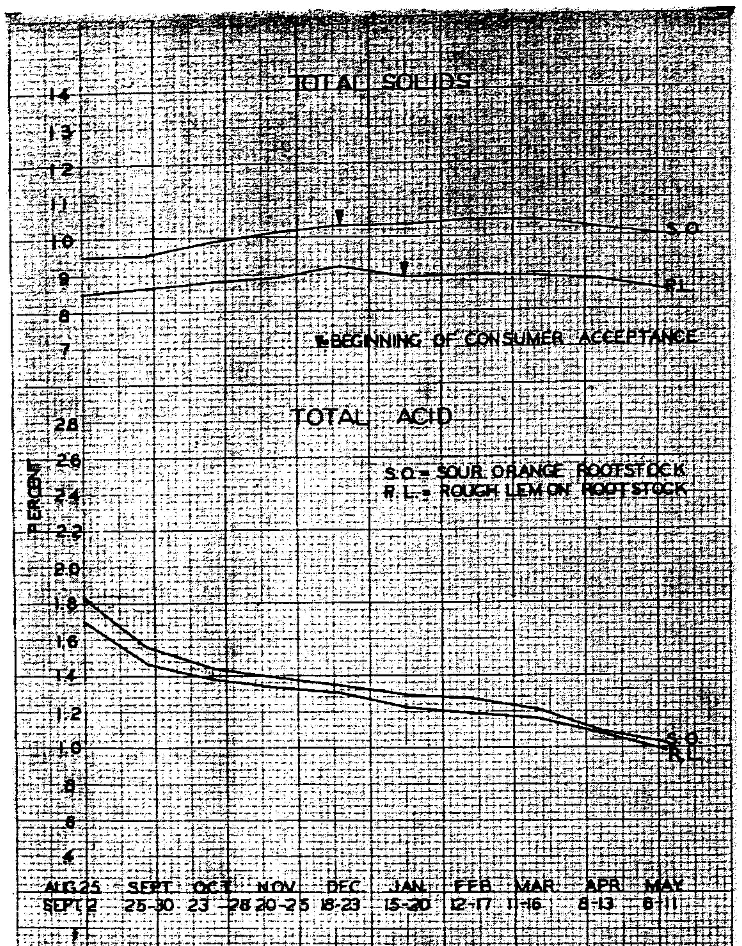


FIGURE 4 - SEASONAL CHANGES IN MARSH GRAPEFRUIT WITH INDICATED DATE WHEN THEY WERE JUDGED MATURE AND WOULD MEET CONSUMER ACCEPTANCE. AVERAGE FOR 4 SEASONS

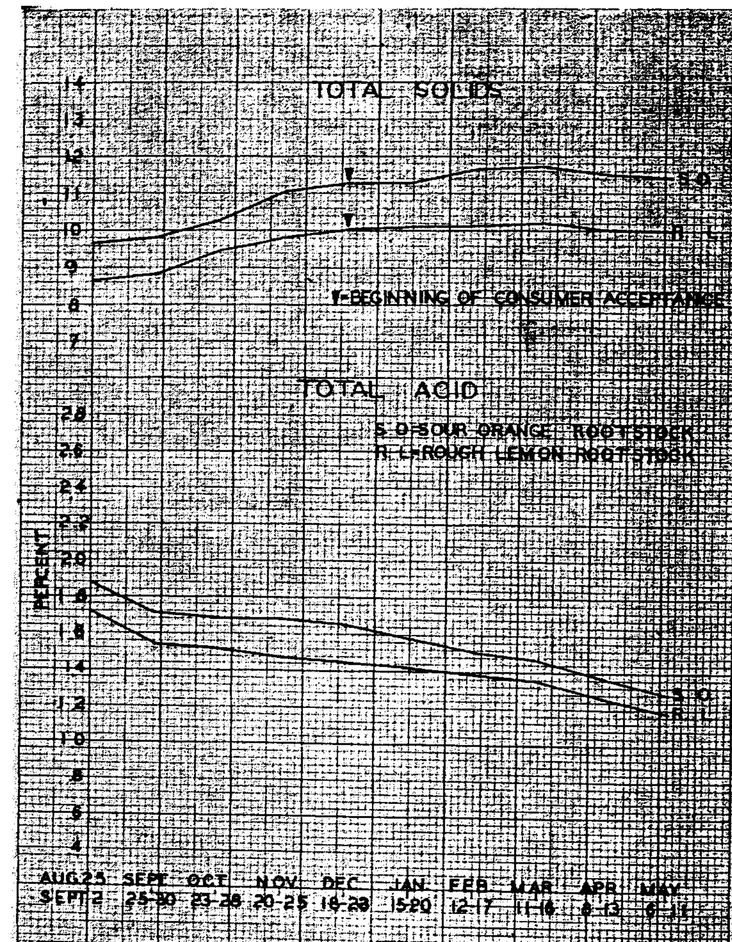


FIGURE 5 - SEASONAL CHANGES IN DUNCAN GRAPEFRUIT WITH INDICATED DATE WHEN THEY WERE JUDGED MATURE AND WOULD MEET CONSUMER ACCEPTANCE. AVERAGE FOR 4 SEASONS

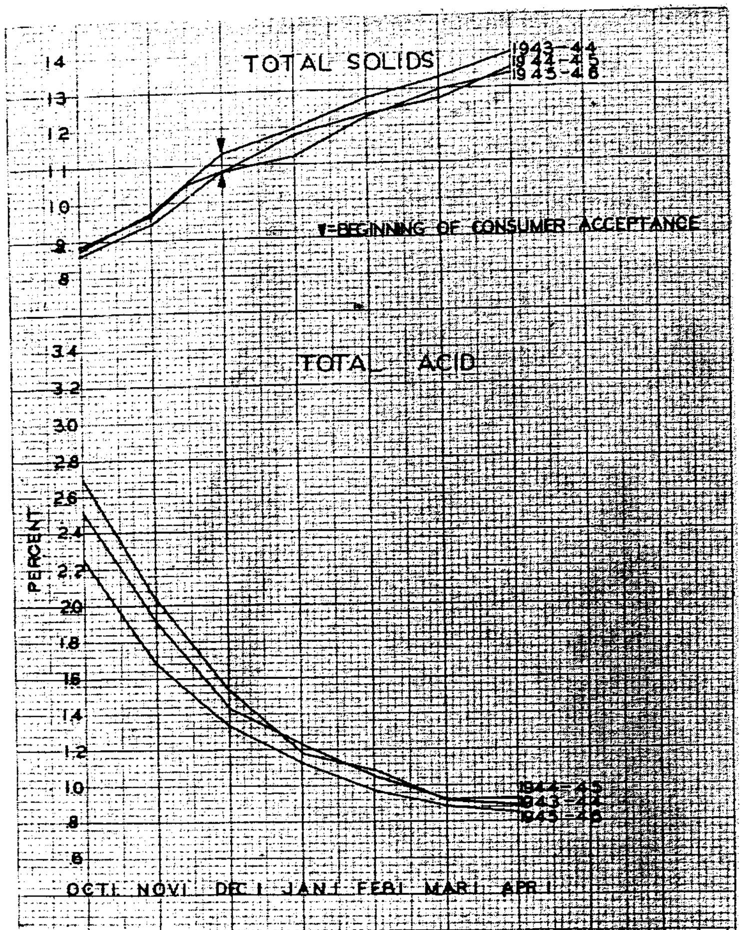


FIGURE 6-YEARLY VARIATION IN TEMPLE ORANGES ON SOUR ORANGE ROOTSTOCK WITH INDICATED DATE WHEN THEY WERE JUDGED MATURE AND WOULD MEET CONSUMER ACCEPTANCE AVERAGE OF TESTS OF SEVERAL GROVES.

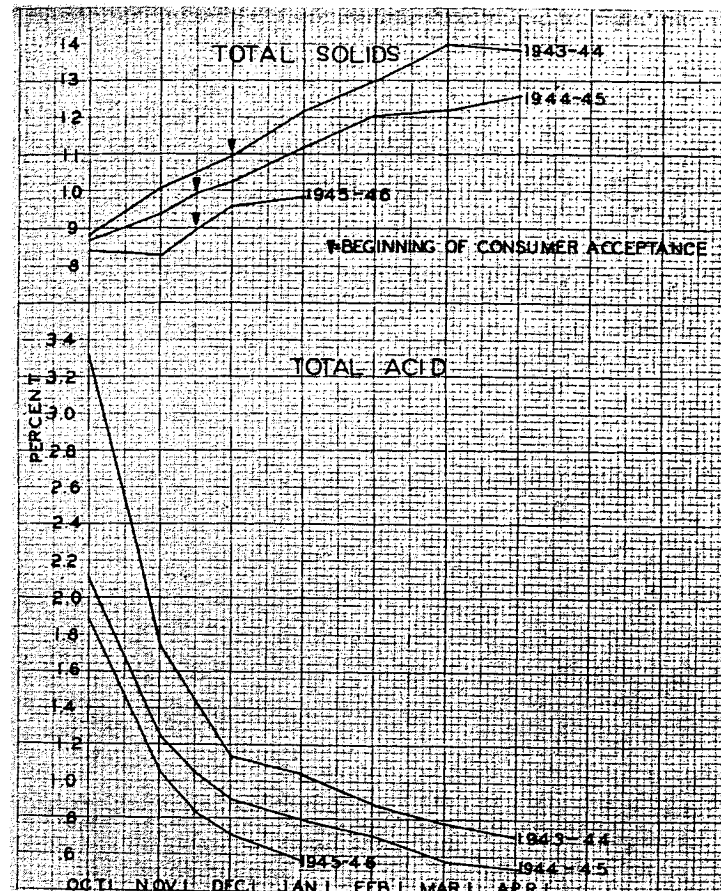


FIGURE 7-YEARLY VARIATION IN TANGERINES ON ROUGH LEMON ROOTSTOCK WITH INDICATED DATE WHEN THEY WERE JUDGED MATURE AND WOULD MEET CONSUMER ACCEPTANCE AVERAGE OF TESTS OF SEVERAL GROVES.

RESULTS

Seasonal changes in early oranges. Tests were made on several varieties of early oranges; however, in this article only the Hamlin and Parson Brown of the early varieties will be discussed. It will be noted in figure 1 that during the development and ripening of the fruits total solids increased, while total acidity decreased. Also in figure 1. it may be noted that Hamlin oranges contained lower amounts of solids and greater acidity than Parson Brown fruits.

Rough lemon and sour orange rootstocks affected the composition of Parson Brown oranges. On rough lemon they contained a lower percentage of solids and acid than on sour orange.

Parson Browns ripened earlier than Hamlins. They were judged to be of acceptable quality about November 11. At this date those on rough lemon contained 9.35 per cent solids, 0.66 per cent acid, and the ratio of total solids to acid was 14.17 to 1. In comparison, Parson Brown oranges on sour orange rootstock were considered to meet consumer acceptance November 15 and contained 10.60 per cent solids, 0.85 per cent acid, and the ratio was 12.47 to 1. Hamlin oranges on rough lemon were acceptable December 3, when they contained 9.30 per cent solids, 0.85 per cent acid, and the ratio was 10.94 to 1.

Seasonal changes in midseason oranges. The trend of solids and of acid in midseason oranges were similar to those of the early varieties in that during ripening solids increased and acidity decreased (see figure 2). Only small differences existed between the Pineapple and Homosassa varieties but the former contained slightly more solids. Florida Seedlings differ greatly from the two named varieties since they contained very significantly greater amounts of both solids and acid.

The three midseason kinds were rated as acceptable between December 20 and January 25. To be specific, Homosassa oranges were of acceptable quality about December 20 when they contained 9.23 per cent solids, 0.98 per cent acid, and the total solids to acid ratio was 9.51 to 1. Pineapple oranges were acceptable December 28 when they contained 10.12 per cent solids, 0.94 per cent acid, and the ratio was 10.85 to 1. Seedling oranges met consumer acceptance January 25 when they contained 13.07 per cent solids, 1.22 per cent acid, and the ratio was 10.71 to 1.

Seasonal changes in late oranges. Studies were made to determine the influence of rootstocks on the composition of Valencia oranges. The various plots were in the same grove and consisted of Valencias on rough lemon, sour orange, grapefruit, sweet orange, and Cleopatra rootstocks. Tests were made during three seasons on the Valencias from the plots on rough lemon, sour orange, and Cleopatra, whereas the fruits from the other two plots were tested during two seasons. Seasonal variations were found and these affected some of the averages, especially those made for two seasons only.

The data presented graphically in figure 3 show that the Valencias on sour orange and on Cleopatra rootstocks contained a greater percentage of total solids and acid than did those on rough lemon. The total

solids produced on grapefruit and on sweet orange were similar to the findings for the Cleopatra rootstock, ranging near those of the sour orange, all being significantly higher than in the case of Valencias on rough lemon stock.

As they ripened the Valencia oranges on all the various rootstocks became less acid. Fruits from the trees on sour orange rootstocks contained the most acid, followed by those from sweet orange, Cleopatra, rough lemon, and grapefruit.

The Valencias on grapefruit rootstock ripened first, being rated acceptable on February 20. At that date they contained 11.07 per cent solids, 1.07 per cent acidity, and the solids-to-acid ratio was 10.35 to 1. The Valencias on the other four stocks were of acceptable quality about March 1. Those on rough lemon contained 10.90 per cent solids, 1.00 per cent acid, and the ratio was 10.90 to 1. On sour orange the solids content was 11.80 per cent, acid 1.20 per cent, and the ratio was 9.83 to 1. Valencias on sweet orange contained 12.00 per cent solids, 1.00 per cent acid, and the ratio was 12.00 to 1. The Valencia fruits on Cleopatra stock contained 11.70 per cent solids, 1.10 per cent acid, and the ratio was 10.64 to 1.

Seasonal changes in grapefruit. Investigations were conducted on Marsh and Duncan grapefruit varieties during four seasons. The studies included changes in composition of the fruits, as affected by variety and rootstocks. Figures 4 and 5 indicate that the changes in total solids and in total acid are more gradual than was the case of oranges. The greatest change appeared early in the season on immature fruit. Total solids content was generally highest when the grapefruit was in prime eating condition, with slightly lower solids earlier in the season in immature fruit and also late in the season in very ripe fruit. The Marsh and Duncan fruits on sour orange root stock contained a greater amount of total solids than did those on rough lemon. Comparisons between varieties on the same kind of rootstock showed that the Duncan contained higher solids than the Marsh. While there was a downward trend in total acid in both Marsh and Duncan as they ripened, the Duncan was consistently higher in acid than the Marsh. Although total acid was influenced more by variety than by rootstock, the fruit on sour orange was rather consistently higher in acidity than that on rough lemon.

Scores for eating quality showed that both Marsh and Duncan were of acceptable eating quality between December 18 and January 15. Marsh fruits on sour orange were acceptable December 18, when they contained 10.32 per cent solids, 1.33 per cent acid, and the ratio was 7.77 to 1. Duncan fruits met consumer acceptance December 18. Those on rough lemons contained 10.04 per cent solids, 1.45 per cent acid, and the ratio was 6.92 to 1; while Duncan on sour orange contained 11.33 per cent solids, 1.65 per cent acid, and the ratio was 6.87 to 1. Marsh fruits on rough lemon were not of acceptable eating quality until January 15 when they contained 8.91 per cent solids, 1.22 per cent acid, and the ratio was 7:30 to 1.

Seasonal changes in the Temple orange. The Temple orange is notable for its fine eating quality. The fruits contain high total solids and high total acid and are also unique in containing aromatic constituents which impart to flesh and juice an unusually desirable bouquet.

The study on the Temple orange is still in progress, and the information presented herein should thus be regarded as only tentative. Space does not permit a full discussion of all the data accumulated to date; therefore, this article deals only with the compositional changes in the Temple fruits on sour orange rootstock, which is the principal one used for this variety.

Figure 6 shows the content of total solids and of total acid in Temple oranges during three seasons 1943-44, 1944-45, and 1945-46. The fruits contained slightly higher solids and acid during 1943-44 than during the season 1945-46, but the yearly variations were not great.

According to the averages obtained through the taste tests, the Temple was of acceptable eating quality by December 1 of each year. On that date, in 1943, the fruits contained 11.03 per cent total solids, 1.53 per cent total acid, and the ratio of total solids to acid was 7.21 to 1. In 1944 the ripe fruits contained 10.82 per cent solids, 1.43 per cent acid, and the ratio was 7.57 to 1; while in 1945 fruit which met consumer acceptance contained 10.82 per cent solids, 1.33 per cent acid, and the ratio was 8.14 to 1.

Seasonal changes in tangerines. The study of tangerines is also still in progress, and the information here presented should also be regarded as only tentative. The information given is for the Dancy tangerine on rough lemon rootstock, which is the principal variety and the most common used rootstock for tangerines.

Yearly variations for tangerines are shown in figure 7. It will be seen that there was considerable difference from year to year. The highest amounts of both total solids and total acid were found during the season of 1943-44, and the smallest during 1945-46.

Tangerines in 1943 were first rated of acceptable quality about December 1 when they contained 10.96 per cent solids, 1.12 per cent acid, and the ratio of solids to acid was 9.79 to 1. In 1944 tangerines were acceptable November 15 when they contained 9.92 per cent solids, 0.89 per cent acid, and the ratio was 11.15 to 1. The fruit met consumer acceptance November 15, 1945. and then contained 8.96 per cent solids, 0.70 per cent acid, and the solids to acid ratio was 12.80 to 1.

SUMMARY

The fruit quality standards arrived at in these investigations resulted from the data obtained through chemical analyses and taste testing by a panel of taste judges.

A statistical study was made of some of the taste ratings of individual judges. It was found that although differences existed among tasters, they were not large. There was a definite association between palatability ratings and some of the more exact measurements, such as total solids and total acid. Thus the statistical studies indicated that the palatability ratings were quite satisfactory to measure quality.

An over-all picture has been presented of the progress of ripening changes in oranges, grapefruit, Temples, and tangerines, and of the quality that might be expected on the market at different times. The general statements given are based on the average results of repeated tests.

The standards of consumer acceptance which were set up by the tasting panel do not agree very closely with the standards in the present maturity laws. The taste judges demanded sweeter and more mature fruit, or, in other words, fruit containing higher ratios of total solids to total acid than that which would pass State maturity requirements. The differences between the standards established through the tasting panel and by the maturity laws were greater for oranges and tangerines than for grapefruit.

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The Need for Orderly Marketing of Valley Citrus

By

ALDEN M. DRURY
General Manager
TEXSUN CITRUS EXCHANGE

Alden M. Drury has been identified with the citrus industry for 25 years, as a grower, executive of cooperation marketing, director of supply and manufacturing activities. His citrus experience began in 1923 with the Whittier District Fruit Exchange in California.
From 1932 to 1947 he was Secretary and Manager of the Tulare County Fruit Exchange, Porterville, California, from which position he resigned to become General Manager of the Texsun Citrus Exchange, Weslaco, Texas.
During the 15 years he was Manager of the Tulare County Fruit Exchange in California, he was a member of the Board of Directors of the California Fruit Growers Exchange, Fruit Growers Supply Company and Exchange Orange Products Company.

I feel highly honored at the invitation of the Rio Grande Horticultural Club to address this session of the Citrus and Vegetable Insitute.

The subject that I want to discuss with you is one that has been very close to my heart for a long period of years. I think perhaps the best introduction to the subject would be to cite a little ancient history for the Valley.

I find that at a citrus institute held at the Edinburg Junior College in 1932, economic conditions of the industry were very similar to those we face today and I quote from the remarks made by some growers at that meeting.

One said, "Most of the money I had when I came to the Valley has gone into my citrus investment here. I'll lose it if we don't market our fruit sensibly. I know plenty of others who are in the same boat." And Omar Miles, former manager and developer of El Progreso, when appointed as secretary of grower group charged with trying to find a solution for the ills of the industry, said, "I realize as well as anybody that we have got a challenging job ahead of us. Citrus is the crop that has brought a great many fine families to the Valley. They hope to find prosperity and contentment down here and it would be a hard blow to most of them if they couldn't make a profit from their trees. Plenty have put a large part of their savings into their citrus investment and need an income from it. I hate to think that all they have looked forward to can be swept into the discard by marketing that is becoming a joke and a by-word for outside observers."

Going back to January of 1947, when I came to the Rio Grande Valley, I was asked by THE MISSION TIMES to write a short statement on how the Valley looks to a newcomer. I should like to quote two or three paragraphs from that statement:

"As one who has just come to the Valley to head the Texsun Citrus Exchange, I see several things that need doing to put Texas citrus fruits out in front where they belong. I see many factors in the shipping and packing field who are apparently working at cross purposes rather than cooperating to solve the distribution problem of all of them. No attempt is made to coordinate the rate of shipments with the demand for our fruit—cars go forward without regard to market prices. Growers seem more concerned about getting the crops off their trees than getting money for their fruit. They could do both.

"So the first need, in my opinion, is for the citrus shippers to get together and establish a control board through which each one can arrange to ship his fair share of the crop week by week throughout the season. Control of the rate of movement each week is fundamental to any sound marketing program.

"I see the need for an industry-wide and representative body of growers, shippers and canners—a citrus commission, if you want to call it that—financed and controlled by real bona-fide citrus growers. Second, a commission can undertake research for the benefit of all. They can discover and publicize better ways of handling our soils, can help solve our pest control problems, can help to improve the quality of our citrus fruits—to name a few of their proper activities. Such a group could also be helpful in securing equitable freight rates for our fruits and products. It could speak for the industry in legislative matters, quarantines and could help with tariffs to protect our young and growing industry. Most important of all is the need for cooperation and working together for the best interest of the citrus growers in the Valley."

And so this brings us up to the present situation confronting the Valley and its citrus industry and to the subject I am to discuss with you today *"The Need for Orderly Marketing of Valley Citrus."*

We find some 175 shippers here in the Valley who compete one with another trying to purchase citrus fruits at as low a price as possible from the grower and to sell at as high a price as possible in the market. In addition to these cash operators, there are other handlers whom we might call commercial packers who do not purchase fruit outright but handle it on consignment for the growers at a fixed packing and selling charge. Such shippers are interested in handling volume but are not too concerned with price. And then there is the other group of cooperative shippers—some affiliated with the Texsun Citrus Exchange and some competing both with Texsun and the aforementioned shippers. All these shipping organizations have a place in the picture provided they all keep uppermost in their minds the welfare of the grower who produces the fruit. If these growers are not adequately paid, they will lose interest in the deal and will suffer such financial losses that they may have to abandon groves and citrus growing. Should that occur, the shippers will have to fold up, too.

With so many sellers there is fierce and ruthless competition here in the Valley between shippers. Sales are made by cutting prices, not by delivering quality merchandise and demanding true value for the service. And to get an extra dime for early shipment, the industry loses thousands of dollars each year by sending out immature Valley fruit that creates an increasing number of dissatisfied customers.

Having seen and sampled citrus fruit from all producing areas, I can state without reservation, that nowhere else is there such fine flavored and excellent eating quality as we have here in the Grapefruit Garden of the World.

If we pack it properly and ship sensibly, we should be able to demand and secure premium prices for it. Without any systematic program, we are at the mercy of the receivers who play one shipper against another and buy at their own bargain counter prices. How long must we tolerate this?

We build our packinghouses on railroad property or where they can be served by them. We handle fruit through the houses towards the railroad loading platforms. Our floor levels are planned to permit trucking fruit direct into refrigerator cars for loading. The railroads operate over fixed routes and on definite schedules so that cars can be traced all the way to destination.

But constantly increasing freight rates drive the industry to seek cheaper transportation. Last year one-third of our fresh citrus fruit was shipped out of the Valley by truck. So far this year, nearly two-thirds has moved that way. Truck routes are variable and their schedules not too reliable; we cannot trace them all the way; loading trucks disrupts the regular packing and loading procedure; *but* they make faster time to destination, they carry loads from shipper's door to customer's door without rehandling, and their rates are cheaper than by rail.

Again, the growers can help to return tonnage to the legitimate carriers, and eliminate the irresponsible truck operator by insisting through their spokesmen that rail rates be reduced rather than increased. This too will make for more orderly shipments—hence more orderly marketing of Valley citrus.

There is another cure for the situation and for the ills the industry suffers. That cure lies in a coordinated plan or program for the movement of the citrus crops produced in the Valley.

I am glad to say that there has been definite progress made during the past two years in breaking down the antagonisms and jealousies between the various shipping elements in the Valley. Much of the credit for this changed attitude can be ascribed to the formation of the Texas Citrus Advisory Council and its functioning on behalf of the industry here in the Valley. New moves are being made at the present time looking towards the establishment of a so-called Citrus Commission to be composed of the same elements—growers, shippers, canners, public representatives—who now make up the Texas Citrus Advisory Council, but the Commission would go one step farther and would have legal

authority to collect funds for purposes of research and other industry-wide activity and also authority to control the movement of fruit leaving the Valley.

Such controls would be applied to the sizes and grades of fresh fruit moving to market periodically throughout the season—probably setting up their regulations for two-week periods. Any such program would prove helpful in preventing the hit or miss shipments that are moving from the Valley under current practices. Such a program also would go a long way towards correcting one of what I call the vicious practices in the industry—namely, running the packing houses into the wee small hours of the night. There is no need for such activity and with the application of the suggested controls it would probably not occur. This would be a good thing for the workers, for the fruit itself, for the shippers, for the market and, therefore, for the growers who produce the fruit.

In times like these when the citrus industry seems to be in a depression by-passed by the high prices paid for other commodities, the growers who own the business should certainly take matters into their own hands, get together and establish some system that will mean a more uniform flow to market.

They could and should demand a revision of the State maturity laws. Do we think our early fruit is palatable enough that we eat, drink or serve our own citrus on our own tables during the first weeks of the shipping season? Improved maturity will mean more orderly shipments. Instead of a few rash purchases followed by a drop in price and a deadening of demand, there will be steady shipment, an active demand, and stabilized prices.

Machinery to really gear supply to demand is available if the growers want to use it—and they are the *only* ones who can put it into operation and run it. They can do this legally, efficiently and effectively—setting their own standards and limitations without fear of any anti-trust action; controls will be local, administration will be by a committee of your own friends and neighbors, selected by and answerable to you as growers. The proposed Texas Citrus Commission composed of industry representatives selected and appointed by the State governor may be able to accomplish this. We *hope* it can from the standpoint of economy. But we *know* that orderly marketing of our citrus can be attained under authority of the State and Federal Marketing Agreements that are already set up and available if the growers wish to make use of them.

We have a relatively short crop this year, but we have shipped so fast that we are already running out of supplies of some of the early varieties. If we continue to ship at the present rate, we will find other varieties dropping out of the picture and that by February or March most of our crop will have been moved, demand will be strengthening and supplies will not be available to satisfy such demand. In other words, an orderly program of distribution and marketing is even more necessary in times of a short crop than it is in times of bumper crops and surpluses.

Soil Sulphur for the Control of Mineral Deficiency Chlorosis

By G. H. Godfrey
Plant Pathologist
Lower Rio Grande Valley Experiment Station

Dr. G. H. Godfrey obtained his Ph. D. in Plant Pathology at the University of Wisconsin in 1923. He has done Plant Pathology work for Oregon State College, U. S. D. A., the Bayer Co., Hawaiian Pineapple Canners and California. He has been Plant Pathologist at the Lower Rio Grande Valley Experiment Station of Texas at Weslaco since 1937. He has done work on nematode diseases of plants, seed and soil disinfectants, and vegetable, cotton and citrus Pathology. The work on sulphur was done, with the assistance of a Research Fellow, Herbert Rich, under a two-year program supported by the Texas Gulf Sulphur Company.

Chlorosis is a plant disease characterised by yellowing of the foliage. It may be due to a wide range of causes, such as:

(1) Insufficient light. Plants growing in too shady a spot will turn yellow.

(2) A soil that is too cold and wet for the particular tree or plant. We have all seen trees with a yellowish cast early in the spring. They will often recover of their own accord when the soil becomes warm later in the spring.

(3) Plain nitrogen starvation. An underfed tree shows poor color as a first symptom.

(4) Salty soil.

(5) A soil that is too alkaline.

(6) Deficiency of certain minor elements essential to healthy plant growth.

The last two points only are to be considered in this paper, together with the place of sulphur as a control measure.

MINERAL DEFICIENCY SYMPTOMS

The symptoms of mineral deficiency chlorosis vary with the particular mineral concerned.

Iron deficiency chlorosis: a yellowing of the leaf blade varying from slightly paler green than normal to almost white, with the midribs and veins green.

Zinc deficiency chlorosis: a shortened twig growth at times approaching a rosette; undersize narrow leaves, and a chlorotic pattern consisting of an inverted "V" effect in green at the midrib and main lateral veins, broad at the base and tapering to a point at the leaf tip and vein tips, the balance of the leaf being yellow to white.

Manganese deficiency chlorosis: a chlorotic pattern similar to that of zinc deficiency (perhaps a bit more spotted with yellow), on leaves less reduced in size and width, and without the distinct rosette effect on twig growth.

Magnesium deficiency: the yellowing starts near the midrib and gradually spreads outward until it takes in the entire leaf after which the leaf sheds frequently leaving the fruit on a long twig devoid of leaves. Only

mature leaves are affected and these are usually on the same twig with and close to fruits. The yellowing often takes on a bronze appearance.

Other symptoms are associated with copper deficiency and boron deficiency. These are probably of minor importance, in the Valley. Deficiencies of more than one element and other adverse soil factors make complicated leaf patterns that are sometimes difficult to interpret.

THEORETICAL CONSIDERATIONS

Minor elements insoluble in alkaline soils.

The minor elements with which we are concerned are insoluble, or practically so, in the soil water of an alkaline soil. Most of our soils are alkaline, ranging from pH7 to pH9 or more. The natural acids constantly being produced in small quantities in the soil from decaying organic matter and root secretions, probably prevent mineral deficiency chlorosis from being more universal than it is.

The answer, soil acidification.

Obviously, from what has been said thus far, acidification of the soil is necessary to release the minor elements from their "tied-up" or "fixed" state, to the soluble condition. However our Valley soils contain at least 40,000 pounds per acre-foot, of calcium carbonate in the form of shell, shell residues, and caliche. That is a minimum; it runs up to 20 times as much: this acts as a constant buffer to prevent complete acidification of the soil. Each pound of calcium carbonate will neutralize very close to 1 pound of sulphuric acid. It would require 40,000 pounds (3000 gallons) of sulphuric acid to bring just to the neutral point that least-calcareous soil, in the upper foot alone. It is only *excess* acid that would have a permanent acidifying effect. The use of straight acids, therefore, would appear to be impractical for permanent correction of an alkaline soil, if indeed a soil on the acid side is what is wanted here, which is highly questionable. What, then is the answer?

The acidifying qualities of sulphur.

Much has been said and written about the use of sulphur as a soil-acidifying material. How could this be when sulphur itself is neutral, (pH7.0), and relatively inert? The answer is that there are present in most soils strains of bacteria, the sulphur bacteria, that, in their growth and activity, oxidize sulphur to produce sulphuric acid as the end product. This is a gradual process. When sulphur is placed in the soil, if the bacteria are present and conditions favorable, activity commences at once. This results in the creation of an acidified zone surrounding the particle, or pocket, or streak of sulphur. First there must be the neutralizing of the reserve of base-forming materials in the immediate vicinity; then the gradual building up of acidity in that zone and its diffusion outward into a gradually expanding zone. Roots growing into that zone or into the area influenced by it are then able to absorb the minor elements available there in soluble form.

The extent of the zone of acidified soil depends upon a number of factors. The actual quantity of sulphur used, in relation to the amount of calcium carbonate or other base-forming material present will govern the length of time over which the sulphur can be effective. One pound of sulphur will eventually be converted to about 3 pounds of sulphuric acid. Then in the course of time the 1 pound of sulphur can do no more than neutralize 3 pounds of calcium carbonate. The finer the particle, the more rapid can be the development of acid. There must be sufficient moisture and favorable temperature. Bacterial action will stop in dry soil. It will be more rapid in warm than in cold soils, other conditions being equal.

It would be completely impracticable to attempt to neutralize or acidify the entire volume of soil in which roots feed with sulphur, just as with straight acid. It would be impossible to distribute the sulphur uniformly. There would be created zones of excess acidity that would be toxic to any kind of plant growth. In actual experience on a test plot on the Station, conducted by W. J. Bach, 5000 pounds of sulphur per acre is reported to have made the soil unfavorable for crop growth for more than a year.

Further, there is reason to believe that soil that is acid throughout the root zone is not necessarily the thing to be desired for citrus. A calcareous soil apparently has some advantages over an acid soil, as is shown by the excellent quality of our Texas citrus. The aim of sulphur applications, therefore, should be to overcome the one main disadvantage of an alkaline soil—that of the tying-up of the minor nutrient elements—to just sufficient to meet the requirements of the plant, leaving the balance (the very large balance) of the soil unaltered. This can be accomplished by zone or spot acidification. If such spots are well distributed sufficient root system may be expected to grow into such zones to provide the plant with its exceedingly small requirement of such elements.

EXPERIMENTAL RESULTS

Thus far this paper has dealt with the theories and with fundamental facts upon which soil acidification with sulphur depends. Abundant work has been done first in the way of actual acidification of soils by sulphur applications, and second, on control of mineral dificiency chlorosis by sulphur applications.

Soil acidification studies

A very few examples, from dozens of tests conducted, are given to show the extreme degrees of acidity that can be obtained in mixtures of sulphur and soil. The first tests were conducted with 50-50 mixtures of sulphur with a finely screened aged barnyard manure, with 50-50 finely screened somewhat charred dehydrated citrus peel and sulphur, and with 50-50 loose top soil and sulphur, all three of the lots being thoroughly mixed. Results in all lots were practically the same—the development of acid within 30 days to such an extent that pH readings (by glass electrode in saturated soil paste) were 2.0 or even lower. Such mixtures were exceedingly acid—far too acid to support plant growth. Out of this study however, there developed the idea of an acid sulphur compost that could be used as a source of immediately available acidity. Further mention will be made of this material and its application.

Other laboratory studies were made with very much lower pro-

portions of sulphur in the mixtures. In one test, finely ground flowers of sulphur was mixed in the desired proportions with loose top soil of an initial pH of 7.85, which is decidedly alkaline, and representative of many of our Valley soils. Compared with this were mixtures of the same soil with initially acid sulphur compost containing equivalent proportions of sulphur. Periodic readings were taken during the course of several weeks to determine the rate and extent of acid formation.

TABLE I

The rate of acid development in a soil of pH 7.85 mixed with sulphur and sulphur compost in low concentrations.

Rate of application, percent sulphur by weight	Number of days (less than)* to attain indicated pH range: 6.0 to 7.0 Sulph.	6.0 to 7.0 Sulph. comp.	5.0 to 6.0 Sulph.	5.0 to 6.0 Sulph. comp.	4.0 to 5.0 Sulph.	4.0 to 5.0 Sulph. comp.	Less than 4.0 Sulph.	Less than 4.0 Sulph. comp.
0.10	--	115	--	--	--	--	--	--
0.15	250	13	--	115	--	--	--	--
0.20	250	13	250	78	--	115	--	--
0.25	146	13	250	78	--	115	--	250
0.30	115	13	250	78	250	78	--	115
0.35	78	13	146	78	250	78	250	115
0.40	78	13	115	78	250	78	250	115
0.45	78	13	115	13	146	78	250	78
0.50	78	13	115	13	115	78	146	78

* The readings were taken only on the days indicated, i.e. on the 13th, 78th, 115th, 146th and 250th days after mixing. Therefore the pH indicated was attained at some time between the day indicated and the previous reading.

** Based on 3½ million pounds of soil to acre-foot.

Not shown in the table is a reduction with sulphur at 0.35 per cent to less than pH 3.0 in less than 250 days and with sulphur at 0.5 per cent to as low as pH 2.6 in less than 250 days; also reduction with sulphur compost at 0.5 per cent to less than pH 3.0 in less than 115 days.

Most striking in the table is the consistently more rapid acidification in the mixtures in which the source of the sulphur was the initially acid sulphur compost, heavily charged with sulphur oxidizing bacteria. For example in the 0.15 percent mixture (rate, 1½ pounds of sulphur to 1000 pounds of soil), between 115 and 250 days were required for the sulphur mixture to become acid whereas less than 13 days were required for the sulphur compost mixture.

These figures show, for the specific soil used (a Victoria fine sandy loam with initial pH of 7.85 and a calcium carbonate content that must have been less than 12,000 pounds per acre foot) that three rather significant findings are to be deducted:-(1) that as low a sulphur content as 0.1 percent by weight in the soil is capable of reducing the pH of the soil to well below the neutral point: (2) that increasing the amount of sulphur consistently hastened the process of acidification and greatly increased the amount of acid produced; and (3) that the use of sulphur compost (heavily charged, initially, with sulphur oxidizing bacteria) still further greatly hastened the rate of acidification, but that ultimately the same degree of acidity was attained with the sulphur alone. The longevity of the acid condition would depend upon the quantity of sulphur remaining in the soil. As long as any unoxidized sulphur remained it would be capable of continuing to generate acid.

The point just made was put to test in a leaching experiment, in which an acid sulphur compost treated soil(pH 1.6) was repeatedly washed with distilled water, thereby removing free acid, until a constant pH of around 3.65 was obtained. The soil was then set aside and kept slightly moist and warm. After 3 weeks extremely high acid was again present, as shown by a pH reading of below 1.0. Simultaneously a parallel test was run in which the soil had been acidified with aluminum sulphate (sometimes used in gardens for acidifying soil.) A minimum pH of 4.0 was reached immediately. Three weeks after leaching, this mixture rose in pH to 7.0, and after another month it was 7.4. The aluminum sulphate treatment did not re-acidify the soil after leaching; the sulphur compost did.

Before dropping the subject of sulphur composts, mention should be made of the several sulphur compost pits that were made at the Station for experimental work and observations. In one pit, exposed to the weather, made on half sulphur and half screened barnyard manure, several hundred pounds of each being employed, the pit was dug to a depth of 3 feet and the mixtures moistened slightly (to a state similar to "good growing conditions" in a soil) as it was inserted. The usual high degree of acidity (pH ranging around 2.0) was attained in about 30 days. Following the heavy rains of that season acid was leached out of the compost mixture and soaked into the ground beneath it to a depth of at least 36 inches, where the pH was 4.7. In the next 3 inches below that, in a calcareous layer, the pH was 6.7.

The proportion of sulphur in excess over calcium carbonate in a mixture, whether 10 or 90 percent, or any intermediate percentage, makes little difference in the rate of acid development. Tests have shown a pH range of from 1.0 to 1.5 developed in 6 weeks in all alike. As long as free sulphur continues to be present in excess over any basifying material the acid content will continue to increase up to a certain maximum range where it will hold rather constant. The base forming materials are first neutralized, after which acidity increases.

Diffusion of acidity from points of application

Studies were made on the vertical and lateral diffusion of acidity developed in spot applications of sulphur made two years previously in orchards. Trenches were dug beside the marked spots and clean cuts made through the center of the still-visible spot of sulphur, about 6 inches below the soil surface. In one orchard of sandy low-calcium soil the diffusion of acid was clearly determined. The pH was about 2.0 in the spot and just below it. The pH increased gradually to a depth of 14 inches, where the reading was pH 4.3. At 16 inches depth it was 6.7, or slightly on the acid side of neutral. Three inches to the side the pH

ranged from 2.2 to 3.7,indicating that acidity existed still farther around the point of sulphur. In another spot application in highly calcareous soil neither the vertical nor lateral diffusion was quite so far but snail shells were found that crumbled when touched, showing that they had been acted upon by acid and changed from calcium carbonate to calcium sulphate. In both cases living tree roots were found within the zones of soil influenced by the acid. Tying this in with the earlier "theoretical considerations" any iron or other rare element necessary for plant growth present in this slightly acidified zone is likely to be in such a form as to be available for absorption by the tree roots.

Control of mineral deficiency chlorosis by sulphur applications

All this theoretical stuff, and even the facts regarding actual acidities produced by sulphur would not be worth the paper it is written on unless it is shown that actual benefits can be derived for the trees by applications of sulphur. The basic facts have been presented, of course, with the knowledge that such benefits *are* derived, and to point the way toward wisely planned methods in the use of sulphur; and the methods of application are indeed a very important consideration.

Early evidence of the value of sulphur for chlorotic citrus trees, was obtained from a carefully planned duplicate-plot experiment started by W. J. Bach, in June, 1936, on a block of yellow trees. Sulphur was applied in post holes at a depth of about 6 inches, at the rate of 20, 30, and 40 pounds per tree, and about 30 pounds per tree in a trench or furrow entirely surrounding the tree at about the same depth. There were 2 blocks of 4 trees each, to each treatment. Readings taken 2½ years later showed striking recovery from chlorosis to almost completely green in most cases. The best result, with an average of 43 percent improvement in proportion of green leaves came with the trench application. The non-treated check trees, receiving only good farming practices including fertilization, showed 12½ percent improvement, but were still decidedly yellow. Tree caliper measurements made at the time of treatment and at the final observations 2½ years later, showed, for some of the treatments an average of 25 percent greater increase in tree diameter than the checks. In the trench-application treatment, which might have cut lateral roots, there was no such increase in rate of growth.

A more comprehensive experiment was conducted on a large citrus orchard near Mission, in which chlorosis was general and severe. Several different sulphur-containing materials were applied in the spring, by different methods including surface-broadcast in a 4 foot band, disked in; a furrow surrounding the tree just at the drip line; post-holes, 20 per tree, evenly distributed under the tree and just outside the drip; and in 8 radial furrows per tree, extending from near the trunk outward to outside the drip. Readings on the severity of chlorosis were recorded on each of the 5 trees included in each treatment at the time of application, and at different intervals thereafter. In general 20 pounds of sulphur were applied to each tree.

Here again, striking benefit from sulphur became evident, mostly in the first summer's growth. Without going into detail, results were somewhat as follows: A natural acid sulphur-bearing earth containing about 10 percent sulphur as such applied at 20 pounds per acre, broadcast and in the furrow showed good first season benefit; but at the end of the second season's growth, with insufficient acid-producing materials to last longer, the trees had deteriorated to their original condition of chlorosis. (2) A granular 30-mesh sulphur, broadcast, was not effective; applied in furrows it showed 15 to 20 percent improvement that was still evident the second year. (3) Acid sulphur compost and an acid blowbox sulphur applied by any of the methods showed long lasting effectiveness, bringing the trees in many cases to an almost completely green color. (4) Gypsum at 20 pounds, broadcast, was not effective. (5) Sulphur compost and gypsum mixed in furrow brought about one of the best manifestations of recovery; possibly improved penetration into the soil was brought about by the gypsum. (6) Check trees averaged actual deterioration of 8 percent in chlorosis. This amount added to the benefit figures shown for the treatments would give a truer picture of the benefits derived from the sulphur applications.

In another extensive orchard experiment on a Weslaco-vicinity grove showing marked mineral deficiency chlorosis symptoms, 5 pounds per tree of mineral salts of various kinds were applied on 2-tree blocks with and without combination with sulphur. The spoke-furrow method of application was followed. At the start it was noted that zinc-deficiency symptoms were very evident in some trees, particularly Temple oranges. On others, manganese-deficiency was indicated by leaf symptoms. Iron deficiency leaf symptoms were lacking. The mineral salts were applied on some pairs of trees singly, on others in combinations with a single element lacking. (For example, zinc sulphate would be applied on one block, and all the elements tested except zinc sulphate on a comparable block.) Then of course there were check trees without any element added. The usual procedure of recording before and after chlorosis condition was followed.

Some of the results were very striking. Temple orange trees that had shown marked zinc deficiency chlorosis (average 50 percent yellow) were brought to practically complete recovery by fall of the first year with zinc sulphate alone, and with all mixtures (including sulphur mixtures) containing zinc. Sulphur alone did not correct zinc deficiency chlorosis. There appeared to be an absolute deficiency of this element in the soil, not just a lack in availability correctible by acid. Where zinc was used, the recovered condition endured for at least 4 years, without further amendments.

Trees, both grapefruit and orange, that had shown manganese deficiency symptoms were corrected by all applications containing manganese sulphate. The salt alone did not bring about quite as complete recovery as did the sulphur-manganese mixture. This was therefore an indication of manganese fixation, correctible by acid. In the case of iron, the first impression of lack of iron deficiency symptoms was verified by the findings. There was no marked improvement from additions

of iron sulphate, etiher with or without sulphur. Magnesium sulphate, and copper sulphate (at 2 pounds per tree) likewise brought about no correction.

This significant test would seem to indicate that one can be guided by examination to determine the particular mineral deficiency responsible for the symptoms found. The method of treatment used in this test was effective. Whether or not it would be the most effective and most practical method of chlorosis control remains to be determined by extensive experimentation. Application of deficient minerals by spraying is not practiced to any great extent in the Valley at the present time, as it is in Florida and California.

Chlorosis control in nurseries.

Without going into details of experiments involved, it is sufficient to say at this point, that striking control of iron deficiency chlorosis has been obtained in the nursery row. In one case, some hundreds of budded nursery trees were so yellow in the fall that they were "written off" by the nurseryman as unsalable. They were made available to the Station for experimental work. In October, a series of soil treatments was applied consisting of sulphur alone and in combination with various other materials, and of certain other materials for comparison. All were applied in furrows beside the young trees just above the root zone. Later observations showed practically complete recovery from all materials containing sulphur, and in the spring, many of the trees were sold. Aluminum sulphate brought about only 82 percent green; ammonium sulphate used for its nitrogen value, left the plants only 70 percent green. Gypsum, though it may have improved permeability of the soil, did not cure the chlorosis.

In another large-scale test, some 20,000 badly chlorotic budded trees were involved. In the spring, acid sulphur compost alone for one lot, at the rate of 250 pounds per acre and sulphur compost at the same rate with added iron sulphate were applied in furrows beside the rows. By September, the sulphur plus iron sulphate treated trees were practically 100 percent green; the sulphur compost treated trees were not quite so good. Other materials such as gypsum and nitrogen were not effective, showing that this was a true case of mineral deficiency and not just nitrogen starvation.

Chlorosis control in ornamentals.

Sulphur and sulphur compost (for quicker results) has brought about good recovery from iron deficiency chlorosis (which is the most common on ornamentals), in tests on roses, gardenias, bougainvilleas, hibiscus, and other ornamental shrubbery, and even on an annual plant, Calendula.

Precautions on the use of sulphur

Any mixture of soil and sulphur can become too "hot" to use promiscuously around plants;——not hot in the thermometer sense, but hot in the chemical-burning sense. It has already been stated that as low as ½ of 1 percent sulphur in a mixture with soil may attain a pH below 3.0 in less than 3 months; and 3.0 is too acid for most plants to endure. The acid sulphur composts referred to in this discussion cannot be considered to be a substitute for ordinary compost heaps and their well decayed organic matter commonly used as top dressing in flower beds and seedbeds of various kinds. Acid composts diluted with soil have mistakenly been used for potting soils with disastrous results. Composts are useful for one purpose, and one only;—that of spot application, at 3 or 4 points around a chlorotic shrub (or 20 to 30 spots around a chlorotic tree) in which acid zones of soil are produced from which acid gradually diffuses to reach and benefit the roots.

Another disastrous mistake that has been made is that of putting sulphur into the soil used for banking young trees in the newly planted orchard. One year, somebody (not connected with the Texas A. & M. system) made the mistake of recommending that procedure to growers. That year hundreds of young trees were killed by the highly acid soil that lay for weeks next to the trunks. Some of the trees that were brought to the laboratory had soil still clinging to the trunks that showed a pH of 2.5. Later the speaker chanced to pass by a recently banked orchard with sulphur showing in the banking soil. The grower was warned of the danger and he proceeded at once to pull all the sulphured soil away from the trees. It is practically certain that by so doing he saved himself the replacement cost of several hundred trees. And that was at a time when trees were costing $2.00 apiece.

SUMMARY

Chlorosis or yellowing of plants is frequently brought about by deficiency of certain minor elements, chiefly iron, manganese, and zinc. With iron at least, and to a certain extent with the others, the deficiency is in availability to the plant, rather than absolute lack of the element in the soil. These elements in an alkaline soil such as that which prevails in the Valley are likely to be in insoluble form. They can be made and kept soluble and so available for absorption by the plant roots, by acidifying the soil. It is not practicable to attempt to acidify the entire volume of soil, as tremendous quantities of acid-forming materials would be required to do this. It is more practical to acidify spots, streaks, or zones of soil, into which some of the roots will grow and thus supply the very low quantities of these minor elements essential to healthy growth. Sulphur, if applied in spots or streaks, well below the surface to avoid disturbance by cultivation, gradually and over a long period oxidizes to sulphuric acid, thus creating long-lasting acidified zones in the soil. This paper details experiments that have demonstrated the value of sulphur for the cure and prevention of chlorosis.

Spray Control for the Control of Mites and Scale Insects in Florida

By W. L. Thompson
Florida Citrus Experiment Station

W. L. Thompson graduated from Pennsylvania State University. He has been at the Citrus Experiment Station since 1925. His work has included the life history of several of the citrus insects, control of scale insects, rust mites, purple mites and various other insects infesting citrus. His work also included the relationship of scale infestation to tree vigor and other conditions which may be a factor which causes scale increase. He has studied the relationship of timing of oil sprays to the percent of solids in the juice as well as the relationship of the effect of oil to natural and artificial coloring of the fruit. Considerable of his time has been spent in seasonal program work for the combined control of insects, mites and diseases on citrus.

Spray programs are recommendations for the control of insects and diseases in a more or less specific area so a program suitable for the control of an insect in Florida may not suit conditions in Texas. Nevertheless, practices of one area may be, with some modifications, of some value in other areas. In this discussion on the control of mites and scale insects in Florida, it is realized that control methods recommended in Florida may not be suitable under Texas conditions.

Because of the limited amount of time to prepare this paper no attempt was made to review the literature related to the subjects discussed except for that work done at the Florida Citrus Experiment Station.

Citrus has been grown in Florida ever since the Spaniards came to this country. At first very few insect pests were present, but as the years have passed, insects from foreign countries have found their way there and the introduction of each new insect or disease pest made the problems more complicated. Constant changes in a spray program have been necessary to keep up with the insect and disease control as well as with the changes in cultural practices. In Florida, because of a change in the nutritional program, the control of purple and Florida red scale and the citrus red mite (purple mite) is more difficult at present than it was fifteen years ago. During the late twenties and early thirties, sandy soils were deficient in magnesium, zinc, copper and manganese. The trees were weak and foliage was sparse and chlorotic. Scale insects and purple mites did not thrive on that type of tree and the spray program was fairly simple. When the known nutritional deficiencies were corrected, the trees became more vigorous, more dense of foliage and the scales and mites thrived. It was not only necessary to improve the insecticides, but also it was necessary to learn how and when to spray in order to obtain the longest period of control with the least damage to the trees and fruit.

The Florida Spray and Dust Schedule for citrus is what might be called a preventive schedule rather than a corrective one. It is a pre-determined schedule which is designed to control the mites, scale insects, and disease before any appreciable amount of damage is, done to the trees or fruit. The preventive schedule is in contrast to a corrective one where treatment is delayed until the insects become numerous. Where the preventive schedule has been followed, the control of mites and insects has been more effective and at no greater cost than where a corrective schedule has been followed. It has been found that the per- iod of control has been longer when the population of mites or scale insects was at a low level when the treatment was made than when the treatment was delayed until a medium to heavy infestation had devel- oped. The preventive program has been especially effective for con- trolling rust mites. If the application of sulfur is delayed until some rus- seting is apparent or until a heavy population of mites develops, a certain amount of injury has already occurred which no amount of spraying can cure. The rust mite, having a short life cycle of 7 to 8 days, can reinfest the trees in a short period of time if any number of rust mites are left alive even after a sulfur application.

In Florida the insects and mites of major economic importance in- festing citrus in the order of their importance are purple scale, rust mite, purple mite (citrus red mite), Florida red scale and whitefly. The two major diseases affecting the trees and fruit are melanose and scab. Mel- anose is common in all areas of the state, but scab is more or less confined to the coastal sections. Compounds of zinc and in some areas manganese are added to the sprays for nutritional purposes. The spray schedule has been made so that insecticides, fungicides and nutritional elements can be combined in one spray where it is practical.

Rust Mite and Purple Mite Control

Rust mite injury and the control of rust mite **will** be discussed first because the injury is of major importance as a grade lowering factor. There are two types of rust mite injury, which in Florida are known as early injury and late injury (7). The early injury may occur between the time the fruit has set and until it is about three-fourths grown. The injury is usually a light to dark brown color and is common on the stylar end of the fruit, but where heavy infestaions have developed before the mites have been controlled, the injury may be all over the fruit. If the injury is examined under a hand lens, small cracks may be observed. Unless very close observations are made, the early type of injury may not be noticed until the fruit has colored. The early rust mite injury is most noticeable on oranges and is sometimes mistaken for melanose.

Late rust mite injury is caused after the fruit has about reached its normal size. It has a smooth appearance, is brown to black in color and will take a sheen when polished.

Rust mites can cause serious injury to the leaves. This injury is known as "greasy spot" and "greasy melanose." (13) In groves where the rust mites are not controlled during the winter, "greasy spot" develops at a later date. Where "greasy spot" is excessive, leaf drop may be severe with a potential effect upon subsequent yield.

Rust mites are controlled with some form of sulfur. The most common forms used are lime-sulfur, wettable sulfur, and sulfur dust. A combination spray of one gallon of lime-sulfur plus 8 to 10 pounds of wettable sulfur has resulted in the longest period of control. However, during dry periods wettable sulfur at 10 pounds per 100 gallons of spray has kept the rust mite population down so that less than 15 percent of the fruit was infested for 60 to 90 days or longer. Wettable sulfur sprays rather than lime-sulfur are recommended during the summer because they are less apt to produce injury to the fruit. Sulfur dust has not been as effective as sulfur sprays, but if properly applied, dusts have given satisfactory control except during rainy weather. If sulfur dust is applied by an airplane or a conventional type duster, it floats on or through the trees and settles mainly on the top surfaces of the leaves where it is most exposed to the elements. Thus, since a higher percentage of the mites are found on the lower surfaces of the leaves than on the top surfaces, the fumigation action of the sulfur must be depended upon to kill the mites on the under surfaces of the leaves. On the other hand, when sulfur is applied with a pressure sprayer a high percentage of the leaves are turned by the pressure of the spray and an appreciable amount of sulfur deposited on the under surfaces of the leaves not only comes in direct contact with the mites, but it is subject to less weathering and may remain for a considerable length of time. For this reason, longer periods of control are obtained by spraying.

Within the last fifteen years, purple mites have become of major importance as an annual pest in Florida. They may be numerous any time between November and June, but the most serious damage, in the form of leaf drop, occurs between November and the spring flush of growth (10).

At present dinitro-o-cyclohexyl phenol, called DN in Florida, is the most common material used for purple mite control. For a spray, 2/3 of a pound of a 40 percent dinitro-o-cyclohexyl phenol wettable powder is used per 100 gallons. For dusting, a sulfur dust containing one percent of the active ingredient is effective. When the DN is applied as a spray, it is supplemented with wettable sulfur so that the rust mites and purple mites will be controlled at the same time. Because of possible injury to both fruit and foliage, DN should not be used when the air temperature is above 88 degrees Fahrenheit.

Neotran, bis (P-chlorophenoxy) methane, has been used in an experimental way and has been found to be very effective when used as a spray at 2 pounds per 100 gallons or as a dust at 4 percent Neotran in sulfur dust. Although Neotran has not been as toxic to foliage and fruit its cost is much higher than DN, and none has been used commercially in Florida on citrus. Oil emulsions at 1.3 percent actual oil are very effective for controlling purple mites, but they are not used extensively for that purpose because the mites are usually present during the fall and winter months when it is not advisable to use oil sprays.

The schedule for rust mite and purple mite control is much the same. In January, or before the spring flush of growth starts, a DN-wet- Even table sulfur spray or a 1 percent DN-sulfur dust is recommended. Even though the crop has been picked, this application is stressed because a DN-sulfur application will reduce or prevent a build up of rust mites and purple mites on the leaves. It is also a safe period to apply DN. This pre-growth sulfur application so reduces rust mite populations that few mites are present when the fruit is set and is thus an important factor in preventing early rust mite injury. Where purple mites are not a problem, DN is omitted and standard sulfur sprays or dusts are substituted. Zinc is often included in this dormant sulfur spray for nutritional purposes. Although neutral zincs are used, zinc sulfate is the most common material applied. It is ordinarily applied at 3 pounds per 100 gallons and is neutralized with lime-sulfur or 1½ pounds of lime (1 pound of lime if DN is included in the spray).

One to three weeks after the fruit has set a second application is recommended. This spray includes sulfur for rust mite control and copper for melanose control. Neutral coppers are used at a copper equivalent of a 3-3-100 bordeaux (2). The usual spray consists of a neutral copper compound plus 10 pounds of wettable sulfur per 100 gallons. Proper timing is essential for the satisfactory control of melanose. Thus, it is important to have the copper spray on the young fruit before any melanose infection takes place. If melanose control is unnecessary, sulfur should be applied alone in order to prevent rust mite injury. Rust mites increase very rapidly during April, May and June and it is imperative to keep them well under control.

During June and July oil emulsion sprays are recommended for scale control. Oil sprays are not highly effective as a means for rust mite control, but if there is only a light infestation of mites, the rust mite infestation will be checked for three to six weeks.

By August or early September a third sulfur application is usually necessary. It is recommended that either wettable sulfur at 10 pounds per 100 gallons or a sulfur dust be applied whenever 15 to 20 percent of the fruit become infested with rust mites.

During a period between October and December rust mites and purple mites may become numerous enough to warrant a treatment. The same miticide combinations are used during this period as in January.

The Program for Scale Control

The same type of preventive program has been used for the control of scale insects as is recommended for mite control. An annual oil spray is recommended even though the infestation of scales may appear to be very light. Heavy infestations of either purple scales or Florida red scales may cause the loss of fruit, leaves, and bearing wood, and also cause a general weakening of the tree. Petroleum oils have been used in Florida for over thirty years, and they have been praised as scalicides and damned for their effect on the trees and fruit. However, it must be admitted that where scale is a problem, the injury caused by heavy

infestations has been more injurious to the trees than the oil emulsion sprays. Where oil emulsion sprays have been judiciously used in the experimental plots or in groves in general, the treated trees are in better condition than where no attempt has been made to control scale infestations. Some of the factors influencing the use of oil sprays are discussed below.

Oil Specifications.— Paraffin and napthene (asphalt) base oils are used for the control of purple and Florida red scales. No significant difference was found between the two types of oil for the control of scale insects where the oil emulsions were used at concentrations between 1.3 and 1.4 percent actual oil. At a concentration of 1 percent oil there was a slight trend in favor of the paraffin base oil.

The viscosity of the various oils used in Florida varies from 72 to about 100 seconds Saybolt. Oils having a viscosity of 72 seconds Saybolt are in more common use than the heavier oils. In experimental work there was no correlation between scale kill and the viscosity of the oil where there was a range between 72 and 110 seconds viscosity. Most of the oil testing was done during the summer months. Under these circumstances no difference in leaf drop or shock to the tree was observed where the viscosity of the oil varied between 72 and 100 seconds.

The unsulfonatable residue of the oils in general use in Florida is somewhat lower than for oils used in some other areas. In general, the range is from 77 to 92 percent unsulfonatable residue, but most of the oils in common use have a UR of 77 to 85. Oils having low and high UR's have been tested in different parts of the citrus growing areas in the state and no differences have been noticed in scale kill or shock to the trees. However, in California Boyce (1) does not recommend an oil with a UR lower than 92 percent. Since the climate in Texas is between that of California and Florida it would be well to test oils with a low UR before recommending them for general use.

Oil Concentrations.— Assuming that a safe oil is available, a prerequisite for effectiveness is the type of oil emulsion made. The precentage of scale mortality depends upon the amount of oil deposited on the leaf. Some oil emulsions are classed as tight emulsions. These oils are slow in separating from the water when the spray hits the leaves and this results in more of an oil run-off than may be desired. A loose emulsion is one that breaks quickly in the dilute spray and when the spray hits the leaves, the oil separates from the water very easily and remains on the leaves so that little is lost in the excess water that drips from the foliage. A fairly loose emulsion is usually desired because a lower dilution of oil may be used. Redd (4) showed that there was a wide range in the amount of oil deposited on foliage when seven different commercial oil emulsions were applied at 1.4 percent actual oil. The oil deposited with one emulsion was about four times greater than the oil deposited with another. The former resulted in inferior scale mortality, and the latter deposited more oil than was needed for scale control and enough to cause a heavy leaf drop.

The concentration of oil recommended in the dilute spray varies from 1.3 to 1.5 percent actual oil. A concentration of 1.3 percent oil has resulted in 85 to 95 percent kill in the experimental plots. Where thorough sprays were applied and the same type of emulsifying agents were used, 1.3 percent actual oil was as effective as either 1.4 percent or 1.5 percent, but due to the different types of oil emulsions used, it is necessary to use the higher concentrations of oil in the dilute spray with a tight emulsion and the lower concentrations with a loose emulsion.

Thoroughness of Application.— Thoroughness of application is as important as having an effective insecticide where scale control is concerned. Oil emulsions are entirely contact insecticides which means that the scale must be covered with the spray if it is to be killed. To obtain a high percentage of kill, both the upper and lower surfaces of the leaves must be covered with the spray, and where either purple scale, or California red scale are present the wood should be thoroughly covered as well. The fact that a high percentage of the females of both purple scale and Florida red scale are found on the under surfaces of the leaves necessitates the coverage of the lower surface of the leaves if satisfactory control is to be expected.

Suitable spraying equipment is of prime importance. The pressure spray machines should be set so that the spray is discharged at between 500 and 550 pounds pressure, and if the trees are 30 feet or more in height, 600 pounds pressure may be needed. However, the volume of spray discharged from the spray gun is as important as the pressure since the leaves are more easily turned where a comparatively large volume of spray is used. The volume of spray may be regulated by the size of the aperture or opening in the disc of the spray gun (8). For instance, either single nozzle or double nozzle spray guns, equipped with discs having 8/64" apertures will discharge a volume of spray sufficient to turn the leaves and penetrate into the dense foliage of the tree. If discs with smaller apertures are used the stream of spray is so reduced that it is difficult to turn the leaves so that the undersurfaces are thoroughly covered. In experimental work, a higher degree of control was obtained at less cost per acre, but it took much less time to spray the trees with a resultant saving in labor costs. In addition, Stearns (6) has found that there was a more uniform oil deposit on leaves from different parts of the tree where the guns were equipped with 8/64" discs than with 5/64" discs.

Broom guns (3 to 8 nozzles) have not proven satisfactory for oil emulsion applications. The stream of spray from broom guns cannot be regulated, and if discs with large apertures are used, there is a waste of material.

The "Speed Sprayer" is now in common use in Florida. Satisfactory control of scale has been obtained if the "Speed Sprayer" is moved at a rate of between 1 and 1.2 miles per hour. The oil deposit decreases very rapidly as the speed of the sprayer is increased (6) and the gallonage per tree is regulated by opening or closing some of the jets rather than increasing or decreasing the speed of the tractor.

Regardless of the type of equipment being used, it is recommended that the man in charge of the spray crew be instructed to inspect the undersurfaces of the leaves from the inside canopy and the tops of the trees in order to determine whether coverage is complete.

Timing of Oil Sprays.—The timing of the oil sprays is not only important as a means of obtaining a high percentage of kill, but it is also important in relation to the effect on the trees and fruit. In Florida, it is recommended that the oil spray be applied during a period between June 1 and July 31 but preferably between June 15 and July 15. There are a number of reasons why the period of June and July was selected for the application of oil emulsions.

During the period between June 1 and July 15 there is usually a hatch of scale eggs. Since the first and second stages of scale are more easily killed than the mature third stage, the timing of the oil spray is regulated so that whenever possible it is applied when there is an abundance of scale in the first and second stages of growth. Unsatisfactory control may result if there is a high percentage of females depositing eggs when the spray is applied. The oil spray should not be applied during the peak of the crawler stage as is practiced where scale is controlled with sulfur applications. The sulfur residue is depended upon to kill crawlers as they appear, but since there is little residual effect from oil, the young scales which hatch after the oil application will not be killed. Since the young of California red scale are born alive, and according to Boyce (1) a female may bear young for a period of two months, the timing for that species of scale may be different than for either purple or Florida red scale.

If the oil application is made before June, Florida red scales sometimes reinfest the trees during the fall months. During the months from August through November, Florida red scales increase very rapidly so it is important to have the scale population at a low level by August. If the spray is delayed until after August the trees may become too heavily infested to obtain a satisfactory control and a second application may be necessary.

Sometimes a heavy infestation of scale is present during the spring which may necessitate two oil applications to clean up the infestation. There are two periods when the first spray may be applied. One is just before the growth starts in the spring. At that time there is the minimum number of leaves which makes it possible to obtain a thorough coverage. There are two objections to spraying at that time of the year. One is the possibility of freezing weather following the oil spray, and the other is that a high percentage of the scales are likely to be in the mature stage of growth. Another period for the first application is from one to three weeks after the fruit has set. Usually at that time there is a high percentage of scales in the younger stages. However, if the spray is delayed until the fruits, especially oranges, have reached 3/4" to 1½" in diameter the oil may burn the fruit. Because of the necessity for controlling melanose, a combination spray containing a neutral copper compound and an oil emulsion may be used for the combined control of melanose and scale. If such a combination is used, it should be applied before any melanose infection develops on the fruit. The copper-oil emulsion combination apparently aggravates any scar or lesion on the fruit, and this results in a raised, cracked lesion which is called "star melanose." As stated in the Spray and Dust Schedule (2): "Grapefruit are less susceptible to this injury than oranges. Not all coppers and oils are compatible and in some combinations the copper is flocculated and lack of melanose control may result or considerable fruit burn may occur. When using a proprietary copper with oil, consult your supplier for information on the compatibility of the particular copper and oil emulsion used and examine the spray mixture in a glass container before using to see whether it has a fine texture or whether the copper is flocculated (curdled) into small flakes or lumps giving the spray mixture a coarse-textured appearance. If flocculation occurs, use a de-flocculator recommended by the manufacturer of the oil used. The copper is usually applied at the regular rate per 100 gallons and oil emulsion at 1.3 percent actual oil."

The second oil emulsion should be applied between June 1 and July 15. The early spring application followed in June by a second application has resulted in excellent control of heavy infestations of scale. An early June oil emulsion spray followed by a second spray six to eight weeks later has also been satisfactory for scale control, but the effect of the two sprays has been more detrimental to the trees and fruit than where the first application was made earlier in the season.

The timing of oil sprays in relation to tree damage should always be considered. An oil spray is a shock to the trees, but the least amount of injury has developed when the sprays were applied while the trees were in a vigorous condition. More dead wood has developed on weak trees than on vigorous trees following an oil emulsion spray. Trees weakened due to drought, scale infestation, crop strain, hunger or any other numerous reasons have developed more dead wood following oil sprays than vigorous trees sprayed at the same time and in the same block. One of the reasons for recommending the period of June and July for oil applications is that the trees in well kept groves are in a vigorous growing condition at that time. It is also a period when there is adequate moisture in the soil. This is very important as trees should never be sprayed with oil emulsions if they are suffering from lack of moisture.

Fall oil applications should be avoided. Results of experiments conducted over a period of 10 years show that less dead wood developed on oil sprayed trees where the applications were made before September than where they were made between September 1 and December 31. There are several reasons for not delaying the oil spray until the fall months. At that period of the year the trees may be weakened by the strain of the crop, by heavy infestations of scale, or by drought, and subsequent cold injury is always possible. The freeze of February 6, 1947 produced some startling effects in an oil timing experiment (12). Plots sprayed in June, July or August had no more dead wood than in the

unsprayed plots, but the amount of dead wood pruned from those trees sprayed in September, October, November or December was in proportion to the length of time the spray was delayed in the fall. There was an average of only 20 pounds of wood per tree pruned from the unsprayed plots and those sprayed during June, July and August. About 40 pounds of dead wood was pruned from trees sprayed either in September or October, 50 pounds from trees sprayed in November, and 70 pounds from those sprayed on December 15. It should be noted that the freeze occurred at least 6 weeks after the last oil application and over 4 months following the September application. This indicated that the injury was not because of the oil on the leaves, but was an effect on the trees in general.

A fall oil spray sometimes upsets the physiological balance of the trees in such a way that they fail to set a normal crop of fruit in the spring. The production records from the oil timing plots and observations made in commercial groves where only part of the grove had been sprayed, show that sometimes, where an oil application was made between Otober 1 and December 1 that the following year's crop was reduced 30 to 50 percent.

Indiscriminate timing of oil sprays may affect the internal quality of the fruit. In Florida an oil application made in August invariably prevents the formation of the maximum percentage of soluble solids (5) (11), and during some years September and October sprays may also affect the soluble solids adversely. June and July applications have had less effect on solids than later sprays, and during some years the early summer sprays have had no demonstrable effect on the solids. Two oil sprays are more detrimental than one spray, but the least effect from two oil sprays was where the first application was made in April and the second in June. The effect of oil sprays on preventing the formation of maximum soluble solids has been much more critical on oranges than on grapefruit. August, September and October oil emulsion application should be especially avoided on early varieties of oranges particularly if they are to be shipped early in the season.

Oil sprays in August, September, and October retard the degreening of fruit (9) (5). When two oil sprays were applied, the degreening process was retarded very materially especially where the second oil spray was applied from August through November or before the fruit had colored naturally.

Effect of Oil Sprays on Natural Control of Scale.— Many growers do not like to use oil sprays because they are afraid they will kill the ladybeetles, parasites and entomogenous fungi (friendly fungi). There has been no indication that the oil emulsion spray adversely affects the natural control of scale insects. Actual counts by Griffiths (3) and by the writer showed only an occasional dead ladybeetle following oil emulsion sprays. Oil sprays do kill parasites, but Griffiths (3) found that the ratio of parasites per live scales was essentially the same before and after oil spray applications. An oil emulsion is usually not considered to be a fungicide and results of unpublished work of Miss Fisher* indicate that oil sprays do not adversely affect the entomogenous fungi.

The qualifications for the use of oil emulsions for scale control may seem rather discouraging. Nevertheless, heavy scale infestation can weaken the tree to the extent that production is reduced and the trees are more affected from cold weather, drought and wind damage than trees comparatively free of scale that were sprayed with an oil emulsion during the time of the year when the oil spray had a minimum effect on them.

Since California red scale is increasing and the blackfly is on its way north, it would seem advisable to initiate research on the efficiency of different types of oils, and oil emulsions on scale control and to determine the effect of oil sprays on the trees and fruit. In Florida the eradication of the citrus canker, the Mediterranean fruit fly, and the blackfly at Key West, were expensive and painful operations, but it paid big dividends to eradicate each of these pests. However, the cost and the "pain" might have been less in the eradication work had more been known about these pests before they made their appearance in the state.

Parathion looks promising as an insecticide for the control of purple scale, Florida red scale, whitefly and some other insects which infest citrus trees. Results to date indicate that it does not shock the tree, affect solids or degreening of fruit to the extent that oil sprays do. If this material is released for the use on citrus, it could be used in areas where oil sprays are especially injurious to the trees.

In conclusion, it is hoped by the writer that some of the work which has been discussed in this paper will be of some benefit to the citrus growers and research workers in the State of Texas.

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HARVESTING FRUIT IN RIO GRANDE VALLEY

Formation of Valley Nurserymen's Association

By Ben Chambers, Jr.

J. B. Chambers, a native Texan, graduated from Texas A & M in 1923. For the past 24 years he has been actively engaged in the Nursery and Citrus business in Raymondville and Harlingen. He is President of the Valley Nurserymen's Association. He has kept abreast with the nurserymen's problems in California and Florida by frequent visits to those states.

The Valley Horticultural Club has had as one of its objectives the sponsoring of other organizations that would help investigate problems arising in our fruit and vegetable industries, and to work for improvements in these lines. This Institute is presented to you through the efforts of the Club, and it is also responsible for the actions taken which led to the formation of the Valley Nurserymen's Association.

During 1946 and 1947 there were numerous discussions of the scaly bark and psorosis problem in citrus trees at club meetings, and some members had the opportunity to observe new control methods being used in California in psorosis. This work was of such a highly specialized nature that the club soon realized it would be difficult to get it started here, and especially to place it in the proper hands to carry on. During the summer of 1947 a special program on the subject was planned and several nurserymen invited as guests to discuss the problem. It was hoped that the nurserymen would choose to become active in the work and form an organization, but the interest was not sufficient at that time.

About the first of this year the club learned through the Experiment station and members of the club that *Dr. H. S. Fawcett, pathologist at the University of California Citrus Experiment Station, who is our best authority on psorosis, might be interested in coming to the Valley to make a survey of the situation here. The Citrus Council and other organizations agreed to under-write the expense of his trip; so the invitation was extended and accepted by Dr. Fawcett to be here during the month of March when conditions would be best for study.

Upon his arrival in the Valley the first of March, Dr. Fawcett was extended use of facilities at the Experiment Station, and many individuals volunteered to show him orchards in all parts of the Valley. Mr. Carl Waibel of Weslaco, who was doing tree surgery and individual tree care work, and who had worked with Dr. Godfrey at the Experiment Station, volunteered to accompany the party and assist Dr. Fawcett at all times. Upon completion of the studies, Dr. Fawcett prepared a complete report of his findings, along with his recommendations for setting up a program for registration of parent trees for budwood, which was presented to the club. A special meeting was called for March 22nd., at which time many nurserymen and various officials were invited to hear him discuss the report in detail.

After hearing this report, the nurserymen were so interested and

*Deceased.

convinced of the necessity for this program being started here that they immediately organized to sponsor the work. Officers were elected, who are, myself as president, Mr. E. W. Linnard of McAllen, as vice-president; and Mr. Walter Bach, of Weslaco, as secretary-treasurer. The seventeen members financed Dr. Fawcett's trip, then at a meeting on April 20th., employed Mr. Carl Waibel and sent him to California for further study under Dr. Fawcett so he would be prepared to begin the work, which he has done exceptionally well since that time.

The nurserymen realized that this was an industry project just as much as their own, but some one had to assume responsibility for its beginning.

They also realized that in order to succeed, more authority than that of the association was needed for it to be accepted by the public; so arrangements were made for Mr. Waibel to be employed by the State Nursery Inspection Department, where he has served officially since July 1st., as special inspector for citrus registration.

The association is now attempting to work out agreements with the Experiment Station and State Department of Agriculture to carry out the complete program as recommended by Dr. Fawcett, which is very similar to that being done in California.

The Nursery Association is made up of men who desire to produce the finest quality of stock possible for the industry. There are no registered trees in the Valley now, and we know it will not be possible to produce them for four or five years. When that time comes, the cost of producing trees and the exactness in nursery work will be many times greater than at present, but orchard owners will be the winners in the long run. Nursery trees produced from known registered parents with desired vigor and production records, and known to be free from psorosis and other diseases should certainly be an asset to the citrus industry, and is the ambition of this association.

The Inspection and Registration of Psorosis Free Citrus Trees

By C. W. WAIBEL
Nursery Inspector
Division of Plant Quarantine
Texas State Department of Agriculture

C. W. Waibel has studied tree surgery at the New York State College of Forestry, Davey Institute of Tree Surgery, Ohio; and the Davey Tree Expert Company of Ohio. He practiced tree surgery in New York for 13 years until 1943. Then he spent 2 years as tree surgeon in the U. S. Navy. He came to the Lower Rio Grande Valley in 1945 where he studied citrus diseases under Dr. G. H. Godfrey until 1948 when he was appointed Valley Nursery Inspector, working with Dr. Fawcett in setting up a Psorosis Free Budwood Program for the Texas State Department of Agriculture.

Psorosis, or Scaly Bark as most people know it, is believed to have originated in the Orient and has been distributed to the other Citrus growing countries with the spread of Citrus varieties and species. It first appeared in Florida after the freeze of 1894 in the orchards rebudded from budwood sent from California. We can readily understand why we have it here in Texas, for most of our Citrus came from Florida and California.

Psorosis is a deadly virus disease and one of the leading factors in small fruit sizes and the short life of our trees. Its only known means of transmission is by graft union either by budding or by natural root graft. Infected trees are produced in the nursery when they are grown from buds from diseased trees. The disease can be detected in the nursery trees by leaf symptom, but otherwise the trees at this stage appear normal and grow as well as uninfected trees. It is only on 5 to 20 year old trees that the scaly-bark trunk symptoms appear even though the tree has carried the virus from the time of budding in the nursery.

In the past, little was known about this virus disease and through no fault of the nurserymen, trees were budded with little regard to its presence. Some nurserymen were careful enough to stay away from trees that showed bark symptoms. This at least was a help. However, most nurserymen take budwood from trees too young to show the scaly bark symptoms.

About ten months ago a program was recommended to the Valley by Dr. H. S. Fawcett for the elimination of this dreaded virus disease by the Lower Rio Grande Nurserymens Association, the Texas State Department of Agriculture and the Lower Rio Grande Valley Experiment Station. That program is now being carried out and is well under way.

Registration of Trees

This program calls for the inspection and registration of parent trees free of psorosis and any other known transmissable disease, as a

source of budwood for propagation of citrus trees. The parent tree must be at least eight years old, its parentage traced down and as much as possible obtained as to variety, production, quality of fruit, and as to what generation from the parent tree. The tree is then examined from top to bottom for bark lesions of both psorosis and gummosis. It is then checked for bud mutations and chimeras etc., and finally the tender flushes of new leaves are inspected from at least ten locations about the tree for leaf symptoms of psorosis. If the tree still shows no indication of psorosis or other diseases, such as Stubborn Disease, Rio Grande gummosis, footrot, or leprosis, the four adjacent trees are examined in the same manner. If all five trees fail to show any symptoms of the diseases named above, the one selected tree is then charted and listed for possible registration. The parent trees to be registered must show no leaf symptoms of psorosis at inspection of all flushes of growth for an entire year plus an extra inspection of a second spring flush. At the first sign of any suspicion of leaf or bark symptoms of psorosis, the tree will be eliminated. A tree that passes the tests will be registered for three years and must be inspected again before it can be re-registered. Progeny of registered trees must be 6 years old before they can be registered. It is planned that after the first spring flush inspection budwood will be taken from the tree and budded on sour and Cleopatra seedlings for testing for the presence of psorosis. Two of the trees on sour and two on Cleo will then be selected and planted in a permanent grove for further observation and a permanent check.

It will be the Spring of 1950 before we have any trees registered, and the Spring of 1951 before nursery men have any registered trees for sale.

During the past year 16,891 parent trees have been inspected and of these 452 have been selected as being suitable to keep under further test for possible registration as parent trees free of psorosis.

In addition to this inspection of bearing trees for possible registration, approximately 200,000, 1 to 2 year old nursery trees have been inspected for leaf symptoms of psorosis. Of these 36,000 were found to have psorosis leaf symptoms, were rogued out by the nurserymen and were thus prevented from reaching groves.

Varieties of Psorosis

There are five varieties of psorosis, "Psorosis A," "Psorosis B", "Concave-gum", "Blind Pocket", and "Crinkly Leaf' of which four have been found in the Valley. Psorosis A has the familiar bark scaling on the trunk and large limbs and its flecking spots on the leaf. Psorosis B produces scaly bark lesions on the large limbs which commonly extend quite rapidly up the limb to the very tip ends. The young-leaf symtoms are similar to A, but in addition the mature leaves sometimes show circular orange colored spots one quarter to an inch or so in diameter. Both Concave and Blind Pocket do not seem to induce Scaly-bark symptoms except in some instances when either psorosis A or psorosis B are also present. Their typical bark symptom consists of concavities or depressions on the trunk or on large limbs. The young leaf symptoms associated with these two types are indistinguishable from the other Psorosis strains except that at times chiefly during the Spring flush or leaf growth the young leaves show an irregular, zonate or oak-leaf pattern along the mid-rib.

Roguing young nursery stock as mentioned above does not eliminate 100% of the infected trees by any means. It has been of some value as it eliminates positive cases, but should not be publicized as insuring psorosis-free trees. One nursery of 11,000 Valencia trees was rogued and only 29 trees were found showing leaf symptoms. Later the Valencia parent budwood grove was checked and all but one tree in the entire grove showed Concave gum and this other one had Psorosis A. The one Psorosis A tree happened to be the source of the 29 nursery trees showing leaf symptoms. The absence of young leaf symptoms in the progeny from Concave gum and Blind pocket parent trees at the time of inspection of the nursery explains why it is neccessary to examine trees during several flushes of growth before one can be at all certain that trees are free of psorosis. Therefore the nurserymen cannot advertise trees to be free of psorosis just because they have been rogued, but he has done the best he can until registered trees are for sale.

'Detective Work is Used'

It has been a mystery as to how Psorosis gets into progeny with
arent tree being free, and in some cases it actually takes detective work
nd out why. One nurseryman claims to have never double budded,
trees out of 16 in one block showed leaf symptom. All sixteen
rees were supposed to have been from the owner's psorosis free
But after several weeks of trying to find out how psorosis got
e he called me to tell me he just remembered the three
replaced them with trees from an unknown source.

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propagated a few hundred trees for himself from
planted half on one site and the other half
groves are outstanding but show four per
tree is psorosis free. After careful check it
gated several hundred Valencia orange
e showing about 100% Blind Pocket
e re-budded the seedling to grape-
e Valencia buds that failed had
k which then in turn, infected
re-budding.

three years 80% of the
This grove was aban-
k on 11,000 nursery
nese trees with leaf

trees were found to have
ne entire grove were found
rove there are 22 non-produc-

tive Washington Navel trees mixed in. The entire grove was double planted to Red blush grapefruit about three years ago. It was the job of the inspector to find the Washington Navel trees to make sure none were selected for registration. After working in the grove for several hours a way was found to tell the Washington from the Thompson other than by production. The Red blush next to the Washington was in every case twice as large as the one next to the Thompson. Evidently in its production the Thompson Navel is taking something from the soil that the Washington in its unproductiveness is not.

In one grove of Red Blush grapefruit all trees but one were found free of psorosis. That tree was along the edge of the planting next to a diseased White marsh grapefruit. The soil was dug from the roots along between the two trees and there two distinct root grafts were found. These trees were 27½ feet apart.

In many cases in the nursery, sour seedlings have been found budded but with the bud dead. In such cases, if the bud was infected and if it remained alive for only a few days, the virus could have been transmitted to the sour seedling. If the Nurseryman decided to bud these trees again it would be a diseased tree in spite of the fact that the new bud came from a healthy tree. In all probability every nurseryman in the Valley has at some time practiced double budding. It is hoped that they discontinue this practice in the future as it is dangerous unless they are using registered budwood in both buddings.

It is a proven fact that bark symptoms alone is not enough by which to judge the health of a given tree. In one case a grove of 105, 8 year old Red Blush trees was checked three years ago. At the time, and even now, only one tree shows bark symptom, but after re-examining these trees recently, leaf symptoms were found on 29 of the trees.

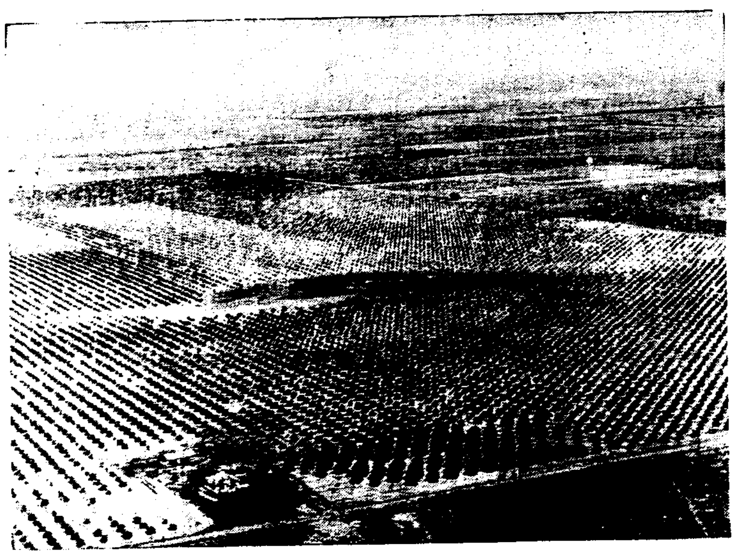
A tree may have a leaf symptom for years and not show any marked effect on fruit size, production or even tree size. It is after bark lesions appear that the trees start to show decline. At the time of the outbreak on the bark, gum starts to accumulate in the vessels of the wood and this obstructs the flow of water and mineral nutrients. In our observations here in the Valley we have noted that psorosis infected trees usually break out with bark lesions at the age of ten to twelve years, but we have found some showing the bark symptoms as early as six years.

Watch Leaf Symptoms

One nurseryman made a trip to California and saw leaf symptom out there, but after returning to the Valley was unable to find it here. He was under the impression that it did not show here due to hot sun or some other reason, but on visiting Valencia parent trees we found 6 out of 151 trees showing leaf symptom. He took note of the tree number and row number and on returning to his nursery it was amazing to see the record he had kept on his budwood. The budwood was bundled according to tree and row number, and after budding each row in the nursery was labeled accordingly. It was an easy matter to remove the diseased trees by locating the stake showing the parent diseased tree number and row number. It is this sort of system that will be used in the future to carry out the program successfully. Psorosis may be the answer to the short life of our tangerine and tangelo trees here in the Valley. I have inspected thousands of them and find only a very few free of psorosis.

This program in the Lower Rio Grande Valley can and will mean a great deal to the entire citrus industry. Our goal is psorosis free trees, and that alone. But the program is leading to trees free of other diseases, better quality fruit, better production, stabilization of the market of trees. We are on the constant search for early and late maturing fruit with better shipping quality.

In the past two years at this same Institute you had the pleasure of hearing Dr. J. M. Wallace and Spencer Apple point out the need for a registration program. It is a greater pleasure to present this paper on the progress of the program, toward which this Institute has contributed so much.



CITRUS DEVELOPMENT IN RIO GRANDE VALLEY

A Progress Report of Studies of Tristeza Disease of Citrus in Brazil

BEHAVIOR OF A NUMBER OF CITRUS VARIETIES AS STOCKS FOR SWEET ORANGE AND GRAPEFRUIT, AND AS SCIONS OVER SOUR ORANGE ROOTSTOCK; WHEN INOCULATED WITH THE TRISTEZA VIRUS[1]

By Theodore J. Grant

U. S. Department of Agriculture
Division of Fruit and Vegetable Crops and Diseases
and Attache, U. S. Embassy, Rio de Janeiro, Brazil

and

A. S. Costa

Instituto Agronomico do Estado de Sao Paulo
Campinas, Brazil

Dr. Theodore F. Grant obtained his Ph. D. in Plant Pathology at the University of Wisconsin in 1933. Since 1933 he has worked actively in Plant Pathology for the U. S. D. A. on such diseases as Banana Wilt, Tobacco Mosiac, and rubber diseases. He has worked in the Cooperative Rubber Field Station, U. S. D. A. Turrialba, Costa Rica. He took over the U. S. D. A. Brazilian Tristeza Investigation of Citrus in Brazil in 1947.

Dr. A. S. Costa is Brazil's expert on the Citrus disease working cooperatively with Dr. Grant.

Introduction

A preliminary report of work at Campinas, Brazil, on the tristeza disease of citrus was presented by C. W. Bennett and A. S. Costa and published in the 1947 proceedings of the Florida State Horticultural Society. A more detailed account of their cooperative work is now in manuscript form entitled "Tristeza Disease of Citrus" and should appear in an early issue of the Journal of Agricultural Research. Their work has demonstrated conclusively that the tristeza disease is caused by a virus. They have also shown that the disease is transmissible by budding and they amply confirm the transmissibility of the virus by the black citrus aphid, *Aphis citricidus* Kirk.

The present progress report deals primarily with the behavior of a number of citrus varieties as rootstocks for sweet orange and grapefruit, and as scions over sour orange rootstocks, when inoculated with the tristeza virus. Although some experiments have been carried out under controlled screenhouse conditions, the larger and more extensive tests are being conducted in two nursery plantings in the field. The first planting is called the Stock Test, in which, sweet orange and grapefruit varieties are being used as scions over as many different varieties of

[1]The writers wish to express appreciation to Dr. Frank Gardner for his helpful guidance and comments especially in relation to the preparation of this manuscript.

citrus seedling stocks as can be established. The second planting is known as the Sour Test, in which each of the citrus varieties, used as stocks in the Stock Test, are employed here as scions over sour orange rootstocks. This report describes the methods of procedure employed and presents current results from the nursery field tests that are still in progress.

METHODS AND PROCEDURES

Seed Sources:—Under the direction of Dr. Frank Gardner and through the citrus stations of the U. S. Department of Agriculture in Florida and Texas and through the cooperation of the Citrus Experiment Station in Riverside, California, seed of 191 citrus varieties and relatives for use in the Stock Test have been sent to Campinas. Brazil. This progress report includes results obtained to date on seventy nine varieties that have been subjected to the tests.

Seed of an additional 51 varieties for the Stock Test have been obtained in Brazil, largely from the Citrus Experiment Station at Limeira and through the kind cooperation of Dr. Silvio Moreira, Head, Dept. of Horticulture, Instituto Agronomico. Seed of a few odd varieties were secured from the Deodoro Experiment Station, Rio de Janeiro, from plants that had been established from seed sent to Brazil by Dr. W. T. Swingle.

Sour orange seeds used in the Sour Test have largely been obtained locally, although some seed of the fifteen varieties of sour orange sent from the United States have also been used.

Screenhouse and Field Plantings:—All seed received have been planted in flats and held under screenhouse conditions. As soon as the plants developed sufficiently, they have been transplanted first to clay pots and subsequently to the Stock Test or the Sour Test nursery plantings. The rows in the first nursery plantings were made one meter apart and four meters in length. Fifteen plants were placed in each row. Whenever possible in the Stock Test, thirty plants or two rows of each variety were established. The first planting in the Stock Test nursery was made in August, 1947. The plant growth in general has been very good and budding operations were undertaken in the latter part of January and the first of February, 1948.

Varieties used as scion:— In testing the behavior of citrus varieties as rootstocks for sweet orange and grapefruit, the following general plan was adopted. On the varieties having thirty buddable plants; five were budded with buds from seedlings of Barao, a standard Brazilian variety of sweet orange and herein designated as Barao A, five with Barao buds taken from orchard trees that were apparently healthy but known to be definite carriers of the tristeza virus and herein designated as Barao B, five with buds from Valencia sweet orange seedlings, five with buds of Leonardy grapefruit seedlings and five with buds from Duncan grapefruit seedlings. In the case of the Barao A, Valencia Leonardy and Duncan seedlings, all plants used as a source of buds were grown from seed under screenhouse conditions and were virus free. The five remaining plants of the thirty were not budded but were allowed

to develop as unbudded seedlings. In instances where the varieties did not have thirty buddable plants, it was decided to bud as many plants as possible and to follow the order given in the general plan above.

The selection of the Barao sweet orange as a top in the tests was based on previous experience with this variety. It was known to be a variety that was susceptible to Tristeza and that showed early recognizable disease symptoms over sour orange rootstocks. Also with this variety both healthy and viruliferous buds were available and could be used on the various rootstocks tested, in order to observe any difference in reaction that might result. The more important economic variety of sweet orange, Baianinha, would have been used in these comparative tests but virus free buds were not available.

It was thought that observable differences in growth of viruliferous and healthy buds on similar rootstocks might occur and might throw some light on the following questions:

1. Would tristeza disease appear any sooner or show any distinctive symptoms over a specific rootstock when the top growth developed from a viruliferous bud as compared with top growth developed from a healthy bud that was subsequently inoculated?

2. Would any one of the varieties react in such a manner that it might serve as a means of indicating that the buds employed were carriers of the tristeza virus?

3. Would the use of viruliferous buds afford any protection and modify symptom expression in comparison with a possible shock effect and more drastic symptoms following the inoculation of healthy plants?

4. In areas where only virus infected budwood is available would the citrus growers have to establish a virus free source of buds or could they use infected buds to establish a new orchard over tolerant rootstocks?

The chief reason for selecting Valencia sweet orange as one of the tops in this rootstock test was so that experience could be obtained with a variety of sweet orange that is used in the citrus trade in the United States and at the same time known to be susceptible to the disease in California known as "Quick Decline." The tristeza disease and Quick Decline have many characteristics in common. It is desirable therefore to test comparable plant material so that as information is gained on the Quick Decline disease on various rootstocks, more detailed comparisons of reactions of both diseases can be made with greater certainty.

Grapefruits were selected as tops in this test because of their economic importance and because experience in Brazil indicated that the reaction of grapefruits to the tristeza disease might possibly be somewhat different from that of the sweet oranges. The use of Leonardy and Duncan grapefruits was due in large part to the fact that some budwood of these varieties was available.

The Sour Test nursery planting was started in 1947. The distance of planting was essentially the same as in the variety Stock Test nursery. The plan has been to establish five plants of each variety over sour orange rootstocks and to observe their behavior following inoculation with the tristeza virus.

Sources of Tristeza Virus Inoculom:—Since previous experience had shown that aphids could be used as a rapid means of inoculating citrus plants with the tristeza virus, steps were taken to secure the large number of viruliferous insects necessary to inoculate over 3,000 stock-scion combinations with more than 100 aphids per plant in the Stock and Sour Tests. Through the cooperation of Dr. Moreira, apparently healthy but virus carrying Barao sweet orange trees in the orchard of the Instituto Agronomico, were cut back so that new growth could develop. Aphids were then brought in and allowed to breed on this new growth for one or two weeks, until the young twigs were practically covered with them. The aphid infested twigs were then picked off of the Barao carrier plants and placed on the nursery plants to be inoculated. In order to fasten the twigs bearing the aphids on to the plants being inoculated on windy days, paper clips or string were used with success. As soon as the leaves on the detached twigs began to wither, the aphids crawled off on to the plants being inoculated and started to feed. It was noticed that the aphids established themselves best on plants having very young terminal growth, thus increasing the chances of disease transmission to such plants.

When it was found that additional sources of aphids would be needed a survey was made in the vicinity of Campinas. Three relatively large sources of aphids were found in orchards were tristeza disease was prevalent. Tests of randomized samples of aphids from these sources were made using plants of the susceptible combination of sweet orange on Sour orange rootstocks to establish that aphids from these sources were able to transmit the disease. The results showed that the aphids were carriers of the tristeza virus and so a portion of the Stock and Sour Tests were inoculated with aphids from these sources.

Aphid inoculations of all plants were carried out in April and May of 1948 and all plants that showed no positive symptoms of tristeza were reinoculated in July and early August.

Behavior of Various Stock-Scion Combinations Inoculated with the Tristeza Virus

It should be kept in mind that the information in this progress report is based on observations and on specific data obtained from readings taken through August, 1948. The tests are still in progress and it can be expected that there will be further additions and possibily some changes as the plant material and disease symptoms develop and as further observations are made and information obtained.

An attempt has been made in table 1 to organize the citrus varieties by general botanical groups and from the data presented it is evident that there have been some common reactions within these groups.

Sweet Oranges:—The Barao and Valencia sweet orange tops and the Duncan and Leonardy grapefruit tops have shown no tristeza disease symptoms over the sweet orange varieties, Pineapple, Valencia, Florida sweet seedling, Hamlin, and Parson Brown as rootstocks. All three varieties of sweet orange, Pineapple, Valencia, and Florida sweet seedling, as well as the three varieties of grapefruit, Leonardy, Foster, and Duncan, when used as scions over sour rootstocks have shown symptoms of tristeza disease.

Lemons:—In the lemon group there were only four varieties included in the current tests, and it is of considerable interest to note the distinctly different reactions that have been obtained. The Barao sweet orange tops over Harris lemon as a rootstock, have shown tristeza disease. Similarly both Barao and Valencia sweet orange tops over Lemon PI 136469 as a rootstock, have shown tristeza disease. In contrast the various sweet orange and grapefruit tops over Columbia sweet lemon and Sweet Lemon PI 1168 as rootstocks, showed no tristeza symptoms.

The results of test of these lemon varieties as tops over sour orange rootstocks are not definite at this time except in the case of the Columbia sweet lemons which as tops over sour orange show tristeza disease symptoms.

TABLE 1.

Results from inoculation of various citrus stock-scion combinations with Tristeza virus in Brazil[1]

List of varieties	Tristeza disease symptoms on stock-scion combination					
	Stock: Listed variety					Stock: Sour orange
	Scion: Sweet Orange			Scion: Grapefruit		Scion: Listed variety
	Barao A	Barao B	Valencia	Leonardy	Duncan	
Citrus sinensis (L.) Osbeck						
Sweet oranges						
94. Pineapple	—	—	—	—	—	+
95. Valencia	—	—	—	—	—	+
96. Florida sweet seedling	—	—	—	—	—	+
97. Hamlin	—	—	—	—		
98. Parson Brown	—	—	—		—	
Citrus limon (L.) Burmann						
Lemons						
61. Harris lemon	+					
64. Columbia sweet lemon	—	—				+
65. Sweet lemon PI 1158	—	—	—	—		
66. Lemon PI 136469	+	+	+			

Citrus reticulata Blanco Mandarins, tangerines and hybrids						
45. Cleopatra	—	—	—	—	—	+
47. Dancy	—	—	—	—	—	+
48. Oneco	—	—	—	—	—	+
49. Temple	—	—	—	—	—	+
50. Mandarin PI 10630	—					+
51.Mandarin PI 117477	—	—				+
52. Mandarin PI 114412	—					+
53. Swatow PI 10032	—	—				+
54. Swatow PI 10031	—	—				+
55 Swatow PI 14054	—	—	—			
56. Ponkan PI 18027	—	—	—	—	—	+
58. Clementine	—	—	—	—	—	
59. Suen Kat	—	—	—	—	—	+
60. Sunki	—	—	—			+
68. Rangpur lime	—	—	—	—	—	+
130. Kinnow	—	—	—		—	+
131. Kara	—	—				
Citrus paradisi Mcf. x *C. reticulata* Tangelos						
31. Sunshine	—	—	—	—	—	+
32. Umatilla	—	—				+
35. Suwannee	—	—	—	—	—	+
36. Orlando	—	—	—	—		+
38. **Yalaha**	—	—	—	—	—	+
39. Williams	—	—	—	—	—	+
40. Minneola	—	—	—	—		+
42. Sampson	—	—	—	—	—	+
43. Seminole	—	—	—		—	
30. Thornton	+	+	+			+
41. Watt	+	+	+	+		+
44. Pina	+	+	+			+
129. Tangelo PI 52018-W-2F	+	+	+	+	+	+
Citrus reticulata x *C.* .... *sinensis*						
105. Tangor PI 653						+

Citrus aurantium L. Sour and Bitter Sweet oranges						
70. Savage PI 128348	+	+	+	+		—
71. Bergamia	+	+	+	+		—
72. Algiers Seville	+	+	+	+		—
73. Oklawaha	+	+	+	+		—
74. Sour 2	+	+	+	+		—
75. Bigardier	+	+	+			—
76. Florida Bitter Sweet	+	+	+	+		—
77. Paraguay sour	+	+	+	+		—
78. Rehoboth Palestine	+	+	+	+	+	—
79. Spain sour	+	+	+	+		—
80. Tunis sour	+	+	+	+		—
81. Dummett Bitter Sweet	+	+	+	+		—
82. Dummett sour	+	+	+	+		—
83. Egyptian sour	+	+	+		+	—
85. Bitter Sweet Stow selection	+	+		+	+	—
Citrus grandis (*L.*) Osbeck Pummelos and shaddocks						
86. Ogami pummelo	+	+	+	+		—
87. Thong Dee pummelo	+	+				—
88. Siamese pummelo	+	+	+			?
89. Nakorn pummelo	+	+	+			+
90. Cuban shaddock	+	+				+
111. Tau Yau pummelo (C. E. S. 2583)	+	+				
113. Flemmings shaddock (C. E. S. 578)	+	+	+			+
114. Hawaiian shaddock (C. E. S. 454)	+	+	+	+		?
Citrus paradisi Grapefruits						
91. Leonardy	?	?	+		?	+
92. Foster						+
93. Duncan	+	+	+	+		+
102. Poorman's orange	+	+	+		+	
Citrus longispina						
125. C. E. S. 754	?	?				+

Poncirus trifoliata (L.) Raf.						
2. Trifoliata (Large flowered)		–	–	–	–	–
Poncirus trifoliata x *C. sinensis*						
Citranges						
22. Savage	–	–			+	? +
27. Saunders	–	–				–
28. Troyer	–	–	–	–	–	+
24. Rusk						
Poncirus trifoliata x *Citrus paradisi*						
Citrumelos						
9. Citrumelo PI 4477	–	–				–
15. Citrumelo PI 4475	–	–	–	–	–	–
128. Winterhaven citrumelo	–	–	–	–	–	
Citrange x *Citrus sinensis*						
18. Citrangor PI 42681						+
Fortunella hybrid						
100. Nippon kumquat	+	+	+		+	
Unclassified						
104. Natsu Mikan	?	?	?	?	?	+

[1] Nursery test plantings established in August 1947, budded in January and February, 1948. Barao B sweet orange buds were obtained from apparently healthy but virus-infected orchard trees. Barao A and Valencia sweet orange and Leonardy and Duncan grapefruit buds were obtained from virus-free seedlings. All apparently healthy plants were inoculated with viruliferous aphids in April and May 1948 and reinoculated in July and August. In above table positive tristeza symptoms indicated by +, negative by –, and questionable symptoms by a ?. Results are based on readings taken through August, 1948.

Mandarins, Tangerines and Hybrids:—The growth of Barao and Valencia sweet orange tops and the Leonardy and Duncan grapefruit tops over the seventeen varieties of mandarins and tangerines tested has been apparently healthy as noted in table 1. At the same time it can be seen that all of the varieties of mandarins, tangerines and hybrids listed in this group and tested as tops over sour orange rootstocks have been found to show definite symptoms of tristeza disease.

Tangelos:—In the case of the first nine varieties of tangelos listed in table 1, all the sweet orange and grapefruit tops tested over these varieties as rootstocks have to date developed apparently healthy growth. In contrast to this the sweet orange and grapefruit tops so far tested over the Thornton, Watt, Pina, and Tangelo 52018-W-2F as rootstocks, have shown tristeza disease symptoms.

All of the tangelos tested to date as tops over sour orange rootstocks have shown tristeza disease symptoms.

Tangor:— Only one tangor has been tested and this only as a top over sour orange rootstock in which instance it was found to show definite symptoms of tristeza disease.

Sour and Bittersweet Oranges:— The sweet oranges Barao and Valencia, and the grapefruits Leonardy and Duncan, as tops over fifteen sour orange varieties as rootstocks, have shown tristeza disease symptoms. On the other hand, all of these fifteen varieties of sour oranges, as tops over other sour oranges as roostocks, have developed apparently healthy growth.

Pummelos and Shaddocks:— The sweet orange and grapefruits tested as tops over the eight varieties of pummelos and shaddocks listed, have shown symptoms of tristeza disease.

These eight varieties when developed as tops over sour orange rootstocks have shown some variations in their reactions. The Nakorn pummelo, Cuban shaddock, and Flemming's shaddocks have shown definite disease symptoms. In the case of other varieties it would seem desirable to await further developments in the current tests before making a definite classification as to their reactions.

Grapefruits:— At the present time we can report on only four varieties in the grapefruit group but additional varieties are being grown for subsequent testing. Of the varieties tested the reactions of the Leonardy and the Duncan are of particular interest because they have been used as tops over a large number of other citrus varieties as rootstocks and thus it has been possible to compare and note some differences in their reactions. In general, over non-tolerant rootstocks such as our orange, the symptoms of tristeza have been more striking and have appeared sooner on the Leonardy grapefruit tops than on the Duncan grapefruit tops. In contrast when these grapefruits were used as rootstocks the tristeza disease symptoms were more distinct and appeared sooner on the sweet orange tops over Duncan than on comparable tops over the Leonardy variety. These differences in reactions may eventually lead to a better understanding of the tristeza virus in relation to host responses.

The Poorman's orange has been included in the grapefruit group because it is said to be a grapefruit, and is sometimes called New Zealand Grapefruit, or Indian Pomelo[1]. Certainly its reactions to the tristeza virus would indicate that it is closer to the grapefruit than it is to the sweet orange group. This perhaps illustrates the imporance of genetic and physiological differences that may play an important part in plant variety responses to the tristeza disease.

Citrus longispina:— The Barao sweet orange tops over *Citrus longispina* as a rotstock show only indistinct or mild symptoms that may or may not develop later into typical tristeza symptoms. This variety has been included in this report because it is an odd variety and the symptoms of tristeza on *Citrus longispina* tops over sour orange rootstocks are definite.

Poncirus trifoliata and Hybrids:— As a whole the growth of Poncirus and the hybrids of Poncirus in Campinas has been comparatively slow, thus the tests of the varieties in these groups has been somewhat retarded. As shown on table 1, the growth through 1948, of the sweet orange and grapefruit tops over *P. trifoliata* has remained apparently healthy. Likewise the growth of *P. trifoliata* over sour orange as a rootstock has remained apparently healthy. Also the growth of the sweet orange and grapefruit tops over the citranges and citrumelos in the combinations as noted in table 1 have remained apparently healthy. In contrast to this apparently healthy growth is the development of tristeza disease symptoms on the Saunders and Rusk citranges and on Citrangor PI 42681 when these varieties are grown as tops over sour rootstocks. The plant reactions in this group are being followed with considerable interest and although it is too early to reach definite conclusions it seems likely that some may prove to be satisfactory rootstocks at least as measured by the apparently healthy development of sweet orange tops in the presence of the tristeza disease.

Fortunella Hybrid:— The Barao and Valencia sweet orange, and the Duncan grapefruit tops over Nippon as a rootstock have shown early and severe symptoms of the tristeza disease. It may be said that the disease symptoms have even been more striking over Nippon than they have been over some of the sour orange rootstocks.

Unclassified:— The citrus variety received under the name Natsu Mikan has developed definite symptoms of tristeza when budded and grown as a top over sour orange rootstocks. When Natsu Mikam was used in the tests as a stock for the Barao and Valencia sweet orange and the Leonardy and Duncan grapefruits tops, the development of questionable mild disease symptoms followed. The further development of symptoms or recovery will be followed with interest.

1—Swingle, W. T. Botany of Citrus. *In* Webber and Batchelor, The Citrus Industry. California University Press, 1943.

DISCUSSION

Although the tristeza disease of citrus and the "quick decline" of sweet orange trees may not be exactly the same, their similarities and potential importance are such that citrus growers are justified in expressing great concern and in having special interest in the tests that are being carried out cooperatively by the Instituto Agronomico de Sao Paulo and the United States Department of Agriculture, Division of Fruit and Vegetable Crops and Diseases, at Campinas, Brazil. It is the purpose of this discussion to point out some aspects of the current investigations that should be of interest and value to the citrus growers and to other scientific workers that may be concerned with studies of tristeza or a similar virus disease of citrus.

With respect to efficiency in the methods employed in the testing of citrus varieties as rootstocks, it was found that results were obtained in a relatively short time (3 – 5 months from date of budding) when buds from a virus-infected but apparently healthy sweet orange tree were employed. When buds from virus-free seedlings were employed it was considered desirable to wait for the development of one flush of growth before inoculating with viruliferous aphids. This prolonged the time required to obtain results (5 months and more from date of budding) and involved the additional work of collecting aphids and making the inoculations.

By using both viruliferous and non-viruliferous buds of the Barao sweet orange it was hoped that we might observe some early reactions on some specific stock-scion combination that could serve as a rapid and accurate diagnosis of the presence or absence of the tristeza virus. Careful records were taken of the budding success and at first it was thought there were certain stocks that might possibly serve as tsst plants because of the poor take of viruliferous buds. However, repeated test buddings indicated that the budding success or failure was due to other factors and could not be directly related to the presence or absence of virus in the buds used.

In the present tests it was observed that the first flush of growth from viruliferous sweet orange buds even over sour orange rootstocks, was usually apparently healthy. In fact early growth records on the development of these viruliferous buds indicated that the sour orange rootstocks were particularly good stocks for the Barao sweet orange. However, this advantage in growth of the sweet orange top over sour orange rootstocks came to an abrupt halt when the symptoms of the tristeza disease appeared.

The experience gained, however, in the use of viruliferous buds in the stock tests indicates that in areas where the tristeza disease occurs a grower could use infected buds to establish a new orchard provided he used tolerant rootstocks such as found in the sweet orange and mandarin groups. This knowledge is of value especially in areas where the disease is prevalent and to growers who have a particular variety of sweet orange that they wish to continue producing. Under tristeza disease conditions the securing or developing of a source of virus-free buds would be expensive and fortunately this would not appear to be necessary.

It is important to realize that sweet oranges can be definite carriers of the tristeza virus and where the disease occurs it may be expected that sooner or later all the sweet orange tops in an orchard may become infected. Once the tristeza virus has become established in an area its eradication would be extremely difficult if not impossible. The only solution to the problem at present rests on the basis of using tolerant rootstocks over which sweet oranges may develop in an apparently healthy condition in spite of virus infection. On the basis of this concept an analysis of the general reactions to date by citrus groups should be of interest. It should help to indicate which groups are most likely to furnish varieties or hybrids that could serve as tolerant rootstocks over which sweet oranges and grapefruits could develop in spite of tristeza virus infection.

In the following attempt to analyze the reactions of citrus groups to the tristeza virus the reactions secured in both Stock and Sour tests have been used because they afford two means of measuring and comparing the citrus variety responses.

Only four lemon varieties were included in the first group of plant material tested but it is of interest that in the Stock test results reported in table 1, it can be seen that two of the lemon varieties have been found to be tolerant rootstocks and two have been found to be non-tolerant stocks. Unfortunately, the testing of these varieties over sour orange rootstocks has not been completed. It is, however worthy of note that the Columbia sweet lemon has shown definite tristeza symptoms over sour orange as a rootstock. This is not the type of reaction expected of true lemons such as Eureka, for in orchards the Eureka lemon has been observed to develop well over sour orange roostock even in areas where tristeza disease is prevalent. The finding of distinctly different types of reactions in the presently tested lemon varieties suggests that these varieties differ appreciably. It may be that a more detailed knowledge of their genetic origin would help to clarify these differences. In any event, the testing of additional lemon varieties appears to be desirable and is being carried on.

The consistent reaction of the sweet orange and mandarin varieties tested is of special interest and importance. So far in the Stock tests all varieties have been found to be tolerant rootstocks while in the Sour test all have been found to show tristeza symptoms over sour orange rootstocks. If there are any sweet oranges or mandarins found that do not in subsequent tests show disease symptoms over sour orange rootstocks they would then be interesting and important exceptions.

The testing of the pummelos, shaddocks and grapefruits is not yet completed but the results to date in the stock test show that none of the varieties tested could be considered as satisfactory stocks for either sweet oranges or grapefruits under tristeza conditions. The fact

that many of these varieties have also shown tristeza disease when developed as scions over sour orange rootstocks and that they are non-tolerant as rootstocks for sweet orange helps to distinguish them as having reactions distinctly different from those encountered in the Lemon group or in the sweet orange and mandarin group and is also different from that encountered in the tests of sour orange varieties. Again it should be noted that the tests especially the Sour tests are not yet completed for the pummelo and shaddock varieties so that final judgement of varietal reactions cannot be made except where positive disease symptoms have been observed. It would seem, however, that the finding of tolerant rootstocks among the pummelos, shaddock or grapefruits would not be as likely as in the mandarin, sweet orange, or lemon groups.

Having in mind the general reactions observed to occur in the mandarin group which has yielded tolerant rootstocks and in the grapefruit group which has given non-tolerant rootstocks, it is of interest to observe the results secured from the testing of a number of tangelos. Certain of the tangelos appear to follow the reactions characteristic of the one parent, *Citrus paradisi* (grapefruit), and show distinct symptoms of tristeza when used as a stock for sweet orange. In contrast other tangelos appear to follow the reaction of the other parent, *Citrus reticulata* (mandarin), and to date have served as good stocks for sweet orange in spite of inoculations and even in the case where viruliferous Barao B buds were used. In comparison with these two types of reaction in the Stock test, all tangelos tested to date as scions over sour orange rootstocks have shown tristeza disease symptoms.

From the discussion above and from data presented in table I, it can be seen that there are several types of related reactions when the results of the Stock and Sour tests are compared. These comparative reactions may be outlined as follows:

General botanical group	*Stock Test* As rootstocks for sweet *orange and grapefruit*	*Sour Test* As scions over sour *orange rootstocks*
	Symptoms	Symptoms
Sweet oranges	–	+
Mandarine	–	+
Some lemons	–	+
Some tangelos	–	+
Sour Oranges	+	–
Grapefruits	+	+
Some pummelos	+	+
Some shaddocks	+	+
Some tangelos	+	+
Poncirus trifoliata	–	–

The above outline is admittedly incomplete but it does offer a framework on which to differentiate the comparative reactions and as the studies progress more specific data will be obtained and it seems entirely possible that we will find some citrus varieties that may show symptoms of tristeza even as unbudded seedlings.

On the basis then of the results secured up to the present time it would seem that the continued testing of mandarins, lemons, tangelos and trifoliate orange as rootstocks for sweet orange and grapefruits is definitely worth while. In addition, the securing of distinct reactions in hybrids such as the tangelos and as indicated by the early results in the Poncirus hybrids strongly suggests the desirability of securing or making crosses between mandarins and sour oranges and between sweet oranges and sour oranges. It might then be possible to find a hybrid that would combine the desirable characters of the sour orange, such as its resistane to gummosis and foot rot, with the desirable tolerance to the tristeza virus. The careful development of such crosses and their subseuent testing appears to be very much worth while.

The results presented in this progress report indicate that when the tristeza virus enters and spreads in an area one may expect that practically all commercial varieties of citrus over sour orange rootstocks, with exception of certain lemons, will sooner or later become diseased. At the same time however the results obtained indicate that the commercial citrus varieties over sweet orange and mandarin, and probably over some hybrids, may not suffer even though they become infected with the tristeza virus. As the work in the Stock and Sour Tests here in Campinas progresses and as additional observations and data are obtained they will be presented in subsequent reports. It is also a part of the definite plan of the Instituto Agronomico to transplant the tolerant stock-scion combinations to the orchard where their development and behavior with respect to tristeza can be followed over a longer period of time and where their resistance to other diseases and their suitability for culture in Brazil can be studied.

SUMMARY

The methods and procedures employed in the establishment of the Citrus Stock Test and the Sour Test are briefly described. Data are given on the presence, or absence, or questionable occurrence of tristeza disease symptoms on 345 citrus stock-scion combinations following inoculation with the tristeza virus.

The sweet orange and mandarin and tangerine varieties tested have to date proved to be tristeza-tolerant rootstocks for the various sweet orange and grapefruit varieties employed as tops even though the plants have been inoculated and are carriers of the tristeza virus.

Results from the present tests show that none of the fifteen varieties of sour orange tested could be considered as a satisfactory rootstock under tristeza disease conditions. Likewise it is indicated that the grapefruits, shaddocks, pummelos and some lemons, some tangelos, and the kumquat hybrid tested would not be satisfactory rootstocks for sweet

oranges or grapefruits when subject to tristeza virus infection.

The distinctly different reactions obtained in tests with the lemon varieties and especially with the tangelo varieties and early results in the Poncirus and Poncirus hybrid groups indicate the desirability of including in the tests known hybrid crosses especially between mandarin and sour orange and between sweet and sour orange.

The current tests are being continued and expanded to include other varieties and at the Instituto Agronomico it is planned to transplant the rootstock-scion combinations that show tolerance to the tristeza virus to large field plantings where their subsequent development can be followed and where their resistance to other disease and their adaptability to local conditions can be studied.

SOME "COLD" FACTS

The report of the Rio Grande Horticulture Club Freeze Committee, on page 174, is included in the 1948 PROCEEDINGS, even though the freeze occurred several week after the Institute. The subject is certainly of interest to everybody who has anything to do with citrus in the Valley.

If any one thing was learned from the freeze it is that the banking of young trees is a good "insurance" investment. Many thousands of young (1 to 3 year old) non-banked trees were killed. Many thousands of banked trees were saved; and two years from now their appearance will hardly show that there was a freeze.

Brownsville Weather Bureau records over a period of about 30 years show for the mid - Valley section (Mercedes) that the average dates of the last killing frost in the spring is January 29; and of the first killing frost in the winter, December 19. This leaves an average length of growing season for frost-tender plants of 329 days. The earliest killing frost over the same period was November 15, 1940; the latest killing frost on the record was March 30, 1930.

A Progress Report For 1948 on the Texas Citrus Rootstock Investigation[1]

By

WILLIAM C. COOPER, *Physiologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.*

William C. Cooper received his B. S. in Horticulture at the University of Maryland in 1929. He received his Ph. D in Plant Physiology at the California Institute of Technology in 1938. He has worked in Citrus research for the Bureau of Plant Industry of the U. S. Department of Agriculture since 1929 and has had experience in all three of the citrus growing states. He worked actively on citrus rootstock investigations in Florida from 1937 to 1946 before coming to Texas in 1946 to conduct citrus rootstock studies.

The problem of finding suitable rootstocks for citrus in the Rio Grande Valley to replace the tristeza—susceptible sour orange rootstock was started in September, 1946. The work was initiated and is being continued as a cooperative project between the Texas Agricultural Experiment Station and the U. S. Department of Agriculture. A preliminary report on these investigations for the year 1947 was given at the Rio Grande Valley Citrus Institute last year (Cooper and White-1947). The present paper reports progress made during 1948.

[1]The work was supported in part by grants to the Texas Agricultural Experiment Station by the Texas Citrus Advisory Council at Weslaco, Texas, and by Rio Farms, Inc., at Edcouch, Texas. The investigations were further aided by assistance from Engelman Products Company at Elsa, Texas, Ray Goodwin and Son at Mission, Texas, Ben Chambers at Harlingen, Texas, and Rio Farms, Inc. in providing general care of the grower-cooperative nurseries at those respective locations. Rio Farms, Inc., also provided materials, labor, and technical assistance for certain phases of the salt tolerance tests which are located at Rio Farms.

In addition to the above, the U. S. Regional Salinity and Rubidoux Laboratories at Riverside, California, have furthered the salt tolerance work with many valuable suggestions, and by making chemical analysis of the leaves from these plots for sodium, chloride and boron.

The writer wishes, in particular, to express his appreciation to the following who have rendered valuable assistance in these investigations: Dr. H. E. Hayward; Dr. C. H. Wadleigh; L. V. Wilcox, J. T. Hatcher, J. W. Brown, Dr. F. E. Gardner, E. M. Savage, Dr. Walter Reuther, W. R. Cowley, Cordell Edwards, Robert Corns, W. G. Godbey, F. M. Reising, and Eugene Goodwin.

SALT TOLERANCE TESTS

Rootstock-Scion Combinations

Salt tolerance trials were made with the following plant materials:

Cleopatra Mandarin seedling
Sour orange seedling
Red Blush Grapefruit on Cleopatra mandarin
Red Blush Grapefruit on sour orange
Valencia orange on Cleopatra mandarin

The Cleopatra stock was started from seed planted in the spring of 1945. The seedlings were lined out in the nursery in April, 1946. Some were budded on October 29, 1946, with Red Blush grapefruit; others were budded on the same date with Valencia orange, and a third lot was left unbudded.

The sour orange stock was started from seed planted in the fall of 1945. These seedlings were lined out in the nursery in April, 1946, and part were budded with Red Blush grapefruit at the same time as were the Cleopatra seedlings. The cleopatra and sour orange seedlings were of approximately the same size at the time of budding. The Red Blush grapefruit buds used for both stocks were taken from the same tree.

All of the above stock-scion combinations and seedlings were dug, balled, and transplanted to three salt plots on September 15, 1947. These plots were 15 x 15 feet square. In each plot the trees were planted in a Latin square design of five rows, three feet apart, with one tree of each of the five test combinations in each row.

Salt Treatments

Two of the plots were salinized by irrigating with canal water to which salts were added to raise the salt content to 2500 p.p.m.[2] (low salt) and 5000 p.p.m. (high salt), respectively.

The third plot (control) was irrigated with canal water to which no salt was added. The added salt in each instance was one-half calcium chloride ($CaCl_2$) and one-half sodium chloride (NaCl).[3] At each irrigation 2 or 3 inches of water were applied to insure wetting of the soil of the root zone.

A wooden frame made of 1x6-inch lumber was built around the plot and 1x6-inch boards were installed upright down the middle of each tree row, thus separating the plot around 5 impounding basins of equal size. The canal water was pumped into a 400 gallon tank where the proper quantity of salts for the entire plot was dissolved in the water. The salty solution was then conducted by gravity to the plots

[2] p.p.m. is parts per million and will be referred to as p.p.m. hereafter.

[3] Hereafter referred to by these symbols.

where it was applied to the soil through a slush box, and the same quantity was applied to each of the five tree-row impounding basins, This salt plot technique is similar to that used by Wadleigh, Fireman, and Cooil (1947) in salt tolerance studies on brome grass.

Soil and Water Conditions

The soil in the test plots is classed as Willacy fine sandy loam. The soil in the main root zone, or surface foot, has a saturation percentage[4] of 32, and a field capacity[5] of 12.2 percent. It is non-calcareous and the saturated soil has a pH value[6] of 7.6. The soil is fertile and tree growth was rapid. No fertilizer was added.

At the beginning of the tests, the free ground water as indicated by piezometers[7] was present at 60 inches below the ground surface. Following a 2-inch irrigation, the water table rose to 48 inches. Following the irrigation on December 1, 1947, and the one-inch rain on December 15, the water rose in the piezometers to 36 inches from the surface of the soil. Samples of ground water removed from these piezometers showed a salinity measurement of 3060 p.p.m. for each plot.

On April 27, 1948, an 8-inch[8] tile drain was installed on three sides of the test plot area to a depth of eight feet, connecting with the main Experiment Station drain 50 feet away. The piezometer reading just prior to installation of the drains was 65 inches. It dropped to 73 inches during the first week and to 83 inches by May 24, 1947, where it leveled off. Irrigation and rains had no further influence on the water-table of the plots during the course of these experiments.

Salinity Measurements

The salinity appraisals of water and soil in these experiments were made by procedures recommended and described in the U. S. Regional Salinity Laboratory treatise (1947). Salinity was measured[9] by determining the electrical conductivity (EC), which will be expressed

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[4] The moisture content of a sample of soil that has been brought to saturation by adding water while stirring. (U. S. Regional Salinity laboratory treatise (1947).

[5] Estimated from drainage curves which were plotted from data obtained by sampling the soil at 2-day intervals for 14 days after the soil was thoroughly wetted. The surface soil was protected from evaporation by a surface covering of canvas.

[6] Symbol used in expressing both acidity and alkalinity. pH Readings above 7.0 indicate alkalinity and below 7.0 indicate acidity.

[7] Consists of ½-inch pipe installed in the ground. (for details see U. S. Regional Salinity Lab. Treatise, 1947).

[8] The tile was made and this drain was installed by the F. M. Reising Corporation, Edinburg, Texas, as a gift to the project.

[9] The instruments used consisted of a Wheatstone bridge (Solubridge soil tester, model RD-26), and a 2 ml.-capacity pipette-type conductivity cell. The bridge carries a temperature correction dial.

as millimhos[10] per cm. To convert these values for irrigation water to the approximate p.p.m. of salt it is necessary to multiply them by 600. Thus, a 4.1 millimhos/cm. reading (as found in the irrigation water applied to the low-salt plot on 12-23-47, table I) indicates approximately 2500 p.p.m., while a 8.2 reading (see figures near this value for irrigation of high-salt plot) indicates approximately 5000 p.p.m.

Soil samples were taken of the surface foot of each tree row about a week or 10 days following each irrigation. The five samples were mixed and a composite sample of about 200 grams was taken for soil analysis.

The soil was air-dried in the laboratory, ground and made up to a saturated paste by adding distilled water while stirring with a spatula. One aliquot of about 25 grams was taken for pH determination and another of about the same quantity for moisture determination. The moisture content in percentage on dry-weight basis is the "saturated percentage" shown in table 1.

The remainder of the saturated paste was extracted by placing the saturated soil in a Buchner funnel and applying suction. The electrical conductivity of the extract was determined. This value expressed in millimhos/cm. is the electrical conductivity of the saturated extract, and is shown in table 2 as ECe. The ECe values for the soil of the three plots are given in the same line as the EC data for irrigation water that was applied a week or ten days previously.

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[10] The standard unit for electrical conductivity, mho per centimeter, is inconveniently large for soil salinity work. Accordingly a unit one-thousandth as large is used, designated millimho/cm.

TABLE 1

WATER AND SOIL DATA ON SALT TOLERANCE PLOTS

Date Applied	Irrigation Water: Inches	Irrigation Water: EC. millimhos per cm. Con-trol	Low Salt	High Salt	Soil: ECe. millimhos per cm. Con-trol	Low Salt	High Salt	pH Con-trol	Low Salt	High Salt	Saturation Percentage Con-trol	Low Salt	High Salt
11- 7-47	0	—	—	—	1.3	0.9	0.8	7.5	—	—	33	35	—
11-11-47	2	0.9	3.0	7.0	1.2	1.7	5.0	—	—	—	33	33	30
12- 1-47	2	0.6	3.7	7.0	0.8	2.2	3.1	—	—	—	—	—	—
12-15-47	1 *	0	0	0	0.8	2.2	3.7	7.8	7.6	7.7	30	28	28
12-23-47	2	0.8	4.1	8.0	1.4	2.9	4.0	7.7	7.5	7.4	28	27	33
1-22-48	2	—	4.0	8.0	1.2	3.8	4.8	7.7	7.6	7.5	28	30	29
4- 6-48	3	1.4	3.8	8.0	1.7	2.7	5.1	7.9	7.5	7.4	30	27	28
5- 5-48	3	1.3	4.8	9.0	—	2.1	6.5	7.5	7.6	7.5	30	32	32
5-24-48	3 *	0	0	0	1.6	4.0	7.0	—	—	—	—	—	—
6- 1-48	3	1.1	4.7	8.0	—	—	—	7.7	7.5	7.6	—	—	—
6-21-48	3	1.2	4.0	9.0	2.0	3.0	7.0	7.7	7.6	7.6	29	26	30
7- 8-48	3	1.0	4.7	9.0	—	—	—	—	—	—	—	—	—
8- 5-48	3	1.0	4.5	8.5	1.5	4.3	7.0	7.8	7.2	7.4	30	28	30
9- 8-48	4 *	0	0	0	—	—	—	—	—	—	—	—	—
9-10-48	4 *	0	0	0	—	—	—	—	—	—	—	—	—
9-18-48	4 *	0	0	0	1.4	1.4	1.7	—	7.9	7.8	24	29	28
10-12-48	2 *	0	0	0	—	—	—	—	—	—	—	—	—
10-14-48	3	0.6	4.0	8.5	—	—	—	—	—	—	—	—	—
10-16-48	2 *	0	0	0	1.1	0.7	0.6	7.7	7.7	7.8	25	22	25
10-30-48	3	0.8	4.0	9.0	1.3	2.3	2.9	7.5	7.5	7.6	—	—	—

* Indicates inches of rainfall to which no salt was added. All other water was Rio Grande river water to which salts (one half CaCl2 and one half NaCl) were added in case of plots labeled low salt and high salt. The control plot received river water without added salt.

Salinity Conditions

Rain greatly interfered with maintaining uniform salinity levels in the plots. Rain comes in the Rio Grande Valley at any time, there being no pronounced regular rainy season. During the test period it rained 7 times.

Tensiometer cups,[11] set to read cup tension in centimeters of mercury, were installed at a depth of 6 inches in the control plot to use as a guide for time of irrigation. During dry periods in the spring and summer, the mercury in the manometer frequently rose to 700 cms. of mercury within 3 weeks after an irrigation, and the plots were irrigated with this tensiometer reading as a guide. However, rains changed this irrigation regime, and further complicated the salinity conditions, by washing out the salt in the surface foot of the plots. Therefore, in order to reestablish salinity levels, it was necessary to irrigate with salty

[11] A porous cup filled with water and connected by a tube with a mercury manometer to measure tension of water in unsaturated soil. Details on construction and operation are described by Richards (1942).

water several days after a rain, even though the tensiometer reading was zero. Finally, the raising came so frequently in September and October that is became necessary to temporarily discontinue attempting to maintain the desired salinity levels.

The period of maintaining the desired salinity levels was further shortened in the early phases of the tests by failure to apply sufficient salt and by rainfall to which no salt was added. The actual period of desired salinity control was from December 23, 1947, to September 8, 1948.

It was not known what effect the salt treatments would have on pH and saturation percentage of this soil. The data shown in table 1 indicate no effect of the treatments on these values. The pH readings were practically the same for all three plots for all times of the year. There was no material difference in the saturation percentages of the three plots, but the values appeared to drop for all three plots following the 16 inches of rain in September and October.

Sequence of Development of Foliage Symptoms

The weather was generally cold during January and February, and there was very little growth on any trees in any of the plots during those months. Spring growth started in early March on all trees in all plots. On April 6 no difference was noted in the size or appearance of the trees on the three plots. The foliage was green in all instances. The appearance of the trees at this date is shown in figure 1.

Hot weather prevailed during the month of April. May 1, 2, 3, 4, and 5 were extremely hot and dry, and on May 4, the first symptoms

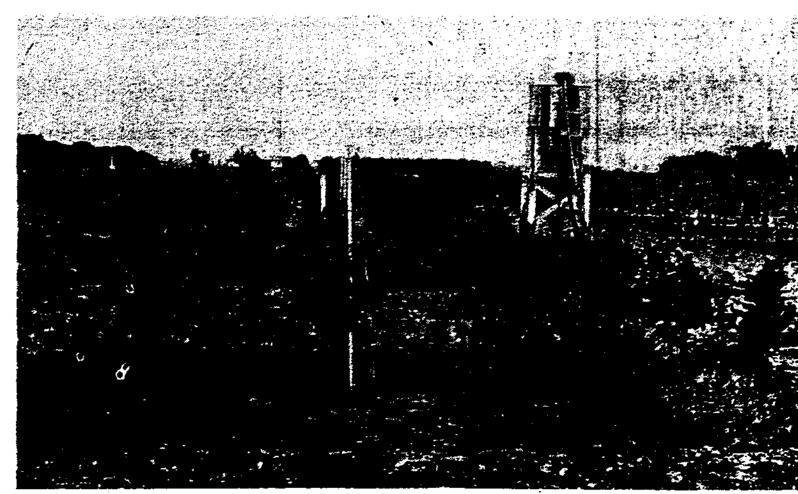

Figure 1. View of salt tolerance plots on April 6, 1948. Control (no-added-salt plot) in foreground. At right large tank used for mixing salt and water.

of salt damage in the high-salt plot were observed. The air temperature during the day rose to 102° F. The tensiometer showed a reading of 730 on May 4. Soil samples taken of the surface foot on May 4 showed moisture percentages of 6.12% for the no-salt-added plot, 6.7% for the low-salt plot, and 5.96% for the high-salt plot. The wilting point for the soil has not been determined, but it is suspected that this value is near 6% for the control plot.

The ECe of the soil collected on this date, May 4, 1948, was 1.7 millimhos per cm. for the control plot, 2.7 for the low-salt, and 5.1 for the high-salt plots. These conductivity readings adjusted to the observed soil moisture percentages in the plots (6.12, 6.72 and 5.96%) give calculated values of 8.3, 12.4, and 25.5 millimhos per cm. respectively. The last figure multiplied by 700[12] would give a calculated value of 17,850 p.p.m. salt in the soil solution of the high-salt plot on May 4, 1948.

The first tree to show salt damage was one of the five Red Blush grapefruit on sour orange stock in the high-salt plot. Only the older leaves, approximately 6 months old, were affected. These showed an interveinal bronzing on the upper side of the leaf which has all the appearance of sun burn. There was a collapse in the bronzed tissue on some of the leaves, and in others there was a necrosis of the collapsed area. These necrotic areas sometimes occurred between the veins halfway between midrib and margin, but most often occurred along the apex of the leaf.

A picture of this tree, taken on May 10, 1948, is given in figure 2. The necrotic leaf margins and leaf-tips are seen. The Red Blush grapefruit on Cleopatra stock showed no symptoms of salt damage at that time (see figure 3).

The plots were irrigated on May 5, and hot weather continued until May 24, when it rained. At this time, four out of five of the Red Blush on sour and all five of the sour orange seedlings in the high-salt plot were showing leaf symptoms of apparent salt damage, while there were no symptoms on Cleopatra seedlings, Red Blush on Cleopatra and Valencia on Cleopatra in the high-salt plot or on any stock-scion combination in the low-salt and control plots.

12 Conversion factor given in U. S. Regional Salinity Laboratory treatise (1947), for soil extracts in the range of 2 to 50 millimhos per cm. This conversion factor for soil extracts differs from the 600 factor given for irrigation water.

Figure 2. Picture taken on May 10, 1948, of Red Blush grapefruit on sour orange rootstock (tree number 24 D4) in high-salt plot, showing necrosis of margins and of leaves.

Figure 3. Picture taken on May 10, 1948, of Red Blush grapefruit on Cleo rootstock (tree number 24 C4) in high-salt plot. No symptoms of salt-excess damage to leaves was apparent.

By June 3, many of the leaves had fallen on the Red Blush on sour orange trees of the high-salt plot and they put on a weak, spindling new flush of growth (see figure 4) which developed symptoms suggesting zinc deficiency. In the same plot, Red Blush on Cleopatra continued to show no symptoms of salt excess (see figure 5).

Boron Complication

On June 21, a boron analysis[13] was made of the irrigation water used on the three plots and it was found to contain 0.28 p.p.m. for the no-salt-added plot, 1.1 p.p.m. for the low-salt plot, and 2.68 p.p.m. for the high-salt-plot.

An analysis of the salts showed that the boron occurred as an impurity on the $CaCl_2$. Following this discovery the contaminated $CaCl_2$ was discarded and a boron-free supply was purchased and used in its place.

The high boron content of the irrigation water used on the high-salt plot prior to June 2, however, raised the question of whether the leaf symptoms occurring on Red Blush on sour and on sour seedling were not due in part to boron excess. Boron is many times more toxic than chlorides and Kelley and Brown (1928) have shown that only a few parts per million of boron in irrigation water will kill citrus trees. In contrast, as shown in the low-salt plot, trees irrigated with water containing 2500 p.p.m. of mixed NaCl and $CaCl_2$ caused no injury.

[13] Analysis made by W. G. Godby, Agricultural Consultant Laboratories.

Figure 4. Picture taken on June 3, 1948, of same tree, 24 D4, as in figure 2. Note that the plant is badly defoliated.

Figure 5. Picture taken on June 3, 1948, of same tree, 24 C4, as in figure 3. No apparent symptoms of salt-excess injury to leaves.

The symptoms of injury observed on the Red Blush grapefruit leaves of the high-salt plot however, are not typically those reported in descriptions of boron excess. Numerous workers (Haas, (1929), Eaton (1935), and Camp and Fudge (1939)) describe boron-excess foliage symptoms as a pronounced yellowing or mottling between the veins at the tip of the leaf, which increases until half or more of the leaf is involved. The mottling extends down along the edges of the leaf with green color persisting along the base of the midrib in the form of an inverted V. As the leaves increase in age, the yellow portion takes on an orange color and develops tip-burn. Older leaves are usually the first affected.

The injured leaves on the salt plots, as of June 2, did not show the yellowing and mottled effect at the tip. The bronzing observed looked exactly like sun-burn. Collapse of tissue and necrosis followed no regular pattern, but, although sometimes occurring at the tip, just as often occurred along the margin of the side of the leaf or between the veins halfway between the midrib and the margin. Also the collapse of tissue following bronzing, but preceding necrosis, occasionally looked like the effect of scalding with boiling water.

Boron and Salt Content of Leaves

Kelley and Brown (1928) have shown that boron, although occurring as only a few parts per million in the soil solution, will accumulate within the leaves of citrus in comparatively high concentrations. They found the boron content of normal orange leaves to be around 50 p.p.m., while the content of injured leaves ranged from 756 to 1679 p.p.m. With lemons, normal leaves averaged 30 p.p.m. and injured leaves ranged from 266 to 839. No data were given for grapefruit leaves.

In order to determine both the boron and salt status of the leaves from the salt plots, mature leaves, approximately 9 months old, were collected without regard to leaf symptoms from each tree in the center row (which includes a tree of each stock-scion combination) of each plot, and were sent to the U. S. Regional Salinity and Rubidoux Laboratories for determination of sodium, chloride and boron. The results are shown in table 2.

It is seen from these data that the boron content of the leaves in the high-salt plot was not significantly higher than that of the leaves of the other two plots. In most instances, the boron content was below 100 p.p.m. and is considered not far from what is typical of normal healthy leaves. It is significant that the boron content of the leaves of grapefruit on Cleopatra, which showed no leaf symptoms, was higher than that of Red Blush on sour orange, which showed leaf burn. At the same time, in the high-salt plots, the chloride concentration was three times as high in the leaves of Red Blush on sour orange which showed leaf-burn, as that in leaves of Red Blush on Cleopatra in the same plot, which did not show leaf burning. Sour seedling leaves in the high-salt plot also showed high chloride content and showed leaf-burn. Therefore, these data associate the foliage symptoms of Red Blush on sour orange in the high-salt plots as of June 18, 1948, with chloride excess and not with boron excess.

Hayward, Cooil, and Brown (1947) have conducted salt tolerance studies with Marsh grapefruit cuttings grown in artifically salinized nutrient sand cultures. They found grapefruit intolerant of a culture solution containing either NaCl or CaCl2 at a level of 5 millimhos per cm. There was leaf-burn followed by abscission of leaves. The chloride concentration on the leaves was 1.7 m. e. per 100 grams for the control; 12.5 for the 5-millimhos NaCl culture; and 42.2 for the 5-millimhos CaCl2 culture. This is in line with results in the tests described in this paper for irrigation with half NaCl and half CaCl2. Red Blush on Cleopatra leaves with a chloride accumulation of 24.9 m.e. per 100 grams, on June 18, showed no leaf-burn, while grapefruit on sour, with 74.8 m.e. per 100 grams, showed severe leaf-burn.

Continued Sequence of Development of Foliage Symptoms

The period of July 25 to August 1, was another extremely hot dry spell and bronzing and necrosis developed on the leaves of the fifth tree of Red Blush on sour and on three of the Red Blush on Cleopatra in the high-salt plot. At this time the Red Blush on sour trees that had showed leaf-burning earlier were now completely defoliated. During the following week leaf-burn on these trees became more apparent; at the same time, no leaf symptoms were observed on Cleopatra seedlings and Valencia on Cleopatra in the high-salt plot. Bronzing occurred to a limited extent on the leaves of all five grapefruit on sour and on two Red Blush on Cleopatra in the low-salt plot, but no necrosis followed

and the bronzing disappeared as the weather moderated.

The September and October rains caused an interruption to the artificial salinization of the plots. During this salt-free period the badly damaged Red Blush on sour orange trees made a partial recovery; but as late as December 4, 1948, they were still in very poor shape and had only a few leaves, mostly dwarfed leaves and many of the branches drooped downward (figure 6) rather than standing upright as in Red Blush on Cleopatra (figure 7).

On October 4, irregular areas of yellow-orange color (mottled) were observed between the veins and along the margins and at the tips of the older leaves of sour seedlings, Cleopatra seedlings, and to a limited extent on the grapefruit on sour and Red Blush on Cleopatra in the high-salt plot. The symptoms were most prominent on sour seedlings (see figure 8) and were suspected of being the early stages of boron toxicity.

Leaves approximately 12 months old, were collected as before, but

TABLE 2

SODIUM, CHLORIDE, AND BORON CONTENT OF LEAVES FROM SALT PLOTS*

Scion-stock Combination	*Control, June 18*	*Low-Salt, June 18*	*High Salt June 18*	*High Salt Oct. 4*
Sodium - m.e. /100 gm. dry weight of leaf				
Cleopatra seedling	1.0	1.2	2.0	—
Sour orange seedling	0.2	0.7	0.9	—
Red Blush on Cleopatra	1.7	1.8	4.0	—
Red Blush on sour orange	1.2	1.7	3.5	—
Valencia on Cleopatra	trace	trace	trace	—
Chloride - m.e. /100 gm. dry weight of leaf				
Cleopatra seedling	1.6	2.5	13.8	—
Sour orange seedling	5.6	23.7	38.9	—
Red Blush on Cleopatra	2.4	6.7	24.9	—
Red Blush on sour orange	4.6	27.6	74.3	—
Valencia on Cleopatra	1.9	5.6	13.7	—
Boron - p.p.m. of dry weight of leaf				
Cleopatra seedling	85	94	91	294
Sour orange seedling	73	90	70	190
Red Blush on Cleopatra	123	99	119	229
Red Blush on sour orange	76	86	93	195
Valencia on Cleopatra	79	87	95	193

* These leaf analyses were made by John T. Hatcher and John W. Brown of the U. S. Regional Salinity and Rubidoux Laboratories at Riverside California.

Figure 6. Picture taken December 4, 1948, of same Red Blush grapefruit on sour tree, (24 D4), as in figure 2. Note sparse foliage and drooping branches.

Figure 7. Picture taken December 4, 1948, of same Red Blush grapefruit on Cleopatra tree, (24 C4) as in figure 3. Note some loss of older leaves.

from the high-salt plot only, and were sent to the Salinity Laboratory for boron analysis. The analysis given in table 2, shows that there was a 100% increase in boron on October 4, as compared with the June 18 collection, and the concentrations in all cases were slightly higher than what might be considered typical for normal healthy leaves. It is not clear from the data, whether the foliage symptoms are from boron excess or not.

Quantitative Growth Responses

The relative growth, as indicated by increase in circumference of trunk for the period of Nov. 11, 1947, to Sept. 23, 1948, of the various stock-scion combinations in the three salt plots is shown in table 3. The data show a highly significant effect of the high salt treatment on retardation of growth. However, the fact that the salt times rootstock-scion interaction is not quite significant suggests that the five stock-scion combinations behave essentially the same with regard to the growth increment even though striking differences were noted in leaf burning during this experimental period. The data do indicate that Valencia on Cleopatra grew more at the high salt level than the other stock-scion combinations but the statistical analysis shows that this could be due to change alone.

The retardation of growth by salt was confined to the high salt treatment, there being no significant difference in growth between the symptoms of salt excess indicates that under the conditions of this experiment irrigation water containing 2500 p.p.m. soluble salts (consist-

Figure 8. Picture of leaves of sour orange seedling on December 4, 1948, in high-salt plot showing mottling at apex. The mottled area has an orange color.

ing principally of a 50:50 mixture of NaCl and CaCl2) had no apparent ill effects on the rootstocks-scion combinations tested.

Seedling Tests In Various Parts Of The Valley

As indicated in the 1947 progress report, seedlings of 127 citrus varieties were planted in nurseries at several locations in the Valley. The seed of these varieties were sent from the U. S. Subtropical Fruit Field Station at Orlando [14], Florida, and planted in seedbeds at the Valley Experiment Station; the seedlings were transplanted to the nurseries in the fall of 1947.

Planting A was made at Monte Alto, B at Stuart Place, C at Elsa, D at Mission and E at Bayview. Nufsery care of these plantings was done by the owners of the property where the plantings were made.

The transplanting took place in October, 1947, and unusually dry windy weather, prevailing at that time, caused some loss of plants at locations A, D and E. The B and C plantings were made under more favorable weather conditions and all transplants lived.

In the spring of 1948, the Valley suffered a prolonged drought. The lower end of the Valley was without water for several months, and as a result, the E planting received no water and had to be abandoned. The other four plantings were able to receive water by special arrangements made with the water districts.

The 127 citrus varieties included in these tests are listed in table 2 of the report by Cooper and White (1947). There were not sufficient seedlings available of some varieties to make plantings at all locations. Consequently, some were planted at all locations, some at 3, some at 2,

[14] The writer is indebted to Dr. F. E. Gardner and Mrs. E. M. Savage at the Orlando Station for procurement of the seed.

TABLE 3

Average increase in circumference of rootstock-scion combinations in salt plots between Nov. 11, 1947 to Sept.. 23, 1948[1]

Rootstock-scion Combination	Control m.m.	Low Salt m.m.	High Salt m.m.	Mean of 3 plots, m.m.[2]
Cleopatra seedling	39.8	39.6	35.0	38.1
Sour orange seedling	38.4	50.8	37.6	42.7
Red Blush on Cleopatra	40.2	39.6	34.2	38.0
Red Blush on sour	46.0	40.8	33.0	39.9
Valencia on Cleopatra	49.6	50.0	45.8	48.5
Mean[3]	42.8	44.4	37.1	-

[1] Analysis of these data indicates that there was a highly significant salt and of rootstock-scion on average circumference but the salt x rootstock-scion interaction was not quite significant.

[2] Rootstock-scion means, least significant difference at 5% level 4.6. Rootstock-scion means, least significant differences at 1% level 6.2.

[3] Salt treatment means, least significant difference at 5% level 3.6. Salt treatment means, least significant difference at 1% level 4.8.

and some at only one. In this report only those varieties grown at two or more locations will be considered.

An unusually cold winter and a hot, dry, windy spring retarded growth of the seedlings at all locations until May. This was followed by rapid growth all summer and fall. At locations C and D various types of nutrient deficiency and excess symptoms appeared in the leaves during the spring and summer. A record of the types of leaf symptoms by variety and location is given in table 4.

Chlorosis

The planting at location D was characterized by a high incidence of chlorosis. The symptoms are as follows: The mesophyll tissue of the leaf is very light in color and sometimes almost white, but a fine network of green veins is present in the background (figure 9). New leaves are first affected and remain so after maturity. The succeeding cycle of growth in some instances is green and is followed by a chlorotic cycle. This is particularly noticeable with some of the citranges on which the oldest leaves show chlorosis; the next cycle of leaves is green; and a new flush at the top is chlorotic. Other varieties show chlorotic leaves only in the lowermost flush; others at the tip only; and in still others (such as sweet orange) all leaves are chlorotic.

An inspection of table 4 shows that 29 of the 58 varieties planted at location D showed chlorosis. These included all varieties of sweet orange, the Cleopatra mandarin and others. The resistant, or consistently green leaf class included the sour oranges, rough lemon, Rangpur lime, Morton citrange, and others.

There was no evidence of either boron or salt excess symptoms on any varieties at location D. The chlorosis was however, severe enough on some varieties to cause necrotic spots in the leaves and defoliation (Figure 9). In case of citrumelos no. 4475 and 4451, the Orlando tangelo, and several other varieties, the plants died back from the top. There were very few plants killed outright from the malady.

An inspection of the soil data (table 5 and 6) for the planting at location D shows a highly calcareous soil (even in the surface foot), a pH of 7.9 and low soluble salt content. The soil appears to be a Rio Grande fine sandy loam,[15] but its exact classification has not been determined.

Chlorosis in citrus is commonly found on over-irrigated calcareous soils in Arizona and California, but there is little agreement among investigators concerning the cause of this phenomenon. The hypothesis is often stated that a calcareous soil becomes more alkaline as the moisture content is increased and that availability of iron is affected. Reuther and Crawford (1947), however, in an investigation of the relationships of soil moisture, soil atmosphere composition, and soil reaction present data that question the validity of this hypothesis. On the other hand, it does appear that chlorosis is due to some soil factor that is related to the availability of a certain group of nutrients including iron.

[15] A classification made by W. R. Cowley.

TABLE 4

TYPES OF LEAF SYMPTOMS OBSERVED ON AUGUST 15, 1948 ON ROOTSTOCK SEEDLINGS GROWING AT THE FOUR NURSERY SITES

Key to type of leaf symptoms
0 - Green foliage C - Chlorosis
1 - Apparent boron excess - speckled effect in old leaves
2 - Apparent boron excess - mottled effect in old leaves
3 Apparent boron excess - mottled tip and marginal burning in old leaves
4 - Apparent boron excess - all seedlings dead

Species	Variety	Location A	Location B	Location C	Location D
Sour orange -	Texas	0	0	2	0
	Oklawaha	0	0	2	0
	Bergamot	0	0	4	0
	Bigaradier	0	0	2	0
	Natsumikan	0	0	4	c
	Bittersweet	0	-	2	0
Sweet orange -	Fla. sweet sdlg.	-	0	4	c
	Parson Brown	0	-	2	c
	Pineapple	0	0	3	c
Grapefruit -	Duncan	0	0	2	c
	Leonardy	0	0	2	0
Shaddocks -	Thong Dee	0	0	1	0
	Siam	0	0	1	c
	Nakorn	0	-	1	-
	Koo Kum Tia	0	-	1	-
Lemon -	Cuban (Cuban Shaddock)	0	-	1-3	0
	Rough	0	0	-	0
	Sweet	0	0	4	0
	Meyer	0	-	2	c
Lime -	Egyptian Sour	0	0	0	0
	Rangpur	0	0	0	0
	Columbian sweet	-	-	2	0
Limequat -	Lakeland	0	-	4	c
	Tavares	0	0	4	c
Trifoliate orange -	Large flowers	c	-	4	c
	Small flowers	c	-	4	c
Citranges -	Morton	0	0	3	0
	Saunders	0	0	-	c
	Troyer	-	-	4	c
	Savage	-	-	-	c
Citrumelo -	No. 4481	0	-	2	0
	No. 4475	0	0	-	c
	No. 4451	0	-	-	c
	No. 4482	-	c	3	-
Citrange -	No. 42681	-	-	2	-
Citrangequate -	No. 48011	-	-	2	c
Citrangedin -	Glen	-	-	c	-
Sweet Mandarin -	Cleopatra	0	0	0	c
	Betanjor	-	0	4	-
	Oneco	-	0	2	-
	Willow-leaf	0	0	-	0
	Chu Koa	0	0	4	0
	Tim Kat	0	-	-	0
	No. 11412	0	-	4	-
	Nobles No. 10642	0	0	2	0
	Swatow No. 10031	-	0	2	c
Sour Mandarin -	Suen Kat	0	0	-	0
	Calamondin	0	1	3	-
Tangor -	No. 653	0	0	4	0
	Kinnow	-	-	2	c
	Wilking	0	-	-	c
	King	0	-	2	0
	Temple	0	0	4	c
Tangelo -	Seminole	0	0	3	0
	Orlando	0	c	3	c
	Thornton	0	0	2	0
	Sunshine	0	0	4	c
	Minneola	0	0	4	c
	Watt	0	0	4	0
	Sampson	0	0	4	c
	Williams	0	0	3	-
	Yalaha	0	-	2	c
	Pina	0	0	2	0
Sataumelo -	No. 10-0-3	0	-	-	c
Severinia sp.	Narrow-leaf form	0	c	c-2	c
	Broad-leaf form	0	-	0	0
C. Macroptera hybrid -	Kalpi (Webber's Philippine hybrid)	0	-	-	0

Apparent Boron Toxicity

The area selected for planting C is one that was considered to be an excess-salt problem area. It is in a section designated to receive mixed river and drainage water. An adjacent grapefruit grove showed leaf-burn but it was not examined closely at that time for evidence of boron excess symptoms.

At the beginning of the test, free ground water occurred at 56 inches and the EC of this water was 10.0 millimhos per cm. The soil is classed as Hidalgo fine sandy loam; the surface foot is slightly calcareous and has a pH of 7.7. The ECe of the surface foot of soil was 1.4 millimhos per cm., and for the next three feet 3.4 millimhos per cm. (see table 6.).

During the fall and winter, the irrigation water consisted mostly of river water. the EC of the irrigation water was 3.0 millimhos per cm. on October 31; 2.4 on Jan. 16; 1.6 on Feb. 23; and 2.2 on Apr. 7. The average ECe of the surface foot of soil (table 6) was 3.6 millimhos per cm. on Dec. 30; and 2.2 on May 1. The surface foot horizon at least, could not be classed as a high-salt soil during this period; yet a great many plants showed yellowing, tip burn, defoliation, and die-back. Also a great many of the plants died at that time, but no detailed diagnosis was made of the leaf symptoms.

Irrigation water applied in May, June, and July had an EC of 5.8 millimhos. The average ECe of the surface foot for 20 locations in the nursery on July 20 was 4.5 millimhos per cm. Some individual locations had an ECe reading of 6.0 millimhos per cm. Therefore, during this period the salt content of the surface foot was perhaps high enough to

Figure 9. Chlorosis found on Duncan grapefruit seedlings at Goodwins' nursery in August 1948.

cause injury to intolerant varieties. The salinity was intermediate between the levels maintained in the high-salt and low-salt plots of the salt tolerance tests.

On August 15, a record was made of the apparent type of injury occurring on the leaves. In most instances it appeared to be a form of boron-excess symptom. The speckled effect (type no. 1) found on the shaddock appeared identical with that described by Camp and Fudge (1939, p. 43). The mottled effect (type no. 2) at the margin of the tip found on sour orange, sweet orange, grapefruit, Meyer lemon, some of the mandarins, tangelos, and citranges was similar to that illustrated by Chapman (1943, p. 170) for lemons. The type no. 3 injury appeared to be an advanced stage of type no. 2 and was similar to that illustrated by Camp

TABLE 5

ANALYSIS OF SOILS AT THE 0 - 12 INCH HORIZON OF THE FOUR LOCATIONS AT VARIOUS DATES IN 1947 AND 1948

Date	Location A	Location B	Location C	Location D
		Lime Test *		
11-13-47	0	-	-	xx
12-30-47	0	x	-	xxx
5- 1-48	0	0	-	xxx
7-20-48	0	0	-	xxx
9-25-48	0	0	0	xxx
11-16-48	0	0	x	x
		PH of Saturated Soil		
11-13-47	-	-	7.8	7.7
12-30-47	7.5	7.3	7.3	7.7
5- 1-48	7.1	7.3	7.5	7.9
7-20-48	7.1	7.1	7.3	7.9
9-25-48	7.2	7.1	7.7	7.9
11-16-48	7.3	6.9	7.8	7.9
		Saturation Percentage		
11-13-47	34	-	-	29
12-30-47	-	33	31	36
5- 1-48	28	36	34	32
7-20-48	27	36	36	31
9-25-48	25	34	35	30
11-16-48	28	36	37	41
		Salinity - ECe, Millimhos per Cm.		
11-13-47	0.4	-	-	2.1
12-30-47	1.6	1.5	3.6	2.3
5- 1-48	1.5	1.3	2.2	1.4
7-20-48	1.1	1.7	4.5	1.1
9-25-48	0.5	0.9	0.9	0.7
11-16-48	0.9	1.8	1.4	0.9

* 0 = Non-calcareous; x = slightly calcareous; xx = moderately calcareous;
xxx = highly calcareous. Rated according to degree of effervescence obtained with acid.
- = no determination.

and Fudge (1939, plate VIII). Cleopatra showed no symptoms of boron excess on August 15, but developed them later.

It is possible that some of the injury observed and labeled as type no. 3 was salt-excess damage or combination of salt and boron excess. In the case of some citranges, citrumelos, citrangedins, citrangequats, and narrow-leaf severinia there was evidence of a combination boron excess and chlorosis of the type found at planting D. It is noted that the surface foot of soil is slightly calcareous. One outstanding difference between the C and D plantings was the behavior of sour orange. In planting D, all sour oranges had healthy green leaves, while in planting C, all varieties of sour orange had the mottled boron-excess effect.

The only varieties showing little or no symptoms of boron excess after one year in planting C were rough lemons, Egyptian sour lime, Rangpur lime and the broad-leaf severinia.

At location A, in contrast to the C and D plantings, all leaves on all varieties except the trifoliate-orange were green and free of chlorosis, boron, or salt toxicity. The trifoliate-orange showed chlorosis similar to that found in planting D. All other of the 53 varieties listed in table 4, and 42 other varieties not listed, had healthy green foliage all spring and summer. The surface foot of soil was a grayish brown fine sandy loam,

TABLE 6.

ANALYSIS OF SOILS AT DIFFERENT HORIZONS OF THE FOUR LOCATIONS ON NOVEMBER 11, 1948

Soil horizon, inches	Location A	Location B	Location C	Location D
		Lime Test *		
0-12	0	0	x	xx
12-24	0	x	xxx	xxx
24-36	0	xxx	xxx	xxx
36-48	x	-	xxx	xxx
		PH of Saturated Soil		
0-12	7.3	6.9	7.8	7.9
12-24	7.1	7.3	7.7	8.0
24-36	7.5	7.8	7.8	7.8
36-48	7.8	-	7.8	7.9
		Saturated Percentage		
0-12	28	36	37	41
12-24	40	41	40	40
24-36	46	49	41	37
36-48	44	-	40	45
		Salinity - ECe, Millimhos per Cm.		
0-12	0.9	1.8	1.4	0.9
12-24	0.5	1.6	3.5	1.0
24-36	0.6	2.1	3.4	0.9
36-48	0.8	-	3.4	0.8

* 0 = Non-calcareous; x = slightly calcareous; xx = moderately calcareous; xxx = highly calcareous. Rated according to degree of effervescence obtained with acid.
- = Indicates no determination.

classified as Brennan fine sandy loam, non-calcareous, with a pH of 7.3 a saturation percentage of 28, and a low soluble salt content. Other soil data are given in table 6.

The record on leaf symptoms at plantnig B was similar to that in planting A. All varieties except Orlando tangelo, Citrumelo no. 4482, narrow-leaf severinia, and calamondin had healthy green leaves. Of the four exceptions, the first three had the type of chlorosis observed in planting D and the calamondin had the speckled stage of apparent boron toxicity symptom. The soil in the surface foot was noncalcareous, pH 6.9, saturation percentage 36, and low soluble salt content. The soil below the surface foot was calcareous.

In recapitulation it is seen that, if the leaf symptom diagnosis was correct, no marked boron toxicity occurred except in planting C and the chlorosis in planting D was of another type, probably the nutritional deficiency common on heavily irrigated calcareous soils. If this were true, there should be less boron in the leaves at plantings A, B, and D, than at C. A boron analysis made on 10-month-old Cleopatra seedlings leaves collected from the four locations on November 1, showed that this was the case (see table 7). The value found (635 p.p.m.) in the leaves at planting C is high for leaves of that age and is in line with that found in mature leaves of areas of boron injury.

It is therefore concluded that boron was a factor in inducing the observed symptoms in planting C. Chloride analysis was not made on these leaves and it is not known whether injurious concentrations of salt were also present.

TABLE 7

Boron Determination * *on Leaves* ** *from Cleopatra Seedlings Grown at the Four Locations*

Location	Boron, p.p.m.
A	149
B	191
C	635
D	165

* These leaf analyses were made by the Agricultural Consultant Laboratories at Weslaco, Texas.

** 10-month-old leaves collected Nov. 2, 1948.

EXPERIMENT STATION FIELD PLANTING

Description of Planting

The first field planting of the present investigations was made at the Texas Agricultural Experiment Station at Weslaco, on December 15, 1947, from nursery stock propagated in the nursery planting at the station. A preliminary report (Cooper and White, 1947) was made last year. The planting consisted of a 10-acre block of Red Blush grapefruit on 39 varieties of rootstocks, with 12 trees of each rootstock. The trees were planted in groups of three trees of each rootstock variety, the three-tree rootstock groups being randomized in each of the four blocks. The planting distance was 25 by 25 feet. A border row of trees was planted on all four sides of the planting to serve as wind protection for the test trees.

The field planting was made adjacent to the salt tolerance plot area. The soil in most of the 10-acre area is classified as Willacy fine sandy loam (non-calcareous in the surface foot) but there are some spots of Hidalgo fine sandy loam (slightly calcareous in the surface foot). A silty clay stratum containing calcium carbonate (limestone) concretions was as close as 18 inches to the surface in some areas but was approximately 36 inches from the surface in the greater part of the planting. A detailed soil survey of the area will be given in later reports on this planting.

Piezometers installed at an 8-foot depth in 12 locations in the 10-acre planting showed free ground water at 68 to 80 inches. The salinity of this ground water was determined as EC 5.0 to 15.0 millimhos per cm.

Following the September rains, considerable chlorosis developed in the leaves of some trees in a small area of the planting on Hidalgo fine sandy loam. The surface foot and the second foot of soil were calcareous, with a pH of 7.6. The saturation percentage of the surface foot of soil was 34, and this soil contained 18 percent moisture 10 days after the rains. The salinity at this time measured ECe 2.9 millimhos, per cm.

The chlorosis was a yellowing similar to that occurring in the seedling planting C at Mission and occurred principally on the leaves of the terminal flush of growth. A great many of the affected leaves developed small circular spots of brown dead tissue. Later many of the affected leaves abscised. Trees on Suwannee tangelo, Orlando tangelo, Pina tan--gelo, Temple orange, Chu Koa mandarin, and Dancy tangerine rootstocks showed chlorosis; while trees on Thornton tangelo, Sampson tan--gelo, and Oklawaha sour orange in the same area showed no chlorosis.

A chemical analysis[16] of affected leaves from grapefruit on Orlando tangelo rootstock showed: boron 164 p.p.m., sodium 4.65 m.e./100 grams. Both the boron and chloride content are too low to cause boron or chloride injury, but the sodium content is as high as that obtained in leaves

[16] Made at U. S. Regional Salinity and Rubidoux Laboratories, Riverside, Calif.

on the high-salt plots (table 2). The significance of these results is not clear.

Quantitative Growth Response

The average growth responses of the plants of the grapefruit trees produced on the various rootstocks during the first year after transplanting are shown in table 8. Growth measurements consist of circumference measurements of the trunk of the tree four inches above the bud union. These measurements were made right after transplanting on December 15, 1947, and on December 4, 1948, approximately one year later.

The measurements at the time of transplanting, represented by the first column of figures in table 8, reflect differential growth of the rootstock in the nursery. This has been described in some detail in the 1947 report where it was shown that sour orange, rough lemon, and Rangpur lime produced the largest grapefruit trees in the nursery. The Williams, Thornton, Watt, and Sampson tangelos produced trees next in vigor of growth, while the mandarins, including Cleopatra, produced a relative growth of grapefruit of only about 70 percent of that of the sour orange.

Statistical analyses of the data in table 8 for increase in circumference of the trunk during the first year in the field indicate that there is a highly significant effect of stock on circumference increment of the trunk. The least difference required for significance between any two stock means is 7.6 m.m. at 19 to 1 odds and 10.0 m.m. at 99 to 1 odds. Eight of the stocks showed significantly smaller growth increments than the Florida sour orange (control). The smaller growth increments for Siam shaddock, Temple orange, citrumelo no. 4475 and the Sampson, Suwannee, and Pina tangelos than for Florida sour orange were highly significant.

The growth increment for lempum, satsuma, and citrumelo in all three instances was significantly lower than that for all other stocks. In most instances the difference was highly significant.. Some of the trees on lempum root were found to have a defective bud union, several breaking off at the bud union. In case of the trees on satsuma and citrumelo stock the bud union appeared sound.

The only stock that showed a growth increment significantly greater than that for Florida sour orange was the Rangpur lime. The increase in circumference for rough lemon, Cleopatra mandarin and others as shown in table 8 did not differ significantly from that for Florida sour orange.

The good growth of grapefruit on Cleopatra root after establishment in the field, is in line with observations made by growers throughout the Valley with this rootstock.

DISCUSSION AND CONCLUSIONS

The salt tolerance studies described in this paper have shown that grapefruit on Cleopatra mandarin rootstock is slower developing leaf symptoms of salt-excess and shows less growth depression from high-salt treatment than does grapefruit on sour orange. The value of this degree of apparent salt tolerance of the Cleopatra rootstock to the

TABLE 8

Growth of Red Blush grapefruit on various rootstock varieties in the Texas Agricultural Experiment Station field planting during the first year after transplanting

Species or hybrid	Variety	Avg. Circumference of trunks at transplanting 12-15-47, mm.	Avg. Circumference of trunks 12-4-48, mm.	Avg. Increase in Circumference of trunks from 12-15-47 to 12-4-48, mm.
Sour orange	Florida (control)	44	96	52
	Oklawaha	43	96	52
	Bergamot	44	96	52
	Sauvage	40	94	54
	Bittersweet	42	96	54
	Natsumikan	30	80	50
Sweet orange	Florida sdlg.	36	88	52
	Hamlin	36	86	50
Grapefruit	Duncan	28	71	43*
	Leonardy	32	87	55
Shaddock	Thong Dee	34	79	45
	Siam	28	70	42**
Sweet Mandarin	Cleopatra	31	82	51
	Dancy	29	72	43*
	Satsuma	27	60	33**
	Clementine	35	83	48
	Chu Koa	31	76	45
Sour Mandarin	Suen Kat	33	88	55
	Calamondin	37	84	46
Tangor	Temple (orange)	34	76	42**
	King	37	85	48
	Umatilla	36	79	43*
Tangelo	Williams	40	84	44*
	Sampson	38	80	42**
	Suwannee	34	76	42**
	Yalaha	26	70	44*
	Sunshine	32	77	45
	Orlando	31	74	43*
	Minneola	35	83	48
	Pina	35	75	40**
	Thornton	46	89	43*
	Watt	40	86	46
Lemons	Rough	47	104	57
Lime	Rangpur	42	102	60*
Lempum	-	38	72	34**
Citrumelo	No. 4475	19	52	33**
C. Macroptera hybrid	Kalpi (Webber's Philippine hybrid)	38	94	55

Least significant difference between any two stocks at 5% level 7.6
Least significant difference between any two stocks at 1% level 10.0

* Signifies significant difference from Florida Sour Orange (control) by odds between 19:1 and 99:1.

** Signifies significant difference from Florida Sour Orange (control) by odds of 99:1 or more. None of the rest differ significantly from Florida sour orange.

growth, yield, and longevity of grapefruit under grove conditions will require trials of grapefruit on Cleopatra root under actual field conditions. One such field test has been established at the Experiment Station and others will follow in different parts of the Valley during the coming year.

The salt tolerance studies also show that Valencia orange on Cleopatra root is more tolerant of salt than Red Blush grapefruit on Cleopatra root. Thus, we find both a stock and scion effect in relation to salt tolerance. These results with Valencia orange are in line with repeated observations made in the field in problem areas of the Valley where a high water table and high soil salinity exist. Under such conditions Valencia orange invariably grows better than grapefruit, with both growing on sour orange root.

The boron impurity in the salt solutions used in the early part of these salt tolerance tests throws some question on the interpretation of the data in spite of the fact that the leaf symptoms were typically salt-excess and chemical analysis of the leaves show toxic amounts of chloride and non-toxic amounts of boron. New salt tolerance tests on the Cleopatra root as well as on 30 other varieties of rootstocks have already been initiated. In these tests particular care will be exercised to use boron-free salts.

The boron complication in the salt plots and the occurrence of apparent boron toxicity in the seedling planting C, have introduced problems of the identification of salt and boron excess symptoms and of the determination of boron tolerance of citrus rootstocks as well as salt tolerance. In order to investigate these new problems a series of test plots of Red Blush grapefruit and Valencia orange on sour orange and on Cleopatra roots have been initiated in a boron-free area at Rio Farms. These will be irrigated with river water containing (1) added salt, (2) added boron, (3) added boron plus salt, and (4) no added salt or boron. The leaf symptoms produced under these known controlled levels of salt and boron and mixtures of the two should contribute to a better diagnosis of boron and salt toxicity.

The different leaf symptoms developed on seedlings growing in different regions of the Valley illustrate some of the problems involved in rootstock adaptability tests in the Valley and shows the importance of conducting comparative rootstock tests on the various soil types. A rootstock adaptable to location D should show resistance to chlorosis and an adaptable stock for location C should have boron tolerance. On the other hand rootstock seedlings susceptible to chlorosis and intolerant of boron grew well in locations A and B. Thus locations A and B may have a greater choice of rootstocks adaptable to those areas. A certain stock may be highly adaptable in all respects except for boron or salt intolerance. Such a stock might possibly prove more adaptable to locations A and B than a rootstock found to be tolerant to boron or salt and adaptable to location C.

The latest census of the Division of Plant Inspection and Quarantine of the Texas State Department of Agriculture indicates that there are now 405,500 Cleopatra seedlings in the nurseries and 22,000 grapefruit

and orange trees on Cleopatra rootstock in nurseries or in field plantings in the Valley. Because of this interest by growers in Cleopatra rootstock as a substitute for tristeza-susceptible sour orange stock, it is desirable to investigate and find out the facts about this rootstock. The salt and boron tests have been designed to test this variety in particular, and it was included in the rootstock field planting at the Experiment Station and will be included in the other field plantings.

The results to date indicate the following in regard to Cleopatra rootstock: (1) when budded to grapefruit it appears to be more salt tolerant than sour orange; (2) grown as a seedling, it is more suseptible to chlorosis on highly calcareous soils than is sour orange; (3) it has the disadvantage in the nursery of growing slowly and requiring more time to reach a good budding size than the sour orange; but once propagated and transplanted to the field, it has grown as rapidly as the sour orange during the first year.

The merit of a rootstock, however, depends primarily on its behavior in the orchard. Important points to be considered are precociousness, yield per acre, quality and size of fruit produced, length of productive life of tree, and degree of resistane to cold.

Although particular attention is being given to investigations of the Cleopatra rootstock, two hundred other varieties of citrus are also being tested. Not only the Cleopatra mandarin, but the Sunki, Suen Kat, Dancy, Ponkan, Clementine, Oneco, Kinnow, and Kara mandarins have been found by Grant and Costa (1948) to be resistant to tristeza when budded with either grapefruit or sweet orange. Perhaps all mandarins will be found to be resistant. Accordingly, the seedling plantings at locations A C and D have been expanded to include 44 different varieties of mandarins. These plus many varieties of limes, lemons, tangelos, and citranges are being tested for their adaptability to the Valley soils.

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Some Important Transit and Market Diseases of Texas Vegetables

By

G. B. Ramsey, *Senior Pathologist*
United States Department of Agriculture, Bureau of Plant Industry, Soils and Agricultural Engineering
Chicago, Illinois

Dr. G. B. Ramsey obtained his Ph. D. in botany at the University of Chicago in 1925. He has done research in Plant Pathology at the Indiana State Experiment Station and at the Maine State Experiment Station. Dr. Ramsey has been actively engaged with Market Diseases of Fruits & Vegetables for the U. S. D. A., University of Chicago since 1928.

From the market point of view any deviation from the normal structure or function of a plant or plant part that endangers its life or decreases its marketability is considered a disease. While there are many factors that contribute directly or indirectly to the loss of produce during transit and marketing, the most serious fruit and vegetable diseases are usually caused by low forms of plant life belonging to the groups known as bacteria and fungi. Many of these bacteria and fungi cause diseases in the field by invading the roots, stems, leaves, or fruit of various commercial crops of vegetables. Such disease-producing organisms not only cause decay and loss during the growing of the crop but they also continue to cause decay of the commodity during transit and marketing. Many of the fungi do not require wounds for entrance into plant tissue and therefore are able to grow from one diseased fruit or vegetable to another in the same package. In some produce like snap beans, peas, cucumbers, lettuce, carrots, etc., the spread of disease-producing organisms like Sclerotinia and Rhizoctonia from one or two infected specimens within the package causes some of the most serious losses during transit and marketing. For this reason special care should be exercised to inspect and grade out all evidences of decay when disease is known to be present in a crop.

During the growing and harvesting of fruit and vegetable crops weather conditions play one of the most important parts in determining loss from decay during transit and marketing as well as in the field. Extremes of temperature or moisture often lead to injury and blemishes which open the way for secondary decay-producing organisms such as the bacteria that cause soft rot. High soil moisture favors the growth of soil organisms that often are particularly damaging to vegetable crops, while high atmospheric moisture facilitates the spread of airborne organisms which cause infection and decay of both fruits and vegetables.

Late blight of tomatoes and potatoes provides one of the best examples of the close correlation of weather conditions to the development of disease. The causal fungus (*Phytophthora infestans*) will not grow under hot, dry conditions but it will grow rapidly during cool, wet weather. During unusually cool, wet weather this fungus has caused serious decay in Texas produce in the field and on the market. From the marketing point of view late blight is especially damaging to the tomato crop at harvesting time because the spores of the fungus contaminate the fruit while on the vine and during packing. On germination these spores usually cause infection at the stem scar or elsewhere on the fruit where the skin has been injured. Since it takes four or five days for visible decay to develop it is possible to pick and ship apparently healthy tomatoes and still have a high percentage of them show late blight rot by the time they reach the market. Furthermore, some inconspicuous infections at the edge of the stem scar are certain to be overlooked by the graders and packers and such infections often cause decayed areas one inch or more in diameter by the time the tomatoes reach the market. So long as the late blight fungus shows as a white downy mildew on the under side of diseased leaves and on the stems of blighted vines, fruit infections will continue to occur, because the presence of this mildew shows that new crops of spores are being produced each day. Shipping tests with tomatoes from blighted vines have shown that it is impossible to grade out all diseased fruit. In a test made by the writer seven lugs of tomatoes harvested from a badly blighted field were carefully inspected twice to be sure that all fruit showing the slightest signs of infection were eliminated. Four of these lugs of tomatoes were immersed in a formaldehyde dip (1-300) and three lugs were left untreated. After five days an inspection showed late blight ranging from 4 to 12 percent in the treated lugs of tomatoes and 8 to 17 percent in the untreated lugs of fruit. The presence of invisible infections made it impossible to eliminate the disease by inspection, and the formaldehyde dip was not effective in checking the development of decay. Several days of hot, dry weather will do more toward checking blight of the vines and decay of the fruit than anything we can do.

Late blight also occurs in the southern potato crop under the same weather conditions that favor its development in tomatoes. In fact the potato crop in some regions often furnishes the source of infection for the tomato crop, since the same fungus (or closely related strains) causes late blight in both crops. Although late blight tuber rot of potatoes is at times one of the most serious diseases causing loss during transit and marketing, it is sometimes possible to have appreciable blight in the field and yet not have much tuber infection. If the soil is comparatively dry a few weeks before digging time the spores of the fungus are unable to get down to the tubers. Most tuber infections occur during wet weather previous to and during harvesting. Spores washed down from the vines through the soil during rains cause most infections of the tubers. However, the tubers may also be contaminated by spores from the wet vines during digging. Infections resulting from the germination of these spores sometimes cause decay during transit. Bacterial soft rot often follows these infections and causes as much trouble as the late blight tuber rot by the time the potatoes reach the market. By harvesting potatoes during dry weather

and by careful inspection and grading of tubers at packing time much of the loss from late blight tuber rot during transit may be avoided.

Among the many transit and market diseases of vegetables that cause great loss in vegetable produce few are as damaging as bacterial soft rot. This disease is caused by *Erwinia carotovora* and related species of bacteria that follow injuries, blemishes, and other decays. The causal organisms are ever present in the soil and water and therefore are a constant source of trouble whenever conditions are favorable for their growth. In the southern potato crop bacterial soft rot causes greatest losses in wet seasons and during hot, wet weather at harvesting time. Tubers with enlarged lenticels, with excessive bruises and cuts, or injury by heat (scald) are especially susceptible to this disease. Potatoes injured by scald at harvest time almost invariably develop bacterial soft rot during transit and marketing even though there may be no visible injury at packing time. For this reason it is advisible to pick up the tubers within 30 minutes after they are dug if the air temperature is 90°F. or above. During hot weather washed potatoes should be fairly dry when packed and they should be shipped under refrigeration in order to retard the development of bacterial soft rot during transit.

In tomatoes bacterial soft rot usually is associated with rains, growth cracks, and insect injuries. Some of this decay may show in the field but often most serious loss occurs in shipments to the market. Tomatoes injured during harvesting and packing or by shifting of the load during transit often develop bacterial soft rot before they are ripe. The injuries caused in lidding excessively bulged packs are often responsible for much of the decay found on the market. Apparently all tomatoes are contaminated by soft-rot-producing bacteria, for all kinds of injuries and decayed areas caused by other diseases are usually followed by bacterial soft rot while the fruit is being held on the market for ripening. Much of the loss from this disease may be avoided by careful handling to prevent injuries during harvesting and packing the fruit.

Bacterial soft rot is one of the most serious market diseases of many other vegetable crops. Under warm, moist conditions it causes great losses in shipments of lettuce, carrots, celery, cabbage, cucumbers, onions, and other commodities. Since this trouble is often inconspicuous in the field the growers and shippers are sometimes greatly surprised when they get receiving-market inspection reports that show high percentages of bacterial soft rot in carlots of produce that they considered in good shipping condition. Usually such severely decayed lots of produce result from excessive injuries from exposure to high temperatures at harvest time or from delays and insufficient refrigeration during transit. The growth of most bacteria that cause soft rot is checked by temperatures of 45°F. and below.

Perhaps there is no better way of emphasizing the need for better methods of controlling loss of fruits and vegetables during transit than to quote some figures from the Freight Claim Division of the Association of American Railroads on the amount of money paid out in claims for loss and damage (Cir. No. FCD-1340). In 1947, $19,209,381 was paid on claims on fruits and vegetables. This amounted to an average payment of $19.05 per car for the 1,008,172 cars handled that year. Greatest loss occurred in the strawberry shipments on which an average claim payment was made of $175.00 per car. The least loss occurred in banana shipments on which an average claim payment was made of $1.26 per car. The average claim payments per car of some other commodities were as follows: tomatoes $72.95, cucumbers $36.60, watermelons $30.62, orange $20.49, and grapefruit $12.69. These sums are paid for loss and damage caused by several factors among which breakage, injuries, and decay are the most important.

TEXAS CITRUS & VEGETABLE GROWERS & SHIPPERS

Seeing the need for unity of action in the industry, a handful of fewer than thirty grower-shippers of vegetables and citrus founded "Texas Citrus & Vegetable Growers & Shippers" in October, 1942.

This Association now has a membership of over two hundred growers, shippers and allied industry firms, located throughout the State of Texas.

Texas Citrus & Vegetable Growers & Shippers is a nonprofit corporation whose primary purpose is to promote and protect the interests of the growers and shippers of fresh fruit and vegetables. In an industry as diversified and complex as this one, this has meant going into many, many problems — State and National Legislation, transportation, labor relations, publicity, and research — to mention only a few.

During the six years this Association has been in existence, it has come to be recognized as the strongest and largest state organization of its kind in the industry. It has and will continue to work for the benefit of the growers and shippers of Texas vegetables and citrus.

Vegetable Spoilage in Transit and Storage In Relation to Certain Field Practices

By

JACK M. BICKERTON, *Plant Pathologist*

E. I. Du Pont De Nemours & Co., Inc., Houston, Texas

Dr. Jack M. Bickerton was born at Victoria, British Columbia, Canada, April 30, 1913. He received his BSA degree from the University of British Columbia in 1934 with a major in Plant Pathology. For two years he was agricultural technician for the National Research Council of Canada at the Dominion Experiment Station, Summerland, B. C. After five years graduate study in Plant Pathology, he was awarded a Ph. D. degree at Cornell University in February, 1941. He was director of Research and Assistant Sales Manager in the Agricultural Division of Innis, Speiden & Co. of New York for six years. From Feb. 1947 to June, 1948 he was General Manager Insecticide Division of the Walker Fertilizer Company of Orlando, Florida. Since July of 1948 he has been technical service representative in the Houston-New Orleans territory for the Grasselli Chemical Department of the E. I. duPont de Nemours & Company, Inc., Wilmington, Delaware.

INTRODUCTION

The enormous extent of losses to fruits and vegetables in transit and storage is indicated in a recent publication by Wiant and Bratley (5). They point out that in the 7-year period 1935-42, with reference to rail shipments to New York City only, decay of 14 fruits totaled 4,936 carlots and decay of 31 vegetables totaled 15,689 carlots, or a grand total of 20,625 carlots; equivalent to nearly 3,000 carlots annually. A study of this article indicates that shipments originating in Texas had their full share of decay!

Today I have been invited to discuss the effect of proper field practices in reducing spoilage of fruits and vegetables after harvesting. This is such a broad topic that time precludes a complete discussion of it. My remarks will be limited largely to a discussion of the important part that the proper use of fungicides and insecticides on vegetable crops in the field can play in minimizing post-harvest losses caused by fungi and bacteria. Even this is a broad topic.

EFFECT OF CHEMICALS ON PRE-HARVEST LOSSES

Before discussing the relation of field usage of fungicides and insecticides to vegetable spoilage after harvest, let us consider briefly the main purpose of using such chemicals; namely, to control, in the field, diseases and insects which reduce total yields of marketable produce and increase the percentage of culled produce. In this regard no one will argue the practicability of an effective control program in the field. The use of newer organic insecticides like DDT and Benzene Hexachloride, having residual killing properties and a wide range of insect toxicity, as well as improved neutral copper and "dithiocarbamate"* fungicides, has without doubt been a large factor in increasing yields as well as net income in most of the important vegetable-producing areas.

The regular use of fungicides on vegetables in the Rio Grande Valley is not yet established practice. Observations indicate that this is certainly not due to the absence of serious foliage diseases on our important vegetable crops. It is apparently due to a natural desire on the part of the grower to economize. and to a scarcity of factual local information regarding practical results to be achieved from using fungicides. In the latter regard numerous examples could be cited from other areas where the disease picture is no more pronounced than ours. For example, Young (6) has shown that the use of copper fungicides, such as Copper-A** on tomatoes in the Jacksonville, Texas area doubled the yield of marketable fruit. We are conducting similar local tests in cooperation with Dr. G. H. Godfrey. The results from one tomato test carried out near La Villa during the 1948 fall season are shown in the following table. Fungicide dust applications, at roughly 25 pounds per acre, were made by airplane at 5 to 7 day intervals on single plots for each treatment. Each plot was approximately 30 feet wide by one-quarter mile long and separated from the next plot by about 100 feet to minimize overlapping of treatments by dust drift. Considerable grey leaf spot (*Stemphyllium solani*) and early blight (*Alternaria solani*) appeared in the field the latter part of October. Harvesting of fruit was started November 4 and was prematurely terminated November 29 by a killing frost.

Yields of Marketable Tomato Fruit

Treatment	*From Two Center Rows*	*Calculated Yield Per Acre*
None	582 lbs.	2982 lbs.
15% Copper-A	785 lbs.	4023 lbs.
10% Parzate	620 lbs.	3178 lbs.
10% Zerlate	802 lbs.	4110 lbs.

In the following discussion on the use of fungicides no reference will be made to seed treatments. However, it should be kept in mind that the use of proper seed treatments in many cases is an important part of the control program as regards minimizing both pre and post-harvest disease losses.

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*Several references are made throughout the text to dithiocarbamate fungicides, which include the following.
Fermate (E. I. duPont) - ferric dimethly dithiocarbamate
Zerlate (E. I. duPont) - zinc dimethyl dithiocarbamate
Parzate (E. I. duPont) - zinc ethylene bis dithiocarbamate
Dithane D-14 (Rohm and Haas) - disodium dimethyl dithiocarbamate
Dithane Z-78 (Rohm and Haas) - zinc ethylene bis dithiocarbamate

**Copper-A (E. I. duPont) - tetra copper calcium oxychloride

EFFECT OF CHEMICALS ON POST-HARVEST DECAY

You may wonder how the use of fungicides and insecticides in the field can have any bearing on diseases which develop in transit and storage. This occurs in at least two ways: (1) primary control by minimizing produce infections which originate in the field and (2) secondary control by reducing insect wounds and disease lesions on the produce through which decay organisms subsequently enter.

Primary Results

Although we discard obviously diseased produce in the grading and packing operations, we fail to discard diseased material exhibiting early symptoms difficult to detect, or in a latent period of infection. There are many examples of minimizing such infections by the proper use of fungicides in the field until harvesting.

Transit rot caused by late blight (*Phytophthora infestans*) on tomato fruits and potato tubers is of common occurrence. Several investigators have shown that this disease can be effectively prevented by spraying or dusting with copper fungicides, such as Copper-A, or with zinc carbamates such as Parzate and Dithane.

Septoria blight (*Septoria lycopersici*), early blaght (*Alternaria solani*, nailhead spot (*Alternaria tomato*), Phoma rot (*Phoma destructiva*) and leaf mold (*Cladosporium fulvum*) all produce lesions on mature tomato fruits. These diseases can be controlled by the use of a suitable copper fungicide in the field (6).

Bean anthracnose (*Colletotrichum lindemuthianum*) is often not evident until the green beans are packed in the hampers. This disease can be controlled in the field by spraying with Fermate (2).

According to Chupp (1) *Cladosporium cucumerinum* attacks the straight neck summer squash in New York State but the damage is most evident after the fruits are crated. Spraying with dithiocarbamate fungicides (not specifically identified) gave excellent control.

Alternaria leaf spot (*Alternaria brassicae*) causes serious rotting of cabbage (4) shipped from both Texas and Florida (5). In the spring of 1947 A. A. Foster at the Florida Agricultural Experiment Station, Sanford, demonstrated that this disease can be controlled by dusting in the field with Zerlate. This was confirmed in Florida by subsequent commercial dustings.

Blue mold (*Peronospora spinacea*) and white rust (*Albugo occidentalis*) cause serious decay of spinach in transit (5). We are currently conducting tests in cooperation with Dr. O. H. Calvert, Texas Agricultural Experiment Station, Winterhaven, to determine if practical control of these diseases can be obtained by dusting in the field with fungicides.

Lettuce is often severely rotted in the field and in transit by gray mold (*Botrytis spp.*). Niederhauser (3) demonstrated that the disease can be controlled in commercial greenhouses by dusting with Tersan.

It is possible that practical control could be obtained with this fungicide under local field conditions.

Secondary Results

Many organisms which cause vegetable rots after harvest enter through wounds, such as insect holes and punctures or growth cracks, or through lesions caused by other organisms. Bacterial soft rot (*Bacillus carotovorus*) is such a case. According to Wiant and Bratley (5), 36 per cent of all vegetable decay in rail shipments to New York City 1935-42 was caused by this disease. Bacterial soft rot can be minimized by proper use of insecticides in the field to keep insect damage to a minimum, carrying out a fungicide schedule to control other diseases and careful handling of the produce from harvest through packing.

Anthracnose infections (*Colletotrichum lagenarium*) on watermelon, cantaloupe and cucumber fruits are frequently followed by secondary decays in transit and storage (4). Several investigators have shown that anthracnose can be successfully controlled on these crops by spraying or dusting in the field with fungicides such as Copper-A, Zerlate or Fermate.

Chupp (1) reports that Mycosphaerella rot (*Mycosphaerella citrullina*) and other fungi follow anthracnose infections of squash. He cites the case of one New York State grower who, in 1947, lost 500 tons out of a 700-ton crop of blue hubbard squash from anthracnose followed by Mycosphaerella. In the 1948 season he sprayed carefully with one of the zinc carbamates and suffered almost no loss, even though the season was very favorable for the disease.

Early blight (*Cercosporapii*) and late blight (*Septoria apii*) of celery permit the entry of *Sclerotinia sclerotiorum* (watery soft rot) in transit and storage. Early and late blights of celery are effectively controlled in the field by spraying with Copper-A or Zerlate.

PHYSICAL FACTORS AFFECTING VEGETABLE LOSSES

A discussion of field practices affecting vegetable decay would not be complete without a few comments on the subject of growing and handling the crop. Greater attention should be given to adequate rotation of crops and disposal of crop debris so as to reduce sources of disease inoculum. The method of planting the crop should be considered with respect to proper spacing, providing for adequate air circulation around the plants to permit rapid evaporation of dew and rain from the foliage and fruit, facilitating uniform coverage with insecticides and fungicides, and keeping the fruit from contact with the soil (viz. by staking tomatoes). Whenever possible crops such as tomatoes, celery, beets, cabbage, eggplants and peppers should be cultivated and harvested when the foliage and fruit are dry to minimize the spreading of disease organisms. Also, the produce should be carefully handled from the time of harvesting until it is packed for shipment to prevent mechanical injuries.

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Transit Losses on Citrus Fruits and Vegetables

By
B. G. Slay, *Agent*
Western Weighing & Inspection Bureau, Harlingen, Texas
In charge of Fruit & Vegetable Inspection

Until recently we have concentrated on the type of transit loss that develops due to broken containers, such as bruising or secondary decay.

When we first began to work on this type of loss, we were very much in the same place we are today with the type of loss that develops due to some inherent defect of the fruit; or some decay that develops secondary to some improper handling in transit; not necessarily from packing shed to receiver but from producer to consumer.

Our efforts in reducing breakage of containers have been rewarded as we have reduced this damage on an average of something like 50% since this was undertaken a few years ago. We do not claim that this is a success but we know we're on the right track; when some shippers have an average breakage of less than $1.00 per car while others average up to $127.00 per car. We are continuing to work with shippers toward better loading, better container construction, and – in a way, with the container manufacturers, toward the manufacture of containers from timber suitable for this purpose and ones that meet the standard specifications. When we suceed in this, no longer will we be reminded when we see a train with 100 cars of Texas grapefruit that on an average 19 of those cars will have 22 broken boxes per car or a like size train of tomatoes will have an average of 36 cars containing 43 broken lugs.

About a year ago, some of the agricultural colleges inaugurated educational short courses that are designed to teach growers, shippers, transportation employees and receivers the best known methods of handling these commodities and the importance of proper handling and the importance of proper shipping varieties to growers.

We have a number of varieties of tomatoes that are resistant to the many fungi decays, yet our growers continue to plant varieties that are susceptible to these diseases. We have a number of varieties of this vegetable that are known for their carrying qualities, yet we continue to plant varieties that we bred for canning plant stock, varieties that are mature green today, pink tomorrow and soft ripe the next day.

This is the type of loss we are considering today, this along with the breakage that causes bruised fruit which soon develops a secondary decay. During 1947 the American railroads paid a total of $11,420,756.00 for this wanton waste on citrus fruits and vegetables. During the same period, the Texas tomato growers realized $13,463,100.00 for their crop. Just about enough to pay the national loss on these commodities. The carriers only paid claims on those cars where there was some irregular

handling, such as breakage or a delay that was alleged to have caused decay. These figures do not include any of the loss to those many cars that arrive on schedule time with decay in excessive amounts. They do not include any of the loss experienced by receivers or retailers. There is no record of the total of such loss but I believe it is best reflected in the 60 to 80% mark up over the purchase price that retailers say they must have to make a legitimate profit. I believe that this mark up gives a better picture of what these losses amount to, than any other record. Such losses are passed on to the consumer and often result in prices he can not afford to pay.

Since the transit of these commodities starts on our farms it is here we should begin our prevention program. Growers should plant only certified seed of a variety known for its shipping qualities and not for canning plant production, a variety that is also best suited for this particular section. Only the mature fruit should be harvested, and careful handling from farm to packing shed should be practiced at all times. The fruit is better protected after packing than at any time during the handling and most of the bruising is usually from farm to packing shed. An invisible bruise on the farm can lead to the decay of not only the bruised fruit but several adjacent ones in transit or storage.

We should not attempt to establish this loss with any one group of the people that are engaged in handling these vital commodities. The shippers are at fault in some places, the railroads in others and the growers come in for their part. The receivers and retailers are guilty in some instances, and, even the consumer is not without guilt. It's a national loss and it must be attacked from a national angle and not a sectional or industry one. Surely we cannot ignore an economic loss equal to the Texas tomato crop.

U. S. HORTICULTURAL FIELD LABORATORY

The U. S. Horticultural Field Laboratory was established at Harlingen, Texas several years ago by the U. S. Department of Agriculture for the purpose of conducting studies pertaining to the maturity, handling, packaging, storage, and transportation of the fresh fruits and vegetables produced in this general area.

The laboratory is located at the Harlingen All-Valley Airport and is equipped with constant temperature chambers, ripening room, pathology laboratory, chemical laboratory, and office space for personnel. Work is currently progressing on the cold storage of oranges and grapefruit, control of post-harvest decay in citrus fruits and vegetables, equipment and methods for transporting fruits and vegetables to market, and the packaging of citrus fruits and vegetables. Other problems will be studied as need arises and as facilities and personnel are available.

PRODUCING DISEASE-FREE VEGETABLE PLANTS

by

P. A. Young and G. H. Godfrey

Dr. P. A. Young obtained his Ph. D. in Plant Pathology in 1925 at the University of Illinois. He did research in Plant Pathology at Montana State College from 1925-35. Since 1936 he has been in charge of the Tomato Diseases Laboratory at Jacksonville, Texas performing outstanding work on tomato diseases.

Dr. G. H. Godfrey obtained his Ph. D. in Plant Pathology at the University of Wisconsin in 1923. He has done Plant Pathology work for Oregon State College, U. S. D. A., the Bayer Co., Hawaiian Pineapple Canners and California. He has been Plant Pathologist at the Lower Rio Grande Valley Experiment Station of Texas at Weslaco since 1937. He has done work on nematode diseases of plants, seed and soil disinfectants, and vegetable, cotton and citrus Pathology.

The production of disease-free vegetable plants in the seedbed is a matter of primary importance to Lower Rio Grande Valley farmers. It is important to him for his own field plantings. In addition, it is important to the building up of a good reputation for the Valley as a source of supply of reliable plants for which there is potentially a considerable demand in east Texas and other points farther north. A grower would not knowingly set inferior plants in his own fields. It would handicap him from the start. His growing costs would be just as high and probably higher than with first quality plants, and crop returns would be substantially less. Exactly the same damage is done to the buyer of inferior plants for setting in other localities. While tomato is the major plant concerned, there is also interest in onions, cabbage and other crucifers, peppers, eggplant, and sweet potatoes. This paper deals primarily with the steps necessary in the production of sound, reliable plants for shipment.

Tomatoes

Tomato plants, if properly grown, dug, and packed, ship better than some other plants. An unfortunate ill-repute for Valley-grown tomato plants has developed as a result of improper management in one or other of these respects. Brief case histories of certain shipments of plants might emphasize the reasons for this ill-repute and point the way toward overcoming it.

Truckers have, in the last several years, independently and without supervision of any kind, bought plants from Valley growers, hauled them to the Yoakum and east Texas tomato areas, and sold them at a good profit.

Many of the plants were dug with inadequate root systems, were carelessly packed, and arrived at their destination with dry dead roots. Only about half the plants have survived in the field in most years, even though aided by rainy weather following planting. In the spring

of 1948 the market for plants was especially good because of failures in the local hotbeds and cold frames. That season, which was dry, about 90 per cent of the plants died in the cold frames and fields. Extensive losses were incurred by the growers.

Another example is the extremely serious loss in the east Texas tomato area brought about in the spring of 1945 by bringing in Valley-grown tomato plants infected by late blight. Late blight, usually rare in the Valley on tomatoes, occurred scatteringly in 1944, and destructively in 1945. An early season change in weather to dry conditions, howevre, checked the disease in the Valley, and most fields produced good crops. A few truck loads of plants, some of which carried infected plants were hauled to east Texas and became widely distributed. The disease got started in that section, with favorable weather there, and became destructive.

One more example will suffice. In this case, some hundreds of thousands of tomato plants were being grown under contract for shipment by air freight to New Jersey, where they were to be planted for the canning industry. One shipment, made without adequate inspection in the growing field, was condemned and destroyed in its entirety at destination, because most of the plants were infected with collar rot. The losses, of course, were great. They included the cost of the plants themselves, the transportation costs, and the potential yield that might have been made had the plants been healthy.

All these examples cited were preventible. In the consideration of the problem of production of disease-free tomato plants for shipment, several diseases must be watched for and controlled if any of them are found.

Late blight: This disease, though as stated, not usually occurring in the Valley, is potentially the most destructive. It is manifest by tender, brown to black water-soaked areas on the leaves, leaf stems, and plant stems, accompanied by a silvery-gray mildew. Affected spots will more than double in size over night. Stems are made brittle, and frequently the whole plant will fall to the ground. The disease is caused by a specialized strain of the same fungus that causes late blight in potatoes, and is apt to occur only in a cool moist spring.

Early blight: The disease is distinguished by brown to black spots on leaves and stems ranging from ⅛ to ½ inch wide. Older spots usually show slightly raised circular rings. The spots may girdle leaf bases or side branches, causing the entire leaf or branch to droop and die. Spread is rapid in warm humid weather with heavy dews at night, and under extreme conditions plants may become defoliated.

Collar rot: This is an extreme manifestation of early blight in which stems are affected near the ground line, resulting in partial or complete girdling. Many plants die in the field. Partially affected plants will show, after planting, continuation of the development of the stem lesion, resulting in death of the plant in the field; or at the very least, will initiate early blight in the planted field.

Gray Leaf Spot (*Stemphyllium*): This disease is characterized by rather small (⅛ to ½ inch) spots on the leaves, showing a grayish dead area in the center. It occurs in seedbeds, in the young rows in the field, and in planted fields. It causes dying and dropping of lower leaves; and infection spreads upward so that eventually even terminal leaves of large plants are affected. In the commercial field, the season of profitable fruit production is shortened and total yield reduced.

Bacterial spot: This bacterial disease, distinguished by very small brown to black spots in leaves, stems, and young fruits, is very destructive in fields in rainy seasons. It is a seed-borne disease, and is transmitted on the seed to the seedlings, by which it is spread to the field.

Septoria blight: Leaf spots usually ⅛ inch in diameter, with brown to black borders and tiny black spots in the centers, are the distinguishing characters. Fortunately this disease is rare in the Valley. It is one of the most destructive of the tomato disease in northern tomato producing areas.

Nematode root knot: The swellings or knots found frequently on tomato roots are caused by the root-knot nematode. If plants are affected in the seedbed, the nematodes in the roots will remain alive if the root remains alive. The nematodes will continue to develop to the egg-producing stage, which insures heavy soil infestation wherever the plants are set. Plants for shipment must be free from nematode root knot.

Mosaic: Tomato mosaic occurring in the seedbed is certain to be transmitted to the field. Plants infected when young are unproductive. They are also a source of infection for spread in the field. Serious occurrence of tomato mosaic in the field has been traced to introduced plants. Since many weeds are infected with the same virus that causes tomato mosaic, an important control measure would be the destruction of all weeds around seedbeds and fields from which plants are to be taken. Handling of suspected plants should be at a minimum, as the disease is transmitted by contact. Insect control is also important.

It is not the purpose of this paper to present too discouraging a picture as to the possibilities for producing healthy tomato plants. Often with ordinary good care an entire planting may be brought to the digging stage of growth without the appearance of any of the diseases mentioned. However, the finding of any one of these six tomato leaf diseases or of root knot or mosaic in the plant bed is sufficient to raise question as to the marketability of those plants in other sections. Rigorous inspections, and when necessary, preventive and control measures are called for, from the start.

Procedures recommended below, if judiciously observed, should except under extremely unfavorable conditions, insure the production of first quality disease-free plants. And there is, potentially, an increasing demand to be met at prices that would insure good profits to the grower of them, when it becomes generally known that really good plants are to be obtained. This might be called a 10 point program.

1. *Selection of field.*

A virgin field is best. If a previously cropped field must be used, previous crop history should be known. Any field known to have been infested with nematodes or wilt should be avoided unless special measures such as soil fumigation have been used at the right time. Even a virgin field does not guarantee freedom from disease, since some diseases are introduced on the seed.

2. *Seed treatment.*

The planting of treated seed should be much more general than it is, Some seedsmen sell treated seed only, and this is indicated on the seed package. When in doubt, a valuable extra precaution is to treat the seed with Yellow Cuprocide by mixing 2/5 ounce of the dust per pound of tomato seed and shaking them vigorously together for a few minutes in a tight can. The cost is only about 5 cents per pound. The treatment not only destroys much of the seed borne disease infection, but also protects the seed from rotting in cold wet soil.

3. *Selection of variety.*

The correct variety for out-of-the-Valley demand will probably be known in advance. East Texas wants Rutgers, Marglobe and Stokesdale. Other sections will of course specify what they want before placing a contract.

4. *Planting.*

Too thick planting increases the danger of foliage diseases. So does basin-planting, in which irrigation must be by flooding. Good air movement helps greatly in reducing leaf diseases. Plant about 25 seed per foot of row. There can be double rows on the bed (36 to 40 inch centers), or beds may be 18 to 20 inches apart with irrigation furrows between.

5. *Irrigation and Cultivation.*

Keep the plants growing by providing plenty of water and good weed control. Avoid flooding the plants, as flooding spreads disease; furthermore plants too long in saturated soil will drown and die. Avoid cultivating when the plants are wet, as this also spreads disease along the row.

6. *Insect control.*

The recommendations given are those of Dr. G. P. Wene, Entomologist of the L. R. G. Valley Experiment Station. Flea beetles and thrips are sometimes injurious at plant emergence. At the first indication of their presence use 5 percent DDT dust. Under Valley conditions, cabbage worms (principally loopers), tomato fruit worms, and army worms may appear at any time up to 8 inches in height of plants. The same 5 percent DDT dust is used. If garden flea hoppers should appear in the seedbed (of rare occurrence), use 1/10 percent pyrethrins from an impregnated pyrethrin dust, or 5 percent DDT.

1. *Disease Control.*

Most fungicides may be combined with the recommended insecticides for application at the time of the first indication of the presence of one of the foliage diseases. An early application (2-inch height) of a fungicide is advisable. It will check a primary center of infection that may not even be visible. Follow with one or more applications as needed until just before time for digging. Good safe fungicides are the various coppers such as Yellow Cuprocide, COCS, Copper-A, and the basic copper sulphates, and the new organic fungicides of which several are on the market. All have been shown to be effective in checking the spread of the tomato foliage diseases. Applications of any of the fungicides in particular must be thorough, covering the entire plant, top and bottom.

8. *Inspection.*

Inspection procedure should include aid in the selection of the field well in advance of planting, at least two inspections in the growing season, and one at digging time. If the plants are to receive State Certification, all inspections must be by a State Department of Agriculture Inspector. At digging and shipping time he should certify only first quality plants, i.e. sturdy disease-free plants from 5 to 7 inches in height, with good live roots.

9. *Digging.*

Plants of the right size should be dug or plowed out in such a way as to loosen the soil to a depth of at least 3 inches, in order to be able to get as much of the root system as possible and to shake out the adhering soil. The plants never should be pulled from hard soil, or bruised in handling.

10. *Packing.*

Tomato plants for shipment and sale should be packed to stand upright in bushel baskets or other containers with their roots on a layer of wet sphagnum moss 1 to 2 inches thick. The leaves should be kept dry. About 750 to 1000 tomato plants 6 inches tall can be packed in a single layer in a bushel basket without injury. A fair estimate of the number of plants should be written on the container. Tomato plants should never be shipped with dry roots, since it is well established from East Texas experience that most of such plants die soon after transplanting. It has been reported from the Yoakum area that, all planting conditions being equal and at the same time, locally grown transplants from the cold-frame, with better and more complete root systems, will get off to a faster start by several days than the best of the purchased plants brought in from the Valley. So it behooves the Valley growers to provide the "best possible."

SEEDBED DISEASE PROBLEMS OF OTHER VEGETABLE CROPS

Crucifers.

Cabbage, cauliflower, and broccoli plants can be sold from the Valley for transplanting elsewhere. Certain diseases often damage plants in the seedbed and in the field. Plants for sale should be free from disease.

Black rot of crucifers: This bacterial disease is characterized in severe cases by distortion of the plant, heavy leaf fall, and black discoloration within the stem and leaf ribs. Infection may arise in the seedbed in two different ways: by direct seed transmission, and by planting the seed in previously infested soil. Extensive secondary infection shown by leaf-margin yellowing and black leaf-blade veins may arise along the plant row from contact with soil or water that has become contaminated from earlier-infected plants. Cabbage worms also transmit the causal bacterium.

Seed treatment is the only remedy. Ordinary surface seed disinfectants do not penetrate sufficiently to kill the infection, which is within the seed coat. The most practical treatment for this section is bichloride of mercury at 1 to 1000 concentration in water (1 ounce to 7½ gallons). The seed is soaked in a loose bag for 20 minutes, then rinsed in water and spread to dry. It should be planted soon after it is dry on the surface. Either too long a soak or drying too greatly after rinsing often results in greatly reduced germination. Seed beds should be rotated, and should never be planted in a field in which black rot is known to have occurred the year before.

Downy Mildew (Peronospora parasitica)

Downy mildew is very common in cruciferous seedbeds of all kinds. It causes small specks that later develop to larger spots with silvery mildew on the lower surface. Many seedling leaves are killed, and if the tiny growing point is affected, the entire plant dies. The disease is controlled practically in the seedbed by dusting with a copper fungicide or one of the new organics. Rapidly growing plants usually outgrow downy mildew.

Black Leaf Spot (Alternaria brassicae)

This disease, manifest by rather large black spots with spores of the fungus developing on both leaf surfaces, while not very common in the seedbed, is one of the diseases that must be watched for in order to avoid carrying it to the field.

General recommendations for crucifers: All three of the crucifer diseases listed may under favorable conditions (several days of continuous rain or mist) become highly destructive in the field. Downy mildew infection may spread from the lower leaves to wrapper leaves, where the spots unite to form large unsightly dead areas. The same is true for black leaf spots. One particular case of the latter is remembered in which a potential 18-ton yield (judging by previous achievements in the same area) was reduced to 3 tons of low grade cabbage. Field control measures are costly and only partially effective. (Dusting with fungicides has reduced but not eliminated wrapper leaf infection.) All three diseases may become transportation problems. Wrapper leaf infections will continue to spread and kill leaf tissues, permitting the entrance of soft-rot bacteria. Control of these diseases in the seedbed by fungicidal dusting and discarding badly diseased plants at plant-digging time is recommended.

Onions

Onion plants for shipment to other producing areas are often obtained by thinning the plants at just the right stage, in a planted field. At the right stage the bulb is well formed, roots few in number but rudimentary roots ready to develop rapidly when transplanted. In one case under observation the well organized crew worked efficiently, leaving the field plants well spaced, packing the plants upright in open crates, and hauling them away without undue delay. It was said that the plants were well received in North Texas. At the time of collection the field was dry, leaf blight had not yet appeared, and thrips were uncommon. In another case, holding the plants in the boxes as long as a week or ten days appeared to kill out all thrips infestation. Onions will stand holding better than plants without bulbs.

Sweet Potatoes

State laws and inspection service already are functioning for the production of healthy slips of sweet potatoes. The rules for raising certified plants include:

(1) Inspection of the field in which the seed potatoes grew to determine freedom from Fusarium wilt.

(2) Treating the seed potatoes with mercuric chloride or Semesan Bel to control black rot.

(3) Avoiding the use of manure in the soil in which the tubers are bedded:

(4) Certification of the slips for freedom from black rot before sale.

(5) Only tubers at least 1½ inch in diameter should be bedded. The tubers should be nicked with a knife near one end for examination. Only tubers with yellow to orange-colored flesh should be bedded. Yellow-flesh tubers have better flavor than white-flesh tubers. Potato strings should not be bedded as they can produce only spindly slips of poorest quality. Bedded strings for slips causes degeneration of the seed stocks and poor yields in fields.

Other Crops

Shipping of plants of other crops is probably not extensive. Pepper, eggplant, and celery should be considered. All are very susceptible to nematode root knot. Pepper is subject to many of the diseases that occur on tomato, and the same procedures would be followed in their control. Eggplant yellows, a virus disease, is very common in the Valley. Even before it was discovered that it was a virus disease, it was found that repeated dusting with sulphur in the seedbed would prevent its occurrence. Celery is very subject in the Lower Rio Grande Valley, to a leaf-blighting disease known as early blight (cause *Cercospora apii*). Repeated and frequent applications of fungicides are necessary, once it

gets started. Freedom from the disease in the seedbeds is necessary with all these crops.

SUMMARY

The production of healthy vegetable crop seedbeds is important to the vegetable grower in the deep South from two angles. It is important to him for his own field plantings, since it is a first step in the production of a profitable field crop. It is important to the building up of a good reputation for his section as a source of supply of reliable plants, for which there is considerable demand for shipment to northern producing areas. Information is given on the nature of the pests and diseases apt to be encountered in the seedbeds of various crops and on methods of combatting them. Recommendations are made regarding the growing, digging and packing of plants for shipment to other areas.

Recommended Supplementary Reading

(1) Dunlap, A. A. and J. F. Rosborough. Plant Diseases in Texas and Their Control. A. and M. College of Texas, Extension Service Circular B-132.

(2) Godfrey, G. H. Effect of Summer Plowing on Root Knot. T. A. E. S. Progress Report No. 837. June 4, 1943.

(3) Godfrey, G. H. Striking Reduction of Nematode Infestation. Texas Farming and Citriculture Vol. 19 No .12. June, 1943.

(4) Godfrey, G. H. The Use of D-D for Soil Fumigation. Tex. Agr. Exper. Sta. Progress Rpt. No. 1062. Feb. 28, 1947.

(5) Godfrey, G. H. and P. A. Young. Soil Fumigation for Plant Disease Control. Tex. Agr. Exper. Sta. Bul. No. 628. April, 1943.

(6) Young, P. A. Tomato Diseases in Texas. Tex. Agr. Exper. Sta. Cir. No. 113. Nov. 1946.

(7) Young, P. A. Tomato Diseases. A. and M. College of Texas. Extension Service Cir. B-146. 1947.

(Most of these articles are obtainable by writing A. and M. College Extension Service, College Station, Texas, or by inquiring of your County Agricultural Agent.)

The First Survey of the Freeze Damage in 1949 and Recommendations For Care of Damaged Trees

A committee of technical personnel was appointed by the Rio Grande Valley Horticultural Club to make a valley-wide survey of the damage to citrus trees and fruits caused by the freeze of January 30th and 31st, 1949. Membership of this committee was confined to that of personnel from State and Federal Agencies. The purpose of this committee was, first; to determine the extent and type of injury to the trees in the various areas of the Valley, the relative amounts of damage to different varieties of citrus, and to varying ages of citrus trees, and if possible, to find the reasons for difference in damage in the various areas or groves. Second; to make recommendations to the grower regarding the best methods of caring for damaged trees. Third; to preserve a record of the weather conditions, the conditions of the trees, the type and extent of injury, and eventually, to record the results of treatments used on the trees.

This committee examined some 300 orchards, averaging about 40 acres each; 132 of these were surveyed in detail. The extent and damage to the fresh fruit on the trees, and the effect of the freeze on the fruit for processing are included in this report. See Figure I.

It was realized by this committee that at this early date, the full extent of the freeze damage could not be determined. Accordingly, this survey should be considered as preliminary in nature. It will be followed by one or more other surveys until the full extent of the freeze damage has been determined. It is planned that a second report on the freeze damage will be included in next year's Proceedings of the Rio Grande Valley Citrus and Vegetable Institute.

This survey was made Feb. 15 to 17, 1949. That part of the committee working on the trees made a rough survey of the Valley as a group on the first day, after that each committee member was assigned to a certain section of the Valley. Each member was given form sheets to complete. This form is shown in Figure II.

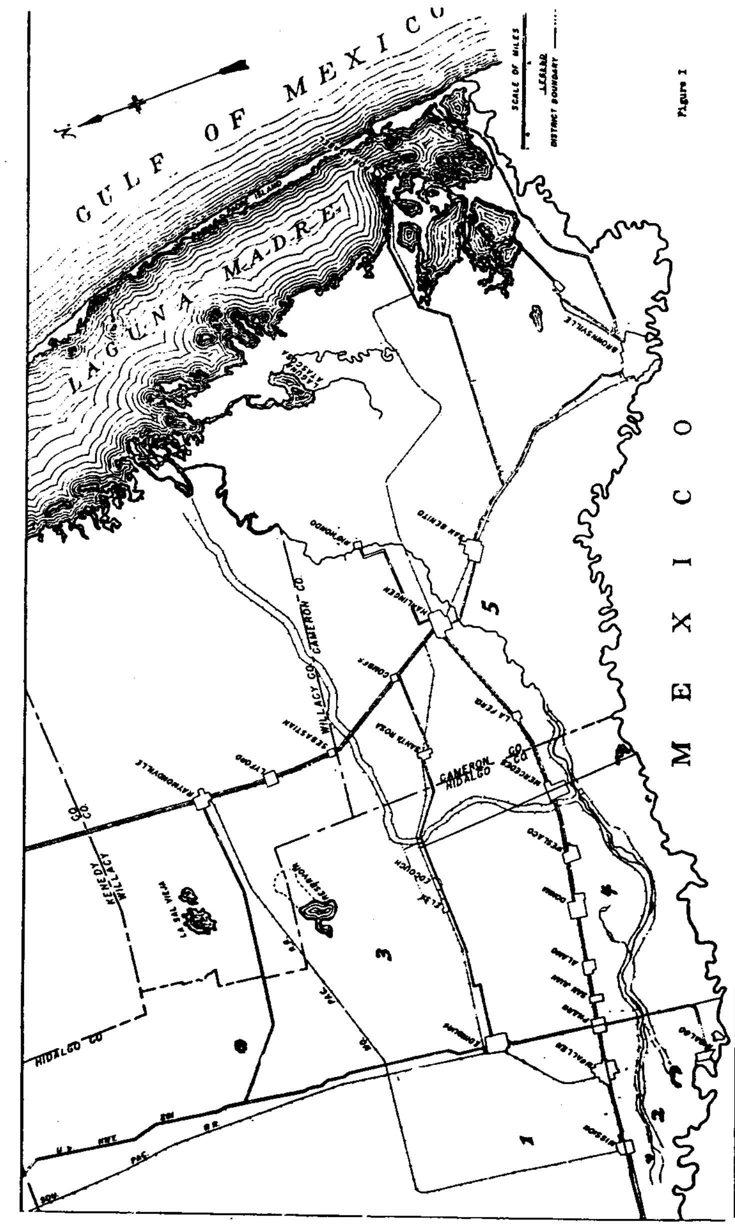

FIGURE 1

FREEZE DAMAGE SURVEY
IN
THE LOWER RIO GRANDE VALLEY

Date________________1949

Variety:
Age:
Owner:
Location:
No. of trees:
Banked: *Yes*_____ *No*_____
Soil type:
Special Conditions:
Trees inspected (*Tally*):
Flush started before freeze. (%)
Defoliation. (%)
Bark cracks. (Scale 0 *to* 5)
Trunk:
Framework:
Dead wood. (*Scale* 0 *to* 5)
Terminal:
Round:
½ inch:
1 *inch*:

Signature________________________

FIGURE 2

Weather Conditions During the Freeze

On Saturday afternoon, Jan. 29th, the temperature dropped rapidly. There was some sleet and rain which froze on the leaves and bark of trees and on the ground, accumulating as much as a half inch of ice in exposed places. Under the prevailing low temperatures, ice remained during Saturday night and Sunday. The sun came out for some two hours on Sunday afternoon raising the temperature and melting a part of the ice, especially on the south side of the trees. Sunday night was clear and still and the minimum temperature of the freeze was recorded as shown in Table I. The weather was overcast and cloudy all day Monday after 9:30 in the morning. The weather stayed wet with mists and light rain almost continuously until the following Tuesday, Feb. 8th. As long as the trees were wet and the leaves did not dry, the trees had a fairly green appearance and it was believed that the damage would not be very severe. The sun came out on Feb. 8th. This accompanied by a dry breeze caused leaves to fall very rapidly from the trees. From this time on the indications of damage continued to mount.

Injury to Young Trees

Young trees which had been balled and were being held ready for planting, and those which had been set out in the field but had not yet started to grow, were not injured whether they were banked or not, except that they were defoliated. This is shown in Table II.

TABLE I

TEMPERATURES AT FRUIT-FROST STATIONS IN THE LOWER RIO GRANDE VALLEY DURING THE FREEZE OF JANUARY, 1949

		Brownsville	San Benito	Harlingen	Edinburg	Raymondville	Mission Dr. Beatty 10 Mi. N. Mission	Falfurrias	Rio Grande City	Pharr	Weslaco Exp. Sta.	Goodwin Tract	Baker-Potts Nursery	Pride of Texas 12 Mi. N. W. Mission
Jan 29	8:00 a.m.	37	34	34	34	33	35	32	36	36	34	34	33	34
	10:00 a.m.	34	32	34	33	30	34	32	35	35	34	34	33	34
	Noon	33	32	34	32	32	32	32	34	34	32	32	33	32
	2:00 p.m.	32	31	31	30	29	31	32	36	30	30	33	30	32
	4:00 p.m.	30	28	31	32	29	32	33	34	32	29	33	30	33
	6:00 p.m.	29	29	32	31	29	31	32	33	32	30	32	30	32
	8:00 p.m.	30	29	31	31	28	31	31	32	31	29	31	30	31
	10:00 p.m.	30	29	31	30	28	30	29	31	31	29	30	29	31
	Midnight	29	28	30	29	28	28	29	30	30	28	29	29	29
Jan. 30	2:00 a.m.	28	28	30	28	27	27	28	29	29	28	28	28	28
	4:00 a.m.	27	27	30	26	26	26	28	28	28	27	27	27	27
	6:00 a.m.	28	27	29	26	25	26	27	27	27	26	27	26	26
	8:00 a.m.	26	25	28	27	26	26	26	26	28	26	26	26	27
	10:00 a.m.	26	26	28	26	25	25	29	28	27	26	27	26	25
	Noon	27	25	29	28	26	26	33	31	28	27	30	27	26
	2:00 p.m.	28	27	30	31	28	32	36	40	30	28	33	28	31
	4:00 p.m.	30	28	32	35	32	38	38	38	34	32	38	32	35
	6:00 p.m.	31	32	32	35	33	35	34	33	37	34	32	31	38
	8:00 p.m.	29	28	28	29	28	28	30	25	30	26	25	27	29
	10:00 p.m.	27	27	27	27	26	25	26	24	27	26	24	27	25
	Midnight	26	26	27	25	23	23	24	23	26	27	23	26	24
Jan. 31	1:00 a.m.	26	25	26	24	24	23	23	22	24	25	23	25	24
	2:00 a.m.	25	24	25	23	24	22	22	22	25	24	21	24	23
	3:00 a.m.	23	23	23	22	24	22	21	20	26	22	21	22	23
	4:00 a.m.	24	22	23	21	23	20	23	20	25	22	21	22	22
	5:00 a.m.	24	22	22	21	22	20	24	19	22	21	20	21	21
	6:00 a.m.	24	22	23	20	20	20	22	18	20	20	20	22	21
	7:00 a.m.	25	23	24	20	20	20	21	18	20	20	23	22	22
	8:00 a.m.	26	23	28	22	27	25	20	26	23	20	28	26	25
	9:00 a.m.	28	25	33	30	32	31	35	33	29	25	33	34	31
	10:00 a.m.	34	32	38	34	41	37	40	37	36	32	38	38	37

Courtesy of Brownsville Weather Bureau

TABLE II

FREEZE DAMAGE ON TREES UNDER 1 YEAR OLD

Variety	Age Years	Acreage	Banked or not	%Leaves Killed	Dead Wood Terminal	Dead Wood Round	Dead Wood ½"	Dead Wood 1"	Splits Framework	Splits Trunk
DORMANT TREES										
Red Gft. on Sour Red Gft. on Cleo Val. Or. on Sour Val. Or. on Cleo	1/2	500 trees	N	100	0	0	0	0	0	0
Valencia Or.	1/12	18	N	100	0	0	0	0	0	0
Valencia Or.	1/12		N	100	0	0	0	0	0	0
GROWING TREES										
Valencia Or.	1/3	14	B	100	5	5	5	5	5	0
Red Gft.	1/3	5	B	100	5	5	5	5	5	0
Valencia Or.	1/3	5	B	100	5	5	5	5	5	0

Degree of damage
0 — no injury
1 —
2 —
3 —
4 —
5 — very severe

Injury to Trees 1 to 4 Years

For the most part, trees one to four years old in all areas were in an active state of growth. There were a few exceptions, notably in the Delta Lake section. All of these trees in active growth were badly injured. Practically all of the one and two year old trees were killed to the bud union, and sometimes to the ground. These which were in active growth, the bark of the trunk and framework was split badly. Although mold was present under the loose and split bark, in many cases the bark was found to be alive and healing rapidly. Most of these trees were quite badly injured and many were killed above the crotch. No banked trees were found which were injured more than a few inches under the soil. The data collected on trees 1 to 4 years old are shown in Table III.

Injury to Trees 5 to 10 Years

Approximately 80% of the trees from five to ten years old were in active state of growth at the time of the freeze. The branches smaller than one inch in diameter were largely killed, had dead leaves clinging to them, (Figure III) and many splits occurred in the bark of the trunk and framework of these trees (Figure IV). The 20% of these trees not in active growth, were defoliated in varying degrees and other injury was limited to a few small twigs. These factors were apparent from general observation as well as from the data shown in Table IV.

Injury to Trees Over 10 Years

In most areas those trees over ten years of age were either dormant or just starting to grow in the tops and damage to those trees was directly in proportion to the amount of new growth. Mature trees with no new growth, showed little injury except defoliation in varying degrees, and slight damage to the terminal growth. Where trees had only a small amount of new growth, they showed damage to the terminal twigs, but had little other damage. The data collected on this age group are given in Table V.

In some areas the trees in general were growing more actively than in other areas. In the Progreso and Raymondville areas, groves were generally in a state of active growth, and therefore, suffered more damage than in some other sections. Mature groves in an actively growing condition, were often damaged to the extent of being killed back to branches one inch in diameter. The mature groves in the Delta Lake area had a high degree of dormancy, and therefore, showed less damage than trees in most areas. Other areas, particularly the Mission area, had some groves in active growth (see Figure V) while others were dormant; thus there are groves with varying degrees of damage.

TABLE III FREEZE DAMAGE ON TREES 1 TO 4 YEARS OLD

Variety	Age Years	Acreage	Banked or Not	Percent Leaves Killed	Dead Wood: Terminal	Dead Wood: Round	Dead Wood: ½"	Dead Wood: 1"	Splits: Framework	Splits: Trunk
DORMANT TREES										
Marrs Or.	4	20	N	100	1	0	0	0	0	0
Marrs Or.	3½	30	N	100	0	0	0	0	0	0
Red Gft.	2	35	N	100	0	0	0	0	0	0
Red Gft.	3½	40	N	95	0	0	0	0	0	0
GROWING TREES										
Red Gft.	2½	5	B	100	5	5	5	3	3	0
Valencia Or.	2½	5	B	100	5	5	5	3	3	0
Red Gft.	3	100	B	100	5	5	5	5	5	0
Red Gft.	2	11	N	100	5	5	4	4	4	2
Valencia Or.	2	11	N	100	5	5	4	4	4	2
Hamlin Or.	4	3	N	95	3	2	2	2	2	2
Valencia Or.	4	3	N	95	3	2	2	2	2	2
Rel Gft.	4	3	N	95	3	2	2	2	2	2
Valencia Or.	3	5	N	100	5	5	5	5	5	5
Orange	1	2	B	100		Dead to Bank				
Orange	1	10	B	90	3	2	2	-	3	1
Valencia Or.	4	-	B	100	5	5	3	2	2	1
Meyer Lem.	4	1/3	B	100	5	5	5	3	5	3
Valencia Or.	3	-	B	100	5	5	5	3	3	3
Red Gft.	3	1	B	100	5	5	5	5	5	2
Red Gft.	4	20	B	100	5	5	5	3	5	4
Red Gft.	2	30	B			Killed to Bank				
Marrs Or.	3½	15	N	100	5	5	3	0	2	2
Red Gft.	2	18	B	100		Killed to Bank				
Red Gft.	3	20	B	100		Killed to Bank				
Valencia Or.	1	18	B	100		Killed to Bank				
Val Or. on Cleo	2	5	B	100	5	5	5	5	3	0
Val. Or. on Sour	2	5	B	100	5	5	5	5	3	0
Red Gft.	2	-	B	100		Killed to Bank				
Valencia Or.	1	10	B	100		Killed to Bank				
Red Gft.	4	80	N	100	5	3	2	0	3	1
Orange	1	40	N	100		Dead to ground				
Orange	3	10	N	100	3	3	1	0	3	4
Valencia Or.	4	40	N	100	5	5	4	3	4	3
Red Gft.	4	25	N	100	3	3	2	1	4	2
Red Gft.	2	30	B	100		Dead to Bank				
Red Gft.	2	15	B	100		Dead to Bank				
Red Gft.	2	40	B	100		Dead to Bank				
Red Gft.	1	20	B	100		Dead to Bank				
Red Gft	2	20	B	100	5	5	3	3	4	4
Red Gft.	3	15	N	100	5	5	5	5	5	5
Red Gft.	4	80	N	100	5	5	5	5	5	5
Red Gft.	1	20	N	100		Dead to ground				
Red Gft.	2	80	N	100		Dead to ground				
Red Gft.	2	-	B	100		Killed to Bank				
Red Gft.	1	20	B	100		Killed to Bank				
Red Gft.	1	-	B	100		Killed to Bank				

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TABLE IV FREEZE DAMAGE ON TREES 5 TO 10 YEARS OLD

Variety	Years Age	Acreage	Banked or Not	% Leaves Killed	Dead Wood: Terminal	Dead Wood: Round	Dead Wood: ½"	Dead Wood: 1"	Splits: Framework	Splits: Trunk
DORMANT TREES										
Red Gft.	7	5	N	80	1	0	0	0	0	0
Valencia Or.	7	5	N	80	1	0	0	0	0	0
Foster Gft.	8	10	N	85	2	0	0	0	0	0
Orange	5	2	N	100	1	0	0	0	0	0
Red Gft.	7	5	N	100	2	1	0	0	0	0
Orange	6	10	N	95	0	0	0	0	0	0
Orange	6	30	N	100	2	1	0	0	2	0
GROWING TREES										
Red Gft.	6	80	N	100	5	5	4	4	5	3
Red Gft.	6	100	N	100	5	5	5	5	5	5
Hamlin Or.	6	4	N	100	1	1	1	1	4	1
Marsh Pink Gft.	6	4	N	100	1	1	1	1	4	1
Hamlin Or.	8	4	N	100	5	5	5	5	5	0
Valencia	8	4	N	100	5	5	5	5	5	0
Temple Or.	6	1	N	100	5	5	5	5	5	2
Valencia Or.	5	5	N	100	5	5	5	3	4	0
Red Gft.	6	-	N	100	4	4	3	2	5	1
Valencia Or.	6	20	N	100	4	0	0	0	0	0
Red Gft.	7	10	N	100	5	5	5	2	3	0
Val. & Hamlin Or.	6	50	N	100	3	3	2	2	3	0
Red Gft.	5	4	N	100	5	5	5	5	3	5
Temple Or.	8	20	N	100	5	5	3	1	3	0
Valencia Or.	8	20	N	100	5	5	3	1	3	0
Red Gft.	8	40	N	100	4	3	0	0	2	0
Red Gft.	5	20	N	100	5	5	4	3	3	1
Valencia Or.	5	20	N	100	5	5	3	1	3	2
Red Gft.	5	10	N	100	2	0	0	0	5	1
Red Gft.	5	5	N	100	5	5	5	4	5	5
Red Gft.	7	40	N	100	2	1	0	0	3	0
Marsh Pink Gft.	7	-	N	100	4	3	1	0	3	0
Orange	6	30	N	100	2	1	0	0	2	0
Red Gft.	6	20	N	100	5	5	4	3	5	3

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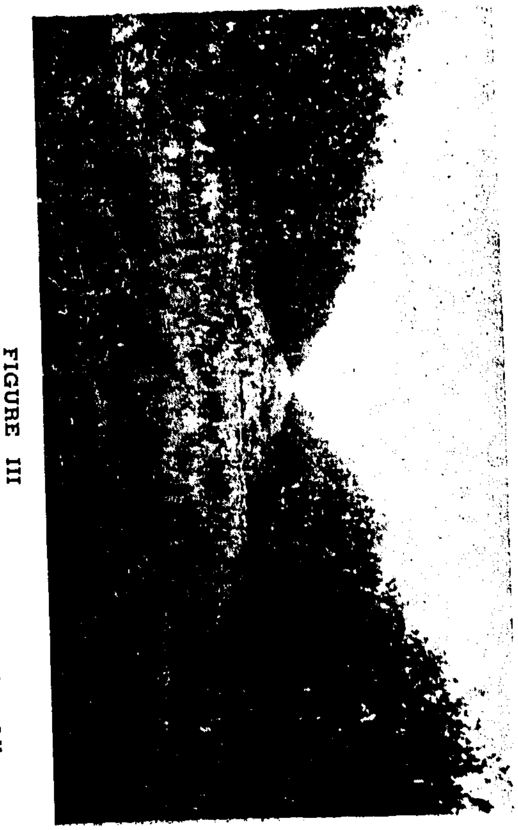

FIGURE III
A 40 acre grove of six year old Ruby grapefruit at Mission. All leaves were killed, but had dead leaves clinging to branches and gives the appearance of normal trees in black and white print. All limbs smaller than two inches in diameter were killed and many splits occurred in bark of trunk and framework limbs. Picture taken February 17, 1949.

FIGURE IV
Splits occuring in trunk and framework limbs of trees shown in Figure III. Picture taken February 17, 1949.

TABLE V FREEZE DAMAGE ON TREES OVER 10 YEARS OLD

Variety	Age Years	Acreage	Banked or Not	% Leaves Killed	Dead Wood Terminal	Dead Wood Round	Dead Wood ½"	Dead Wood 1"	Splits Framework	Splits Trunk
DORMANT TREES			N							
White Gft.	20	20	N	60	0	0	0	0	0	0
White Gft.	12	20	N	90	2	0	0	0	0	0
Valencia Or.	15	5	N	90	1	1	0	0	0	0
Marsh Pink Gft.	17	5	N	35	1	1	0	0	0	0
Hamlin Or.	17	5	N	35	1	1	0	0	0	0
Marsh Gft.	17	10	N	35	1	1	0	0	0	0
Red Gft.	12	6	N	100	1	1	0	0	1	0
Marsh Pink Gft.	20	30	N	60	0	0	0	0	0	0
White Gft.	12	5	N	95	1	0	0	0	0	0
Dancy Tang.	15	2½	N	95	2	0	0	0	0	0
Marsh Pink Gft.	17	-	N	95	1	0	0	0	0	0
Valencia Or.	16	13	N	90	1	1	0	0	0	0
White Gft.	22	13	N	90	1	1	0	0	0	0
Marsh Pink Gft.	21	13	N	90	1	1	0	0	0	0
White Gft.	18	40	N	70	1	0	0	0	0	0
White Gft.	18	40	N	98	1	1	0	0	0	0
Marsh Pink Gft.	18	40	N	95	2	1	0	0	0	0
White Gft.	14	40	N	97	2	1	0	0	0	0
White Gft.	18	40	N	95	3	1	0	0	0	0
GROWING TREES										
Eureka Lem.	19	5	N	100	5	5	5	4	3	0
White Gft.	20	20	N	100	5	5	4	4	0	0
Eureka Lem.	15	1	N	100	5	5	2	2	2	0
Red Gft.	12	5	N	100	3	2	0	0	3	1
Meyer Lem., Red & Marsh Pk. Gft.	12	20	N	100	5	5	5	2	1	0
Temple Or., White & Foster Gft.	17	40	N	100	5	5	5	3	3	0
White Gft.	14	40	N	95	2	1	0	0	0	0
Duncan Gft.	15	40	N	100	5	5	3	1	0	0
White Gft.	20	10	N	98	4	3	1	0	0	0
White Gft.	20	40	N	100	5	5	3	0	0	0
White Gft.	20	5	N	95	2	1	0	0	0	0
White Gft.	20		N	100	5	4	3	0	0	0

In the Delta Lake area, the mature orchards (over 10 years of age) which were irrigated and fertilized regularly and were in a dormant condition, suffered the least damage. In those areas where water was scarce, and where the trees were allowed to become dry in summer, then received water in the fall, they were in an actively growing condition and were badly damaged by the freeze. On the other hand, many young groves (1 to 7 years of age) which had been kept in a dry condition, and which had not been fertilized to make them grow, were not injured as severely as those which were being forced.

This survey showed very little difference between varieties of oranges and grapefruit in their resistance to injury by the cold when groves of the same age and state of growth were compared. These observations were made principally on Hamlin, Valencia, Joppa and white and pink Marsh grapefruit and red grapefruit. Approximately 75% of the red grapefruit trees in the Valley were young trees in an active stage of growth and they were badly damaged. They did not appear to be hurt worse than many young Valencia orange trees of the same age and state of growth. Some adjacent plantings of young Valencias and red grapefruit showed more damage on Valencias than on the grapefruit. Others showed more on the red grapefruit than on the Valencia. The main factor involved appeared to be the extent of new growth and not the variety. Most white and pink Marsh groves are

FIGURE V

Fifteen year old white Marsh trees at Mission which were growing actively before the freeze. Dead leaves are shown clinging to dead twigs and branches. Picture taken February 17, 1949.

above 10 years of age and were dormant, thus showing less injury than young actively growing red grapefruit trees. In the few old red grapefruit groves in the Valley, the tree damage was not found to be more severe than that on comparable white or pink Marsh trees.

Temple oranges, limes and lemons were, in most instances, killed back to the larger limbs. They were, in practically all cases, growing actively.

Although it was clearly evident that the main factor affecting tree damage from this freeze was the state of growth, there was ample evidence that dormant old trees in poor condition, or low vigor from salt or boron excess, and from psorosis and gummosis, sustained more damage than dormant trees of comparable age and in good health. In many of the trees in low vigor, it was difficult to correctly ascertain the extent of damage caused by the freeze, as many of them were partially defoliated and had considerable dead wood before the freeze. Nevertheless, a careful inspection of normal and "salty" groves indicated more leaf and wood damage on salty than on healthy groves. Also, it was noted that although new shoots were appearing on sound wood of trees of both healthy and salty groves, it was slower in developing in the latter.

Effect of Rootstock

Rootstocks apparently have shown little effect on the susceptibility of the Valley trees to injury in this freeze. One and two year old red blush grapefruit on sour orange and Cleopatra mandarin rootstock in the Weslaco area and the Engelman Gardens area, were both frozen back to the banks. Also, in the citrus rootstock experiment at the Texas Experiment Station at Weslaco where red grapefruit was growing on 37 different rootstocks in a randomized 10 acre planting, all trees froze to the bank. The rootstock varieties included Rough lemon, Rangpur lime, Cleopatra mandarin, sour orange, Savage citrange and others. The trees were one year old and were growing vigorously.

An inspection of 23 nurseries of the Valley showed that 84% of the budded nursery trees were killed to the ground. Very few of these trees were banked. Wherever nursery trees were dormant and not growing, even though they were fully exposed, they were not damaged severely.

Fruit Injury Survey — Made During the Period
Feb. 16 to 25, 1949

A survey of fruit damage resulting from the low temperatures of Jan. 30-31 has indicated that the degree of fruit injury was fairly consistent with the severity of tree injury as judged by damage to leaves, twigs and wood. It seems probable that even where trees were subjected to comparable temperatures subsequent fruit deterioration is related to the amount of leaf and twig damage. Time did not permit sampling fruit from orchards showing all conditions of injury, but definite attempt was made to obtain samples from those orchards most severely affected, and those moderately affected. It is, therefore, felt that a fair cross section was sampled.

The data in Table VI show that some damage to the fruit was apparent in all lots sampled. Injury at the end cut was of varying degree from buckling of partition walls with a few ruptured cells and air spaces to complete drying and collapse of the flesh. At the transverse center cut, injury involved from one segment to all segments, but in lots from the least injured trees rarely more than 2 or 3 segments were affected. Fruit was scored as injured when distinct separations between segments were apparent, or when drying or cell breakdown was clearly visible with the segments. A considerable proportion of the fruit scored as injured would not be classed as showing "marked drying" as defined by the Federal Food and Drug Administration. As shown in Table VI, injury at ½" below the stem-end was visible in over 50 percent of the fruits cut in all but one lot. The exception was from trees which showed little leaf or twig injury. The percent of fruits showing injury at the center cut varied from 6 to 94 with the best fruit rather consistently from trees showing the least injury.

External rind injuries were not evident to a serious extent in any of the lots examined. Most lots of grapefruit showed some browned or pitted areas which were probably freeze injury. For the most part these were not serious enough to affect saleability but would involve a considerable hazard as entrance points for decay organisms.

Flavor of the fruit was in rather close relation to the degree of internal injury. Both oranges and grapefruit from trees which showed less than 90 percent leaf kill were of acceptable dessert quality at the time examined. Individual fruits showing severe drying or cell breakdown were usually of poor flavor.

Some relation was found between position of fruit on the trees and amount of injury. Valencia oranges from an orchard which was 60 percent defoliated, showed 66 percent of the fruits affected at ½" under the stem-end and 5 percent affected at the center when the fruits were harvested within 3 feet of the ground. Fruits picked at the 6 to 7 foot level showed 95 percent and 13 percent fruits injured at stem-end and center cut respectively, while those picked at 10 to 12 feet showed 100 percent and 30 percent injury at stem-end and center. Pink Marsh grapefruit picked within 4 feet of the ground showed 87 percent of the fruits injured at the stem-end and 47 percent injured at the center, while those picked at 12 to 14 feet from the ground showed 100 percent and 50 percent respectively, of injured fruits.

Several test cuttings, to determine whether size of the individual fruits was a factor in the degree of injury, have indicated that all sizes were affected about equally. Marsh Seedless grapefruit were selected from a single tree which was about 95 percent defoliated. The sizes checked were 126, 112, 96, 80, 70 and 64. No consistent difference in the amount or severity of injury was noted. Pink Marsh were likewise selected from a single tree and divided into sizes ranging from 126 to 54. In this variety somewhat less injury was found in the two largest sizes, but 70's and smaller showed a very uniform degree of injury. Val-

TABLE VI

SURVEY OF FRUIT INJURY FROM FREEZE OF JAN. 30-31, 1949

DATA RECORDED FEB. 16, 17, & 18 - EACH SAMPLE REPRESENTS AT LEAST 50 FRUITS FROM 5 TREES

Location	Variety	Age of Trees	Foliage Killed	Dead Leaves on or off	Twig Injury	External Rind Injury	Drying visible to severe 1		Firmness	Flavor
							½" stem-end Percent Affected	Center Cut Percent Affected		
Edcouch	Marsh S.	Over 10 Yrs.	% 75	off	Slight	Sl. - Mod.	78	48	F. firm	Fair to stale
Delta Lake	Marsh S.	Over 10 Yrs.	10	off	None	Slight	34	6	F. firm	Good
Engelman	Marsh S.	Over 10 Yrs.	100	few on	Severe	Sl. - Mod.	94	72	soft to f. firm	Mostly stale
Engelman	P. Marsh	Over 10 Yrs.	90	off	Slight	Slight	96	48	soft to f. firm	Fair to stale
Adams Gardens	P. Marsh	Over 10 Yrs.	60	off	Slight	Slight	94	28	F. firm	Good
N. W. Mission	P. Marsh	Over 10 Yrs.	95	off	Mod.	Slight	93	48	F. firm	Fair to good
Delta Lake	R. Blush	7 yrs.	60	off	None	Mod.	78	74	F. firm	Fair to good
Engelman	R. Blush	7 yrs.	100	Many on	Mod.-Severe	Mod.	94	62	Soft to f. firm	Poor to fair
Adams Gardens	R. Blush	8 yrs.	70	off	Slight	Slight	100	76	F. firm	Fair
N. W. Mission	R. Blush	10 yrs.	10	off	None	None	52	32	Firm	Good
N. W. Mission	R. Blush	8 yrs.	100	Mostly on	Severe	Slight	100	94	Soft to F. firm	Poor to fair
North Engelman	Valencia 2	Over 10 yrs.	100	Few on	Mod.	Slight	96	16	F. firm	Poor to fair
North Mission	Valencia 2	15 yrs.	60	off	Slight	None	84	11	Firm	Good
N. W. Mission	Valencia 2	10 yrs.	15	off	None	None	87	11	Firm	Good

1 Any degree of visible drying was scored whether 1 section or all sections were affected.
2 Hesperidin crystals were visible on segment membranes of all Valencias cut.

encia oranges in sizes 150, 176, 200, 216, 250, 288 and 324 all showed 100 percent of the fruits injured at a stem-end cut and varied from 15 to 40 percent injury at the center cut. No consistent difference was apparent between sizes.

Recorded evidence of past freeze experience in citrus growing areas indicates that drying and granulation of frozen fruit increases with the passage of time. Data in Table VII covering fruit from the same trees examined 18 days and 25 days after the freeze tend to confirm previous observations. Fruit from Red Blush trees, which were relatively little injured, showed 52 percent of the fruit affected at the stem-end and 32 percent affected at the center when cut 18 days after the freeze. After an additional week in the trees an examination showed that 58 percent of the fruit was visibly injured at the stem-end and 60 percent of the fruits affected at a transverse center cut.

Red Blush trees which were seriously injured by the freeze had shown 100 percent of the fruit injured at the end and 94 percent injured in the center on Feb. 18. One week later all fruit showed injury at both stem-end and center. Valencia oranges from trees that showed little evidence of freeze injury also deteriorated materially between Feb. 18 and Feb. 25. It seems reasonable to assume that such deterioration will continued at a rate at least partially governed by temperature, air movement, and atmospheric humidity.

In addition to the effects mentioned, the freeze apparently caused a distinct thickening of the rind in grapefruit. All grapefruit cut from Feb. 14 to Feb. 25 have shown an abnormally thick rind. Some measurements made on Marsh Seedless and Pink Marsh in the Bayview area, which is noted for the production of thin-skinned fruit, showed rind thicknesses varying from 3/8" to ½" on Feb. 23. Unfortunately no measurements had been made before the freeze, but such rind thickness is certainly not normal for fruit grown in that area.

The Effect of Freeze on Fruit For Processing

Fruit brought to canneries during the week of cold cloudy weather following the freeze was as satisfactory for processing as before the freeze. With the advent of warm, sunny weather beginning 8 days after the freeze, decay of fallen fruit set in rather rapidly. Efforts of harvesters to salvage as much fallen fruit as possible, led to a decline in juice quality from that date. This decline was evidenced by increase in naringen, decrease in acid, and loss of flavor. Yield was reduced to an average of 21 cases, No. 2 can, per ton, from 28 cases, No. 2 can, per ton.

By Feb. 14, two weeks after the freeze, fruit with severe rind injury had decayed sufficiently to permit selection of relatively uninjured fruit by unskilled laborers. Following this, the quality of fruit delivered to canneries began to improve.

By Feb. 16, the naringen content had decreased almost to normal,

TABLE VII

CHANGES IN FRUIT ON TREES AFTER FREEZE OF JANUARY 30-31, 1949

Location	Variety	Condition of Trees After Freeze	Fruit Injury — Drying and Granulation: Examined 2/18/49 — ½" under Stem-end % Affected	Examined 2/18/49 — Transverse Center Cut % Affected	Examined 2/25/49 — ½" under stem-end % Affected	Examined 2/25/49 — Transverse[1] Center Cut % Affected
N. W. Mission	R. Blush Grapefrt.	Slight leaf kill in tops. No twig injury.	52	32	58	60
N. W. Mission	R. Blush Grapefrt.	Total leaf kill, leaves clinging, severe wood injury.	100	94	100	100
N. W. Mission	Valencia Oranges	Slight leaf kill mostly in tops, no twig injury.	82	14	98	22

[1] Drying generally more extensive in individual fruits than that found at first examination.

acid had increased to a safe margin above the minimum required for Fancy grade and the flavor returned to the level of normal late April or May juice. Juice yields were variable, some canners receiving more than 23 cases per ton.

Apparent recoveries of juice based on cases per ton of fruit are misleading, as drying of stem-ends reduces the weight per fruit, and many more fruit are required to weigh a ton than formerly. It seems probable that rapid continued drying of fruit hanging unshaded on defoliated trees may conclude salvage operations by Feb. 25th.

All fruit examined Jan. 31st contained ice, and all fruit examined to Feb. 17, showed some degree of damage. Some canners believe some varieties suffered fruit damage more than others in the following order: red grapefruit, seeded grapefruit, pinks, Marsh white and Valencias. Such observations, however, were not supported by correlations of tree age, state of growth, and exposure.

Recommendations

After making the foregoing survey, the members of this committee unanimously agree that to the best of their knowledge, the following practices should be followed in caring for freeze injured trees.

1. It is too early yet to determine the full extent of damage in most cases, therefore, we urge the grower not to be in any hurry to remove loose bark from his trees. In many instances, callus tissue is growing back over these in ured places, (see Figure VI) and they will heal

FIGURE VI
Bark cut away from a split to show callus tissue beneath that was healing the wound. Picture taken, February 17, 1949.

better without being disturbed. Some grapefruit trees may become infected with Rio Grande Gummosis, but it is believed fewer trees will become infected if they are not disturbed for a while. It is suggested that no bark treatment be done until a further report from this committee is issued.

2. If the trees are small and were not banked and all bark is dead to the bud union, there is no chance of saving such trees and they might as well be pulled out and the field replanted or planted to some other crop. Trees which have the bark killed more than a third of the way around the trunk (see Figure VII) usually will not make satisfactory trees. The exact amount of dead bark cannot be determined at this time, but probably can be determined by the time pruning operations should begin. Figure VIII shows the trunk of a 4 year old grapefruit tree with many small splits. The bark has been scraped with a knife and was found to be alive and green. The committee believes splits such as these should be left alone for the time being and given a chance to heal.

3. If the trees were banked and are dead to the bank, the dirt should be taken down a few inches, exposing a couple of inches of live wood all around the trees so that new shoots can come out from the live wood above the ground. The bank should be completely removed as soon as danger of freezing is past.

FIGURE VII
The bark on the trunk of this 3 year old unbanked grapefruit tree had the bark killed two-thirds of the way around the trunk all the way down to the ground. Picture taken, February 17, 1949.

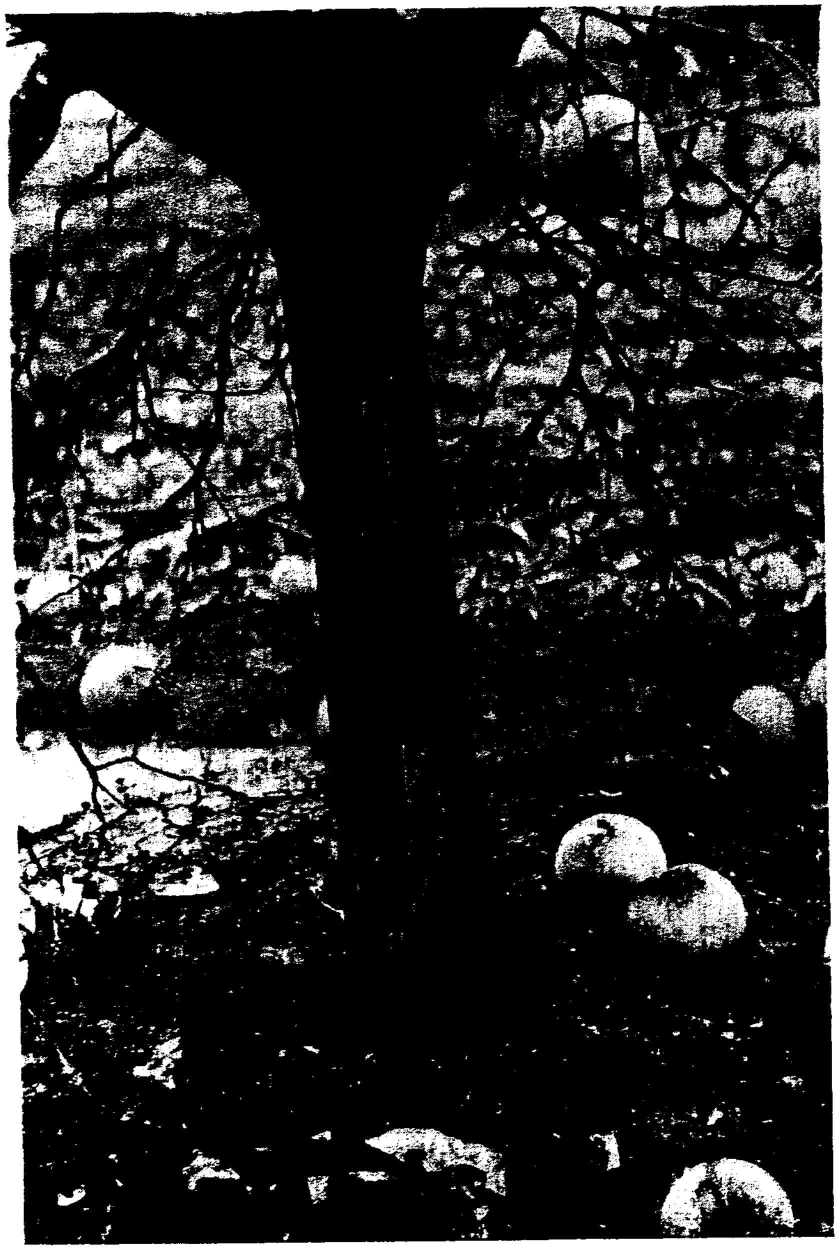

FIGURE VIII
The trunk of a 4 year old grapefruit tree showing many small splits in bark. The bark has been scraped with a knife and was found to be green and alive. Picture taken, February 16, 1949.

4. Pruning should not start until well after the new shoots have come out so that one can tell definitely what tissues have been killed and sufficient time has been allowed for those splits to heal that will heal over quickly.

5. Although the committee does not recommend a valley-wide spray program for injured trees, the danger of sunburn of the bark of defoliated trees may be minimized by spraying or painting trunks and larger limbs with whitewash or a high lime bordeaux mixture. There are molds growing in many bark cracks, but it is believed that not many of these molds are disease producing fungi and most of them will disappear when the wound heals or is treated at a later date.

6. It is believed that orchards should not be given abnormal quantities of fertilizer, water, or other treatments to stimulate them at this time. Let them come out of their trouble in a normal ordinary manner.

7. If young trees are frozen back so severely that the crotch or trunk is badly damaged, a good procedure to follow is to leave the tree until new shoots come out on the trunk above the bud union. Let all of the shoots grow until they are well hardened, then thin them out to about 5 well placed shoots. The trunk should then be removed with a sloping cut downward from the base of the uppermost shoot which we wish to become a part of the new tree. This cut should be made low enough so that it is in sound green wood and the wound should be thoroughly treated with a disinfectant and sealing compound. This type of cut, properly done and cared for, will heal over rapidly. The uppermost shoots can be trained as a central leader and then headed back at the proper height to form a new framework, or several shoots may be left to form a multiple headed tree.

8. This committee also wishes to again emphasize that when pruning operations begin, utmost care be exercised in the selection of materials for treating and disinfecting the wounds in injured trees. Many materials suggested for this purpose are not safe and cause considerable damage to trees. No materials containing caustic substances, oil, kerosene, creosote, tar, or more than 1½ to 2% of carbolic acid or phenol, should be used. The material commonly recommended is a mixture of 50% of carbolinium and 50% of asphalt (melting point 140 degrees or below). This mixture should contain from 1½ to 2% phenol or carbolic acid. In order to make a 1½ to 2% phenol content in the asphalt carbolinium paint, it may be necessary to add additional phenol. Added cuprous oxide, up to 1% of the total, prolongs the disinfectant qualities of the paint.

9. This committee advises against the importation of citrus nursery stock from other areas, because of the danger of introducing new diseases and insects. It is also recommended that the grower wait until fall to obtain any trees from the nursery, since by that time the amount of freeze damage on nursery stock should become apparent. While no registered psorosis free trees can be obtained for another two years,

trees for replanting should, in so far as possible, be obtained from reliable nurserymen who are trying to eliminate the psorosis disease from their nursery stock.

Summary

A valley-wide survey of the damage done by the freeze of Jan. 29-31, 1949, have been made. The results of this survey and descriptions of the damage done, as well as recommendations for treating the damaged trees, are given.

A study of the data assembled in this survey, as well as many other observations made during the survey, shows there was little difference in tree damage in the various sections of the Valley when the tree conditions were similar. It was clearly evident that wherever the trees had put out a flush of new growth, or were in an actively growing state, they were badly damaged.

The committee:

Dr. P. W. Rohrbaugh, Chairman
Mr. C. W. Waibel
Dr. W. C. Cooper
Dr. G. H. Godfrey
Mr. N. P. Maxwell
Mr. W. R. Cowley
Mr. J. A. Oswalt
Mr. W. H. Friend
Mr. A. L. Ryall
Mr. W. C. Scott

OPEN FORUM SESSION

One evening of the Institute was devoted to an "open forum" session. The authors of the papers presented at the Institute were seated on the platform to answer questions from the floor and to take part in any general discussion that might arise. The forum idea was a new one, initiated at this, the third Valley Citrus and Vegetable Institute, with a view to testing its possible value as a permanent feature on the Institute. Judging by the attendance and the response, its value would appear to have been well demonstrated. It appeared for awhile that the session would continue indefinitely!

Mr. C. R. Heaton and other visitors from the East Texas tomato area contributed much to the discussion on transit losses in vegetables, particularly tomatoes. The lower Rio Grande Valley as a source of supply of tomato seedlings for shipment to and transplanting in North and East Texas tomato producing sections received considerable discussion. It was emphasized that only strong disease-free plants with ample living root systems were wanted.

FIELD DAY

Lower Rio Grande Valley Experiment Station.

Field day activities were concentrated at the Valley Experiment Station, under the general leadership of W. R. Cowley. Every phase of the day's activities was carefully organized in order to handle a large crowd of visitors with a minimum of waste motion. Traffic and car parking were directed by Farm Foreman J. A. Holmes, with the assistance of Carrol Youngblood, Robert Schwab, Santiago Duran and Paul Smyth. Visitors as they came into the grounds were segregated into small groups (approximately 30) and assigned to group leaders Charles Beasley, Frank Brunneman, W. G. Godbey, Tommy Solether, Gene Goodwin, Leon Whitaker, and Robert Corns (in charge). Mr. Cowley gave detailed instructions regarding the sequence and locations of exhibits about the Station grounds, and the groups were lead at once to their individual starting points. About 15 minutes were alloted to each group for each exhibit or demonstration, each of which was in charge of a specialist or group of specialists, as indicated below.

Ornamental Plants, D. E. Kornegay, Baker Potts Nursery, Harlingen, Tex.

Insect Control Research, Dr. G. P. Wene, Valley Experiment Station, and Herman Mayeux, Associate County Agent, Entomology, (for Lower Rio Grande Valley).

Citrus Varieties, Dr. G. W. Adriance and Dr. H. T. Blackhurst, A and M College.

Vegetable Varieties, J. S. Morris and G. R. Williams, Valley Experiment Station, J. R. Padgett, Rio Farms, Monte Alto, and Dr. J. B. Corns, Edinburg Junior College.

Irrigation Equipment, Emil Stuter, U. S. Dept. of Agriculture, at Valley Experiment Station.

Farm Machinery, Morris Bloodworth, Valley Experiment Station.

Citrus Rootstocks, Dr. W. C. Cooper, U. S. Dept. of Agriculture, at Valley Experiment Station.

Citrus Tree Diseases, Dr. G. H. Godfrey, Valley Experiment Station, and Carl W. Waibel, State Department of Agriculture.

The fine cooperation on the part of Valley Farm Implement, Machinery, and Equipment dealers is worthy of especial note. One or more men were provided with every piece of machinery concerned. Firms and

equipment were:

Weslaco Implement Company, Weslaco, Tex., represented by Gordon A. Brown.
International Harvester Implements and Farm Equipment

Food Machinery and Chemical Corporation, McAllen, Tex., by Mr. Herb Chance.
John Bean Sprayers and Spraying Equipment

Woods Garage and Implement Co., Donna, Tex., by Mr. C. F. Woods.
J. I. Case Farm Implements

Boggus Tractor Company, McAllen, Tex., by Mr. N. W. Solether.
Ford Tractors and Dearborn Equipment

Boggus Tractor Company, Harlingen, Tex., by Mr. Jack Calhoun.
Ford Tractors and Dearborn Equipment

Alamo Tractor Company, Alamo, Tex., by Mr. Orson L. Hendrick.
Allis-Chalmers Farm Equipment

Mr. F. S. Schodts, 133 *East Highway, McAllen, Tex.*
Willys ("Jeep") Automotive Equipment and Buffalo Sprayers

Gustafson Manufacturing Co., Corpus Christi, Tex., by Mr. A. W. Gustafson.
Dusting and Spraying Equipment, *particularly Hi-Veloctiy Liquid Dust Applicator.*

Mr. Newton E. Wigle, 87 *West Main St., Kingsville, Ontario, Canada.*
Wigle Cultivating and Hoeing Attachments for cultivators

Hollon Tractor Company, Mercedes, Tex., by Mr. Clyde Hollon.
Ford Tractors and Dearborn Equipment

Holt Equipment Company, Weslaco, Tex., by Mr. Carl F. Schober.
Caterpillar Tractors, Stationary Engines and Sprinkler Irrigation Equipment

Mr. George B. Russell, 122 *East Cleveland, Harlingen, Tex.*
Spraying Equipment

Oaks Irrigation Equipment Company, Pharr, Tex., by Mr. John E. Oaks.
Sprinkler Irrigation Equipment - Pumps and Motors

Handley-Langston Implement Co., 1011 *Highway, McAllen, Tex.*
Ferguson Farm Equipment and Radiant Orchard Heaters

Elsa Implement Company, Elsa, Tex.
Graham-Hoeme Plows

Stewart Stevenson Services, 19 *East Highway, McAllen, Tex.*
General Motors Diesel Equipment and Sprinkler Irrigation Systems

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Following the noon barbecue at Weslaco City Park, the afternoon of Field Day was devoted to a general visitor period for further inspection of exhibits and informal discussion with leaders of the different lines of work at Texas Agricultural Experiment Station, Lower Rio Grande Valley Branch.

ACKNOWLEDGEMENTS

The members of the Rio Grande Horticultural Club gratefully acknowledge the contributions of the following organizations and individuals to the success of the Lower Rio Grande Valley Citrus and Vegetable Institute for 1948:

To staff members of A. and M. College of Texas for their important contributions to the program, and other loyal support;

To Texas A. and I. College of Kingsville for providing rooms for the meetings at their Valley Branch near Weslaco;

To the City of Weslaco for providing facilities for the noon barbecue;

To the Lower Rio Grande Valley Experiment Station for Field Day activities;

To the Committee chairmen and members listed below, who gave liberally of their time and effort.

Rio Grande Horticultural Club
D. J. McAlexander, Elsa, President,
W. C. Cooper, Weslaco, Vice president.
George Motz, Harlingen, Secretary-treasurer.

Institute Committees

Publicity:
J. B. Corns - Chairman
J. A. Oswalt
N. F. Schmitz
Stanley Crockett

Registration:
E. B. Dubuisson - Chairman
Ben Chambers
T. B. Wright, Jr.
D. E. Kornegay

Field Day:
Raymond Cowley - Chairman
W. C. Cooper
Morris Bloodworth
Robert T. Corns

Food:
Norman Maxwell - Chairman
W. T. Moon
Albert Hughes
J. A. Oswalt

Prooceedings:
W. G. Godbey - Chairman
George H. Godfrey - Editor
P. W. Rohrbaugh
Clifford Scott

Auditorium-Property:
W. H. Friend - Chairman
P. W. Rohrbaugh
D. E. Kornegay
Walter Bach

Banquet:
W. H. Hughes - Chairman
Jaime Morris
Stanley Crockett
Walter Baxter

Program:
A. L. Ryall - Chairman
Joe B. Corns
W. H. Friend
E. B. Dubuisson
W. C. Cooper

SESSION CHAIRMEN

General Session, Dec. 8.

Morning session, D. J. McAlexander, president Rio Grande Horticultural Club, Elsa, Tex.

Afternoon session, Floyd Lynch, District Agent, A. and M. College of Texas Extension Service.

Vegetable Sessions, December 9.

Morning session, Cleve Tandy, Port Fertilizer Company, Los Fresnos, Tex.

Afternoon session, Sam Tayloe, General Manager Rio Farms Inc., Elsa, Tex.

Evening session (open forum), J. B. Corns, Professor of Horticulture, Edinburg Junior College, Edinburg, Tex.

Citrus Sessions, December 9.

Morning session, Charles Rogers, Grower and Shipper.

Afternoon session, C. L. Skaggs, president First National Bank, Weslaco, Tex.

Field Day, Experiment Station.

W. R. Cowley, Acting Superintendent, Lower Rio Grande Valley Experiment Station.