PROCEEDINGS

of

THE SECOND ANNUAL

LOWER RIO GRANDE VALLEY

CITRUS AND VEGETABLE INSTITUTE

Weslaco, Texas — *[illegible] 18 to 20, [illegible]*

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Second Annual Meeting — Nov. 18 to 20, 1947

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CONTENTS

(Continued)

ADDRESS OF WELCOME

By

WILLIAM H. HUGHES, *President, Rio Grande Horticultural Club*

Ladies and gentlemen of the Citrus and Vegetable industries, in behalf of the Texas Extension Service and the Rio Grande Horticultural Club I welcome you to our second annual Rio Grande Valley Institute. We are pleased with this fine attendance of interested people and appreciate the effort you have made to come here.

You will note that vegetables have been added to this Institute because we feel that in a well-rounded Valley agricultural program, it should be included and there is much research work to be done along the lines of new varieties and types, salt tolerance, cultural practices, disease and insect control and marketing. Each year this industry has grown and the problems have multiplied. Therefore, may this Institute helpfully serve this industry.

The citrus industry lacks the glamour of a few years ago because of declining prices, new plantings and increased cost of production. Nevertheless we must tighten our belts and tackle our citrus problems with the utmost skill and determination. We hope that these discussions may be of great benefit to you.

In behalf of the Citrus and Vegetable Industry of the Rio Grande Valley, I welcome the distinguished speakers and visitors from California, Florida and other states. We trust that your visit will be most pleasant and one you will long remember.

The staff members of A & M College have greatly helped in planning this program and are taking an active part in it. They are continually working on our problems and have an expanded program which will be beneficial to every phase of our Valley agriculture.

Again, for the Texas A. and M. College Extension Service and the Rio Grande Horticultural Club, I welcome all in attendance here. Please take part in the discussions and help us to receive the greatest benefit possible.

A PROGRAM OF HORTICULTURE FOR THE LOWER RIO GRANDE VALLEY

By

A. W. ADRIANCE, *Department of Horticulture, Texas A. & M. College*

Horticulture, in itself, is a term of broad meaning. Derived from the Latin "hortus," it comprises gardens of all types, whether they be flowers, vegetables, or fruits. Since many of us refer to this area as the "Garden Spot of the World," anything having to do with horticulture should be peculiarly appropriate here in the Valley.

In this, as in any branch of applied science, the work may be clearly differentiated into the fields of research, extension, and resident teaching. All of these types of work proceed most satisfactorily when they are closely associated; if research provides new funds of information for the extension worker and the college teacher, so do these men in turn serve to keep the research worker more closely aware of the problems that are in need of attention.

Research has been defined as "critical and exhaustive investigation or experimentation, having for its aim the discovery of new facts and their correct interpretation, the revision of accepted conclusions, theories or laws, in the light of newly discovered facts, or the practical application of such new or revised conclusions." Such a definition provides ample latitude to include both "pure" and "applied" research, both of which have a definite place in the program of any agricultural experiment station. The transition from the laboratory to the orchard is a most logical procedure, in view of the rapid advances in our methods of management.

The Weslaco Station has been recognized as being primarily a horticultural station, with permanent personnel consisting of a superintendent whose training was in horticulture, a horticulturist, an entomologist, and a plant pathologist. The work of the two latter has been very closely associated with horticulture, due to the nature of the crops with which they were working. The United States Department of Agriculture has recently placed an experienced horticulturist at the Station, for work on citrus rootstocks, and it is hoped that other workers in related fields will also be assigned for duty here.

More recently, the urgent need for soil studies has led to the addition of a soil chemist to the local staff. The next specialist to be added, and for whom a search is now under way, is an agricultural engineer, to devote his attention to problems of irrigation drainage. Still another important type of work soon to receive attention is marketing. Under the Federal Research and Marketing Act, certain funds which have been made available are being used to employ one man to devote full time, at the present, to marketing of citrus fruits and tomatoes.

In addition to all of these men of specialized training, the present budget for the station will provide for several technical assistants,

who will be assigned to the different specialized fields of work. With the assistance of these men, it will be possible to undertake more outlying experiments, which can be conducted in the immediate area where the problem is most acute. It is hoped that this aspect of the station program may be expanded so as to provide a great amount of new information in a relatively short period.

Since the primary function of the Experiment Station system is to conduct experimental work and obtain information, it is obvious that the same system cannot undertake the program involving the carrying of this information to the people in the various agricultural enterprises. It is at this point that the Agricultural Extension Service comes into the picture. The County Agent, located in the county seat, is near at hand, in a position to supply the needed information at the proper time.

Under the arrangement which now prevails, the Extension Service has provided one full time horticulturist for the Valley area. He is located at the Experiment Station, along with the District Agents. In this way, the Extension Horticulturist has the opportunity to assemble the results of experimental work at the Valley station, coordinate it with general information from other stations, and make it available to the County Agents for dissemination in their respective areas. Each month, these agents meet at the Station with the Extension Horticulturist and the Station staff. Such a meeting serves a two-fold purpose: on the one hand, the Agents bring in problems from their respective areas, for the attention of the Station staff: and on the other hand, the Station staff supplies information, obtained from research work, to the agents.

This program could be considerably facilitated, as far as horticulture is concerned, if we had an Extension Specialist for citrus and another for vegetables, with an assistant County Agent for horticulture in each county.

There is always a feeling among the growers of the area that they can obtain more recent and more complete information by going directly to the Experiment Station. It is easy to see where such a procedure may lead when the Station Superintendent reports personal interviews with 117 people in one month, which contained approximately 200 working hours. The work of the Station personnel can be conducted much more efficiently if the information from the station is disseminated by the Extension agents as outlined.

After these two types of work are considered, there remains the problem of resident teaching. There is always a question in the minds of many people as to why horticulturists for work in the Valley should not be trained under Valley conditions. The answer is obvious to anyone who will take time to study the curriculum in a modern course in agriculture. The day is long since past when so-called "practical" courses suffice. First year courses include chemistry, mathematics and botany; second year courses bring more chemistry, physics, and other science courses, along with the ever-present English; advanced courses go into soils, plant physiology, entomology, plant diseases, irrigation and drainage, and background courses in the social sciences and in economics. Through the whole period, courses in horticulture and the other applied sciences, follow along in a logical sequence. The magnitude of the problem of organizing such a curriculum, and providing men and materials to handle it properly, makes it difficult to build up a comparable course for a small, isolated group of students.

In contrast to this under-graduate training, which must be centralized for reasons of efficiency, the training of graduates, or even advanced under-graduates, may be handled most satisfactorily on some of the outlying stations. It may be a source of interest to the people of this area, that the Weslaco Station has been chosen as the most desirable location for starting this third phase of the agricultural program. Even at the present time, three graduate students have projects under way at the Station, which will be used to satisfy the requirements for these of the degree of Master of Science. As the staff at the Station is increased, in both numbers and training, it is anticipated that men working toward the degree of Doctor of Philosophy (that includes horticultural philosopher!) will spend one or two years in residence on the Station, working on problems of a more advanced nature.

The horticultural possibilities of the Valley include the three major fields of production—fruits, vegetables, and ornamental horticulture. The fruit and vegetable industries are well established and show promise for profitable expansion. The growing of ornamentals and flowers normally cover somewhat later in the development of a section, but it is becoming apparent that there is opportunity for a most satisfactory and profitable expansion in this particular field.

It is equally true, however, that there are already many cultural problems, centering around soil and water management, with drainage standing out as a limiting factor in many entire areas. One fact is certain above all else, and that is, that there are more problems than all of us, working together, can solve as soon as we would like. Only by coordination of all available facilities can we look for the rapid progress that all of us desire so much.

THE HORTICULTURE EXTENSION SERVICE PROGRAM FOR THE VALLEY

By

FLOYD LYNCH, *District Agent of Texas A. & M. College Extension Service*

It is indeed an opportunity and a real pleasure that I be given this distinct honor of appearing on the program of your second annual Citrus and Vegetable Institute to discuss with you the Horticultural Extension Service Program for the Valley.

In recent months the headquarters for District 14 of the Texas Extension Service was moved from College Station to the Texas Agricultural Experiment Substation at Weslaco. Miss Beulah Blackwell

and I are District Agents for District 14, which is composed of 16 Counties in South Texas. District 14 includes the Lower Rio Grande Valley and its northern boundary is marked by San Patricio, McMullen, and Webb Counties. The two District Agents are the official administrative representatives of the Extension Service in their respective districts. Their job is to supervise the County Extension Agents who are the County Agricultural and Home Demonstration Agents and Assistants. The District Agents also make plans with the Specialist as to how they may assist the County Extension Agents in serving the people in the County.

Another member of the Texas Extension Service Staff recently located at the Substation at Weslaco is Spencer Apple, Extension Horticulturist. As a subject matter specialist, his specific job is to supply the County Extension Agents with all the available and up-to-date information in horticulture. The County Extension Agents derive their information from the results of research work conducted at the Weslaco Experiment Station as well as from other sections of the State, and even from out of state research work if applicable to this area. Other sources of information come from other federal, state and local organizations and agencies, and others engaged in agricultural activities and from proven methods of crop production that have been demonstrated by farmers or ranchers.

All subject matter specialists of the Extension Service work directly with the research staff of all informational sources in order to evaluate and interpret the work done in the light of its practical value to growers. The County Extension Agent's job then is to take these findings to the people as rapidly as possible through practical demonstrations. The Specialist's and the County Agent's duty also include the responsibility of bringing to the attention of the research staff the specific problems that growers are faced with so that research can be conducted along these lines.

The Smith-Lever Law, setting up Extension work, defines our responsibilities in these words: Cooperative Extension work consists of the giving of instructions and practical demonstrations in agriculture and home economics to persons not attending College, and imparting to such persons information on such, through field demonstrations, publications, and otherwise.

The duties of the County Extension Agents from the standpoint of the people in the County are covered in the law. But how that duty is carried out must vary according to conditions in the various Counties, as I am sure you realize. For instance here is an Agent in a thickly populated County with four thousand farms and ranches. If this Agent worked with individuals, you can see that it would be a physical impossibility for him to reach but a very small fraction of the people who are entitled to his services. He has only so many hours in a day and so many days in a month. There are the special interest groups and then the civic organizations that the Agents must cooperate with, for there is hardly a luncheon club or Chamber of Commerce that does not have an agricultural program that helps the educational efforts of the Agent. So you can see that it is hardly possible to lay down any definite, set pattern of procedure or method for the County Agent to carry out his responsibilities of imparting information. And that is why we insist that the Extension Agents work out the County agricultural program with the advice and council of the people to fit the problems and conditions of the County.

Since the Valley Counties have many common problems, the County Agents, Assistant County Agents, Extension Horticulturists, and District Agent met recently and formulated plans of work for our 1948 horticultural program. The major problems recognized were:

1. Drainage, salinity and irrigation.
2. Fertilizers for vegetables and citrus.
3. Insect control of vegetables.
4. Citrus diseases.
5. Diseases on vegetables.
6. Marketing of citrus and vegetables.

In considering the problems and in taking an inventory of available information the County Agricultural Agents plan to establish field demonstrations to demonstrate the following:

1. Contrasting systems of irrigation.
2. Contrasting systems of drainage.
3. Show effects of drainage and irrigation on salinity.
4. Chiseling effects as practiced by a farmer.
5. Demonstration on one of green manure crops.
6. Demonstration on control of vegetable insects such as: a, tomato fruit worms; b, corn ear worms; c, cabbage worms; d, cowpea curculio, and e, worms on blackeyed peas.
7. Method demonstration on identifying Scaly Bark and how it can be eradicated.
8. Method demonstration on identifying Gummosis and temporary treatment.
9. Demonstration on the value of systematic summer plowing for the control of nematodes.
10. Tour of markets with 4-H boys and adults. Educational work on value and best methods and timeliness of harvesting of vegetables for marketing of high quality vegetables.

Then there is another type of demonstration which the County Agricultural Agents will work with. This is an outfield research demonstration in cooperation with the Texas Agricultural Experiment Station. The County Agricultural Agents will be responsible to help select the demonstrators, check to see that the demonstration is

carried out, help check on progress of demonstration, aid in collecting data, and hold field days and tours to show results. Demonstrations that are being considered cooperatively are:

1. Fertilizer plots of tomatoes, potatoes and snap beans.
2. Control work with onion thrips.
3. Control work with aphids on turnips and lettuce.
4. Fertilizer on cabbage and tomatoes.
5. Vegetable diseases, identification and control.

All known methods of disseminating information will be used in carrying the results of these demonstrations to the people, such as news articles, radio, field days, tours, exhibits, use of film and slides, subject matter meetings and many others. All of this as you can well see will require a well organized and adequately equipped County Extension Office. Otherwise, there will be a bottleneck in getting the information to the people. The Extension Service, as you know, is the educational agency for the dissemination of all agricultural information in all of the states. The County Agricultural and County Home Demonstration Agents are the representatives of the Extension Service in their respective counties. With their intimate knowledge of local conditions they are the people who are best able to ascertain the needs and desires of the people, and to formulate an educational program to meet these needs.

I hope that I have left with you this fact that after all the Extension Service program is the people's program, and we are here to put our shoulders to the wheel along with all others interested in agriculture in order that we may all have a better place in which to live.

SOME ASPECTS OF THE SALINITY PROBLEM IN IRRIGATION AGRICULTURE

By

H. E. HAYWARD, *Director, U. S. Regional Salinity Laboratory, Riverside, California*

There are many aspects of the salt problem in irrigation agriculture, and it is not possible to discuss all angles of the subject at this time. Therefore, I shall raise certain key questions and discuss each briefly. In this way, I hope to give you a reasonably good picture of the situation with respect to salinity in the Western States.

Irrigation agriculture is the backbone of the economy of the Western States and the continued prosperity of the entire West is directly dependent upon irrigated lands.

Based upon the 1940 Census, there are approximately 30 million acres of irrigable land in the 17 Western States, and about two-thirds of this acreage is under irrigation. Of this total, Texas has 2,180,000 acres regarded as irrigable, of which 1,045,000 were under irrigation in 1940. The acreage under irrigation is less than 1 per cent, probably nearer one-half per cent, of the total land area of the

State; but in certain counties irrigated acreage constitutes a significant portion of the total farm acreage. Hidalgo and Cameron counties rank first and second in area under irrigation. In Hidalgo county, there are nearly 200,000 acres under irrigation of a total farm acreage of 687,000, and in Cameron county 88,000 acres out of 319,000 acres are irrigated. This is 28.8 per cent and 27.7 per cent of the total farm acreage, respectively.

In areas where irrigation agriculture is practiced the economic importance of the salt problem is generally recognized. Although the soils of some irrigated areas are nonsaline and are in little danger from salt injury, the accumulation of salt is continuing danger to crop production on much of the 20 million acres of irrigated land in the Western States. Losses from reduction in yield and quality of crops may occur on lands containing some salts but not enough to throw them out of production.

It is to be expected that the salt danger will increase rather than diminish since the trend in irrigation agriculture is in the direction of utilizing all the available water, including the drainage water and return flow from lands that are being irrigated. Loss of drainage water from irrigated areas upstream and the pick-up of saline ground water by the main stream result in more salt downstream. The downstream waters are therefore less desirable for use in irrigation.

Why do we have a salt problem? Three factors are primarily responsible for the salinization of soils: arid climate, poor drainage, and irrigation. Salinization occurs under conditions favorable to the accumulation of salts and takes place through the medium of water. Owing to their solubility in water, salt constituents are readily transported by water and are deposited in the soil or on its surface when the water evaporates.

Saline soils occur for the most part in regions of arid or semi-arid climate. Under humid conditions, the deep percolation of rain water carries the soluble salts, originally present in soil materials and those formed by the weathering of minerals, downward into the ground water and ultimately by way of streams to the oceans. In arid regions, leaching and transportation of soluble salts to the ocean is by no means as complete as in humid regions. Leaching is usually local in nature and the soluble salts may not be transported far. This is true because of less rainfall to leach and transport salts and because of the high rates of evaporation characteristic of arid climates.

Salinization of soils is almost invariably associated with poor drainage conditions, as otherwise excessive soluble salts do not accumulate. Restricted drainage of soils is due primarily to the presence of a high ground-water table, to low permeability of the soil, or to a combination of both factors. High ground-water tables are frequently related to topographic position. The poor development of surface water-ways in arid regions and the occurrence of areas with basin-shaped topography and no outlet to permanent streams accentuate the salt problem.

Low soil permeability causes poor drainage by impeding the downward movement of water. Low permeability may result from an unfavorable soil texture or structure, or from the presence of indurated (hardened) layers which may consist of a clay pan, a caliche layer, or a silica hardpan.

Salted soils may occur under natural conditions, but the salinity problem of chief economic importance arises when previously nonsaline soil becomes saline as a result of irrigation. This may result from the injudicious use and management of irrigation water or through the use of water of poor quality with respect to salt content.

Water is frequently plentiful during the early development of irrigation projects and there is a tendency to use it in excess. This may accelerate the rise of the water table unless provision is made for adequate drainage. As long as the water table is at considerable depth, excessive use of water tends to keep the root zone free of soluble salts; but, when the water table rises to within 5 or 6 feet of the soil surface, the ground-water moves up into the root zone. Under such conditions ground-water may contribute to the salinization of the soil.

What about quality of irrigation water as related to the salt problem? The three most important factors are: total salt content, soluble-sodium-percentage, and boron content. Irrigation waters may contain from 0.1 to as much as 5 tons of salt per acre foot of water.

River waters may vary within a wide range in respect to soluble salt content, sodium percent and boron. It is possible to set up some approximate standards of quality based on these characteristics, and the following table gives standards of quality for three classes of water.

Table 1. Standards of Quality for Irrigation Waters

Quality Rated / Rating	Class I Excellent to good	Class II Good to injurious	Class III Injurious to unsatisfactory
Conductivity millimhos/cm. [1]	0 - 1	1 - 3	above 3
Salt content, p.p.m.	700	700 - 2000	above 2000
Soluble-sodium-percentage	less than 60	60 -75	more than 75
Boron, p.p.m.			
sensitive plants	less than 0.4	0.4 to 1	above 1
tolerant plants	less than 1	1 to 2	above 2

1. If conductivity is expressed as $Kx10^5$ these values would be 0 - 100, 100 - 300, and above 300, respectively.

If water falls into Class III with respect to any of these qualities, it is classed as unsuitable under most conditions. It should be emphasized, however, that it is difficult to set limits and that other factors may be present which would modify the determination of water quality. For example, if the salts present are largely sulfates, the values for salt content in each class can be raised 50 percent. The effect of a high soluble-sodium-percentage will depend in large measure on soil structure. A high proportion of sodium in the irrigation water results in a high proportion of sodium in the soil solution and on the exchange complex of the soil. This may cause a poor physical condition of the soil and result in puddling and low permeability. However, some soils which naturally have good structure and permeability, may not give trouble with a sodium percentage as high as 75, providing total salt content is low. Boron is an essential element for normal plant growth and small but definite amounts must be available either from irrigation water or the soil. Toxic effects occur if more than traces of boron are present in the irrigation water. The permissible limits are given in the preceding table. River waters seldom contain toxic amounts of boron, but in certain areas well waters are known to have high boron content.

Irrigation agriculture in the lower Rio Grande Valley is dependent upon water from the Rio Grande drainage basin.

What about quality of water in this instance? The next table gives the total discharge and weighted mean concentration of dissolved solids for the Rio Grande and tributaries. The significant points

Table 2. Rio Grande and tributaries. Total discharge and weighted mean concentration of dissolved solids. Samples and discharge by Geological Survey, Bureau of Reclamation and International Boundary and Water Commission, analyses by Rubidoux Laboratory.

1944

Station	Rio Grande			Tributary		
	Annual discharge	Dissolved solids [1]		Annual discharge	Dissolved solids [1]	
	acre-feet	t.a.f.	p.p.m.	acre-feet	t.a.f.	p.p.m.
Otowi Bridge, N.M.	1,303,990	0.246	181			
San Marcial, N.M.	1,024,300	0.539	396			
Elephant Butte Dam	878,900	0.605	445			
Caballo Dam, N.M.	866,500	0.634	466			
Leasburg Dam, N.M.	800,980	0.706	519			
El Paso, Texas	611,900	1.07	787			
County Line, Texas	256,200	2.38	1750			
Fort Quitman, Texas	272,900	2.41	1772			
Upper Presido, Texas	243,140	2.41	1772			
Rio Conchos, Mexico				813,300	0.707	520
Langtry, Texas	1,332,200	0.834	613			
Pecos River, Texas				211,200	5.22	3838
Devils River, Texas				255,000	0.257	189
Eagle Pass, Texas	2,094,180	1.06	779			
Rio Salado, Mexico				612,006	0.572	421
Roma, Texas	3,729,100	0.807	593			
Rio San Juan, Mexico				1,717,159	0.65	478
Rio Grande City, Tex	5,558,700	0.714	525			
Lower Brownsville, Tex.	3,107,800					

1 Weighted mean.

are the increase in dissolved solids in the upper Rio Grande for Otowi Bridge to Upper Presidio, Texas, and the effect of the annual discharge of the tributary streams below that point. The waters of the Rio Conchos and Rio Salado are of good quality, while that from the Pecos River would be rated as Class III. The water from the San Juan is also of good quality. The next table gives data on the quality of

Table 3. Rio Grande at Rio Grande City. Total discharge and weighted mean conductivity, percent sodium and dissolved solids for each year from 1937 to 1946. Samples and discharge by International Boundary and Water Commission, analyses by Rubidoux Laboratory.

Year	Discharge acre-feet	Conductivity ECx10[6]	Percent sodium	Dissolved Solids	
				t.a.f.	p.p.m.
1937	2,642,000	1260	45	1.11	816
938	6,135,300	807	42	0.70	515
1939	3,188,000	947	44	0.81	596
1940	4,008,000	791	45	0.68	500
1941	7,691,000	1300	43	1.19	875
1942	6,947,000	1200	49	1.06	779
1943	2,809,000	1320	51	1.15	846
1944	5,558,700	826	45	0.714	525
1945	3,189,800	1040	49	0.902	663
1946	3,487,000	911	47	0.788	579
Mean	4,565,580				
Weighted mean		1043	46	0.917	674

water at Rio Grande City for the 10-year period 1937-1946. On the basis of the weighted mean, this water can be regarded as Class I water. However, there are marked annual and monthly fluctuations which should be noted. For example, on an annual basis total dissolved solids have varied from as low as 500 p. p. m. to 875 p. p. m. On a monthly basis, 1946 figures show a high of 1250 p. p. m. in March with a low of 397 in June. These variations appear to be related to the flow in the Pecos River which may carry from 3.62 to 5.48 tons of dissolved solids per acre-foot.

What are the characteristics of salted soils? In connection with the diagnosis and improvement of salted soils, the Salinity Laboratory has found it desirable to classify soils into four groups on the basis of three characteristics: conductivity of the saturation extract which is a measure of total salts, exchangeable-sodium-percentage, and pH or hydrogen-ion concentration. This classification is given in the following table:

Table 4. Characteristics of Nonsaline, Saline and Alkali Soils

Group \ Characteristic	Conductivity of saturation extract millimhos/cm.[1]	Exchangeable-sodium-percentage	pH[2]
Nonsaline soil	Less than 4	less than 15	less than 8.5
Saline soil	greater than 4	less than 15	less than 8.5
Saline-alkali soil	greater than 4	greater than 15	
Nonsaline-alkali soil	less than 4	greater than 15	Usually above 8.5

1. If conductivity is expressed as $Kx10^5$ this value would be 400.
2. pH is helpful for diagnostic purposes but exceptional cases do occur. For example, some soils high in exchangeable sodium have an acid reaction.

The nonsaline soil can be described in general terms as one which does not contain enough soluble salts to be detrimental to plant growth. The Division of Soil Survey sets the upper limit of salinity for nonsaline soils at 0.2 percent on a dry soil basis. On the basis of conductivity of the saturation extract, we regard values less than 4 millimhos/cm. as indicating nonsaline soil provided the exchangeable-sodium-percentage is not high — i. e., less than 15%. The pH of such soils is usually less than 8.5.

Saline soils are those high in total soluble salts but low in exchangeable sodium. These correspond to the "white alkali" soils of Hilgard. The conductivity of the saturation extract is more than 4, exchangeable sodium less than 15, and the pH less than 8.5. When adequate drainage is established and the soluble salts are removed by leaching, they again become normal soils. Owing to the presence of excess salts and the absence of appreciable exchangeable sodium, the colloids in saline soils are highly flocculated. In consequence, saline soils usually have a favorable structure and are readily permeable to water and air.

Nonsaline-alkali soils are low in total soluble salts (conductivity less than 4) and high in exchangeable-sodium-percentage (greater than 15). The pH values are high, ranging between 8.5 and 10. These soils correspond to Hilgard's "black alkali" soils and frequently constitute the so-called "slick-spots" that occur in semi-arid and arid regions in small irregular areas. Except when gypsum or other source of soluble calcium is present, the leaching and drainage of saline-alkali soils leads directly to nonsaline-alkali soils. The soil organic matter is highly dispersed and distributed over the soil particles, thereby darkening the color—hence the common term "black alkali." The physical and chemical properties of nonsaline-alkali soils are determined largely by the exchangeable sodium present. As sodium increases, dispersion increases and pH values may be as high as 10.

Saline-alkali soils resemble saline soils in being high in total soluble salts, but differ in having high exchangeable sodium—greater than 15%. The pH of the soil solution is usually about 8.5, but may be higher or lower. As long as excess salts are present, they resemble saline soils in appearance and properties, and the colloids remain flocculated. When the concentration of salts is lowered by leaching, the properties of these soils may change markedly and become similar to nonsaline-alkali soils. This occurs because some of the exchangeable sodium hydrolyzes and forms sodium hydroxide which may change to sodium carbonate upon reaction with CO_2. The soil usually becomes strongly alkaline (pH above 8.5), the colloids disperse, and the soil develops an unfavorable structure.

Why do salted soils constitute a hazard to successful agriculture?

One aspect of this question has been mentioned: the unfavorable effect of certain ions on soil structure. It has been pointed out that the sodium ion, if present in large amounts on the exchange complex, will cause deflocculation of the soil particles and that this may result in soils that are low in permeability and difficult to till. Such problems are related to the nonsaline-alkali soils.

Another phase of the problem is the plant-soil-water relationship as it is affected by the presence of salt in the soil solution. The aim of a successful agriculture is to grow plants of economic value in soil—in other words, we want production in terms of tons or bushels per acre, field boxes of citrus fruit per tree, or adequate forage for pasture. In what ways do excess salts affect this aim? Studies at the Salinity Laboratory indicate that excess salt in the soil solution may affect plant growth in two ways: it may reduce the water available for plant growth and/or the salts or their constituent ions may be toxic to the plant.

It is well known that water is essential to plant growth. Water is needed for cell enlargement, to transport materials through the plant, as a solvent for substances required in plant growth, and for other necessary life functions. If the salinity of the soil solution increases owing to the accumulation of soluble salts in the soil, the osmotic pressure of the soil solution is increased. When this happens, the rate of entry of water into roots or the ability of the root system to absorb water is decreased. We have been able to measure quantitatively the rate of entry of water and our results indicate that as the osmotic pressure of the soil solution is increased water intake decreases. In fact, we can demonstrate experimentally that water intake by the plant can be completely stopped or the direction of flow reversed if sufficient salt is added to the soil solution.

Under field conditions there is another factor affecting the availability of water. This is soil moisture tension. This force is substantially zero in water or in frequently irrigated sand cultures. However, under field moisture conditions soil moisture tension increases from field capacity to the wilting range. When the soil is wet, the moisture films on the soil particles are thick and water may be removed easily.

As the soil dries out, the moisture films become thin, and therefore are under the stronger molecular force action near the surface of the soil particles. The soil moisture tension can be measured and is approximately 1/10 atmosphere when the soil is at field capacity.

In the nonsaline soil, the growth of most crop plants continues until the moisture content in the root zone approaches the wilting percentage. We have found that this corresponds to about 15 atmospheres of soil moisture tension. Under saline conditions, the situation is somewhat different. The growth rate decreases and approaches zero when the total soil moisture stress reaches 10 to 15 atmospheres. At the point of growth cessation in a saline soil, the moisture content may be considerably higher than when growth stops in the same soil under nonsaline conditions.

The reason for this difference is that the osmotic pressure of the soil solution depends on the kind and amount of salt as well as on the amount of water present in the soil. In other words, total soil moisture stress is the sum of the soil moisture tension and the osmotic pressure of the soil solution.

Although we consider total soil moisture stress as the primary factor in causing growth reduction and crop failure in salted soils, the effect of specific ions on the growth of crop plants should not be ignored. In general, plants show few characteristic symptoms of salt injury unless the concentration of salt is very high. The outstanding growth response to saline conditions is a reduction in the size of the plant and its yield. Unless plants grown under nonsaline conditions are available for comparison, it is not always easy to detect this type of response as the dwarfing may not be apparent. Under high salt conditions, common symptoms of salt injury are leaf burn or browning of the tips and margins of leaves, premature dropping of leaves, and die-back of twigs. Ions known to have toxic effects when present in the soil solution in excessive amounts are B, Cl, SO_4, Na and Mg. The toxic limits of boron have been mentioned in connection with quality of water. On a weight basis, chloride salts are more toxic than sulfate salts to peaches and beans, while the reverse is true for flax and some grasses. Leaf scorch of deciduous trees (peaches, prunes) may occur in soils relatively low in total salts but high in sodium. These examples indicate that there are definite plant differences with respect to tolerance to specific salts in addition to the depressing effect of total moisture stress.

Let us assume that a real or potential salt problem is suspected in a given area. *What can be done about it?* The medical men tell us that accurate diagnosis is the first essential for the proper treatment and cure of the ills of man. We believe that this equally is true in dealing with the salt problem. A survey and diagnosis of the area under consideration are necessary if salinity or alkalinity or both are suspected. In most instances, too much is at stake in terms of money and the hopes and happiness of the persons involved to rely on guesswork or incomplete information.

The first step is to determine whether or not a salt condition exists. This involves a determination of the chemical properties of the soil and of the water to be used for irrigation. In discussing the three principal classes of salted soils, I indicated the preliminary measurements that we regard as desirable in surveying an area. First we need to know the total soluble salts in the soil and irrigation water. This can be determined by conductivity measurements of the saturated soil paste, the saturation extract, or some other dilution of the soil solution such as a 1:1 or a 1:5 extract. There are advantages and disadvantages for each method. We favor the saturation extract because results obtained are easier to interpret in terms of plant responses.

The soil reaction or pH is helpful in diagnosis as it serves as an index of the acidity or alkalinity of soils. There is no general agreement with regard to details of the measuring technic or the interpretation of pH values obtained; but, in general, values above 8.5 indicate appreciable exchangeable sodium. The point is that pH considered alone may be difficult to interpret properly, but it is always a useful test in connection with other measurements.

If the pH of the soil is high, we suspect the presence of sodium; and, under such conditions certain basic data are needed for an accurate diagnosis. These measurements are: exchangeable sodium content, exchange capacity, and exchangeable-sodium-percentage determinations. The exchangeable - sodium - percentage will indicate whether or not an alkali condition exists, the presence of the "slick spot" problem, etc. If a high sodium condition exists, it is necessary to know the exchangeable sodium content in order to determine the amount of amendments to apply.

There are other measurements that may be helpful under such conditions. The presence or absence of gypsum or other calcium sources may materially affect the feasibility of reclamation. Determinations related to soil structure or physical condition are also helpful. The feasibility of reclamation may depend upon whether the soil can be leached readily. The measurement of infiltration and permeability rates is probably the best single index to the physical condition of the soil. There are field methods for determining infiltration and laboratory methods for measuring permeability that are reasonably reliable.

If our diagnosis indicates that the soils of a given area have been salted, i. e., that either saline or alkali conditions prevail: *What are the possibilities of improving the situation?* Adequate drainage is essential in any reclamation program. The ground-water table must be maintained at a sufficient depth below the soil surface to minimize the upward movement of water. No arbitrary depth can be set, as this will depend upon local conditions, including texture of soil, salinity of the ground-water, type of crop to be grown, and the feasibility of periodic leaching. In general, a depth of 6 to 10 feet is considered desirable, but there are exceptions, as in the Delta Area, Utah, where a depth of 5 feet or more is regarded as adequate for drainage.

Poor drainage may be indicated by the presence of surface water, hydrophytic vegetation, a high ground-water table, or the presence of salted soils. The installation of observation wells (piezometers) to observe the height of the water table and changes in water table level is a very useful procedure that should be followed in areas where inadequate drainage is a potential problem. If drainage is feasible it may be accomplished by the use of deep open ditches, tile drains or by pumping from wells. The method selected will depend upon the location of permeable strata in the subsoil. For example, if there are gravel strata underlying a loam or clay topsoil at a depth of 6 to 12 feet, tile or open drains are generally effective. On the other hand, if topsoils of low permeability are underlain by sand and gravel deposits or aquifers at greater depths (20-200 feet) pumping may provide effective drainage.

If drainage of a salted soil is possible, the next step is leaching by irrigation. The proper use of water for this purpose, both as to amount of water applied and method of irrigation used, is a most important consideration. The excessive use of water is wasteful and may complicate the drainage problem. On the other hand, enough water must be applied to meet the requirements for the crop and at the same time provide sufficient water to pass through the soil and leach out the excess salts. Once the level of soluble salts is reduced to limits which will permit successful agriculture, the application of water should be adequate to maintain a favorable salt balance.

Methods of leaching vary with conditions—topography, soil characteristics, available water, salt content of water, salinity status of soil, and crop to be grown. Flooding methods (border strips or border check flooding and basin flooding) are of first importance for salted soils. Wild flooding under most conditions is wasteful and is not used extensively except on level areas and for certain crops such as pastures, alfalfa and small grains. Furrow irrigation is adapted to row crops and is suitable where the topography is too rough for other methods. Salt may accumulate in the ridges between the furrows when the irrigation water contains appreciable amounts of salt. Subirrigation is not suitable when salinity is a problem unless the area has periodic leaching by rainfall or surface irrigations.

In summary, reclamation is best accomplished by impounding water on the soil surface. Repeated applications may be required. The maintenance of a favorable salt balance—that is, a situation where more salt is removed from the area in drainage water than is carried in by the irrigation water—will determine the permanence of the agriculture of any given farm or irrigation district. If the soils of an area are saline, leaching procedures will usually effect reclamation provided drainage is adequate, and sufficient water of acceptable quality is available.

Let us now consider the saline-alkali soils. Such soils usually become nonsaline-alkali soils as the soluble salts are removed by leaching. This is especially the case if the soil is leached with water

of relatively low salt content and high sodium percentage. For this reason, the treatment of saline-alkali soils after leaching is similar to that of nonsaline-alkali soils. We have indicated that these soils are high in exchangeable sodium. The problem, therefore, is to add chemical amendments which will replace the sodium on the soil exchange complex with calcium. Amendments which may be applied to alkali soils are of three types: (1) soluble or slightly soluble calcium salts ($CaCl_2$ and gypsum); (2) acids or acid formers (S, H_2SO_4, SO_2, $FeSO_4$); and (3) insoluble calcium salts (limestone, sugar lime).

The effectiveness of each amendment depends on a number of soil characteristics, particularly the insoluble carbonate content and the pH value. Any of the soluble calcium salts, acids or acid formers are effective on alkali soils. Limestone may be beneficial on alkali soils having a pH value less than 8 to 8.5 but its solubility is so low above this value that its use is questionable at pH 8.6 or above. Other considerations relative to amendments are time required for reaction in the soil and the economic factor. In general, the cheaper amendments are the ones that react the slowest. Calcium chloride, owing to its high solubility, is probably the most readily available source of soluble calcium for replacement. Sulfuric acid and iron and aluminum sulfates which hydrolyze readily to form sulfuric acid are also quick-acting amendments, but these sulfates are not economically feasible, owing to their cost. Because of their relatively low cost, gypsum and sulfur are the amendments most commonly used for reclamation. The speed of reaction of gypsum is limited only by its solubility in water which is about 0.2 percent at ordinary temperatures. Sulfur must be oxidized by microbial action before becoming available for reaction and it is usually classed as a slow-acting amendment.

Because of salty irrigation water, high water table or impermeable soil it may not be economically feasible to maintain low salinity. *What about the selection of salt tolerant crops in such cases?* Are there crops which can produce good yields under slight to moderately saline conditions?

There have been numerous investigations and observations on the salt tolerance of crops in the last 50 years so that we have some data on this subject. But tests have been conducted under such a variety of conditions that reasonably precise quantitative data are lacking. In most instances, information on soil texture is not given and it is not possible to correlate observations with osmotic pressure, total stress or kind of salt.

Climate is an important factor in salt tolerance. Work at the Salinity Laboratory indicates that plants which are not well adapted to a given climate may be more susceptible to salt injury than those which are well adapted. We have found that the salt tolerance of a given species may vary somewhat with different climates. Tentative lists giving the relative salt tolerance of a number of crop plants are available, but much more study on a quantitative basis is needed.

What is the role of the Regional Salinity Laboratory in regard to the salt problem? What are its functions and objectives, and what are its relations to the experiment stations of the Western States and to other agencies?

The U. S. Regional Salinity Laboratory was established under the provisions of the Bankhead-Jones Act approved in 1935. In 1937, a conference of the directors of the agricultural experiment stations of the eleven Western States and Hawaii, and representatives of the U. S. Department of Agriculture was held to discuss regional problems. It was agreed that salinity is a major problem in irrigation agriculture and the recommendation was made that the Federal Government establish a regional research laboratory to study the relationships of saline irrigation waters and salted soils to plant growth and to investigate other related factors involved in a permanently successful agriculture.

The function of the Laboratory is:

> To conduct basic research on the problems encountered in producing crops on saline and alkali soils, including their reclamation; the relationship of soil salinity to physical and chemical properties; irrigation, drainage and soil management practices; the salt tolerance and water requirements of crops.

I wish to emphasize two points regarding the function of the Laboratory. First, the research program of the Laboratory is cooperative with the States; and, second, this research program is in addition to and not in place of the research done by the States. It is our aim to integrate the research program of the cooperating States and the Laboratory to avoid duplication and to promote the most effective progress in the solution of salinity problems.

It is not possible to serve the region adequately on a service or action program basis, and it is not the opinion of the collaborating States that this should be the function of the Laboratory. We feel that the Laboratory can render the greatest service through basic research on salinity problems, the development of sound and usable methods and technics, and by acting in an advisory capacity in action programs carried on by the States and Federal action agencies.

DRAINAGE PROBLEMS IN THE RIO GRANDE VALLEY

By

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Introduction

The drainage problem is the most serious threat to local economy that has ever faced the Valley. This is a strong statement. There is a surprisingly small number of men who take this condition seriously. An air of complacency presently prevails. This is probably based on inflated incomes from agricultural products,—the Valley's good fortune in the last years. It is human nature to feel secure while

one's income exceeds all previous expectations. I sincerely hope that this feeling of security will not tend to blind the Valley's property owners to the conditions as they actually exist. Perhaps this is nature's way of getting under man's guard, of retaining control of her resources through the countless passage of time. Perhaps this is the crest of the wave—the high point which this civilization will never see again in this area. Other problems, when they are eliminated and their contributing conditions are corrected, will leave no permanent scar on this area. When our water supply problems are solved, we will not be worse off for having had the problem. When the local marketing and maturity problems have become a memory, there will remain no permanent mark affecting the lives of future generations. But, deterioration of lands due to inadequate, improper, and insufficient drainage, cannot be classed with the problems just mentioned. Reclamation of salted and water laden lands is generally slow. The cost of reclaiming such lands increases greatly while the unsatisfactory conditions prevail, and some lands can never be returned to their original production capacities.

Thus, many of the Valley's lands are rapidly approaching a degree of decline which will make their reclamation a poor economic venture. The results will leave a permanent scar on a valuable resource—a mark against the men who have profitably used this area for the past 40 years and to whom the next generation can point an accusing finger and say in jusification that we have not kept faith with nature. We have upset the balance. Other irrigated areas have become historical cases in such a manner—in Babylon, Egypt, the European lowlands, and our own West which rose and fell in a cycle parallel to its irrigation development before recorded history. Land drainage, together with excess water from the skies or by irrigation, has been one of the most important factors in increasing the wealth and security of nations. According to one eminent authority, without the large areas of lands that drainage and irrigation have made productive, it would not be possible to feed the present population of the earth. Fertility of the soil is the most valuable of all natural resources and is practically inexhaustible if proper methods of handling the soil are employed. Fertility of the soil alone, however, is not sufficient in itself to produce crops. Like man, plants must have available the proper amounts of air and water. These can be supplied only by removing the gravitational water in the topsoil, where the roots develop, allowing air to enter the pore spaces and providing the space necessary for good root development. This condition can be accomplished only by drainage, natural or man made.

In some areas the necessary moisture for plant development must be obtained from streams. Most streams contain a variable quantity of mineral salts, which are detrimental to plant growth. Such is the condition here in the Rio Grande Valley. Under such circumstances, drainage of the soil is called upon to perform an additional service; that is, to remove or prevent injurious salt accumulations within the root zone.

Where this precaution is not taken the process of salt accumulation is extremely costly to the nation. In 1944, the U. S. Department of Agriculture estimated that annual crop losses caused by excessive salinity of the soil were $75,000,000 or more annually. It was estimated that crop yields on much of the 20,000,000 acres of irrigated agricultural lands west of the Mississippi were reduced 10 to 20 percent by excesses of soluble salts in the soil. This is not a static condition, but one which is growing rapidly and which can undermine the agricultural economy of the West. From 1929 to 1939, more than 1,000,000 acres were abandoned, probably half of which can be attributed in large part to salinity, according to the Department. The Federal census estimated that the average value of irrigated farms was $67.78 per acre in 1930 and $35.87 per acre in 1940—a decrease of 47 percent in land value!! Such losses directly affect the income of the landowner. To them may be added the losses to the Local, State, and Federal Governments in the form of taxes on valuation and income, losses to industry through decreased markets, and the intangible, depressive effect on the individuals involved. Similar losses have been occurring in our own Valley during the past years.

The major cause of the increasing salinity within the root zone of plants and at the surface of the soil, is the physical phenomenon of capillarity. This force is continually bringing the highly mineralized waters upward through the soil from the existing water table. In areas where a high water table exists, the water is being forced upward until it reaches the surface where it evaporates, leaving its heavy salt load. Under such conditions productive lands soon become barren.

The logical, permanent relief for lands so affected is drainage. Sufficient drainage facilities must be provided so that lateral and vertical movement of waters applied to the soil will be increased to an extent great enough to counteract capillary. When this is done, soluble salts will be carried downward through the soil, into the drains, and out of the area. The time is at hand when such works must be provided for those lands still in production, if the Valley is to maintain a stable agricultural economy. Each day's delay is proving more costly.

In order to understand the drainage problems of the Valley, we must have knowledge of conditions presently contributing to them. The most important may be summarized as follows:

1. The "water table."
2. Accumulations of salts in the soil.
3. Present operations.

Let us examine these problems individually.

The Water Table

The term "water table" is rather loose, and is generally taken to mean the distance below the ground surface of free water in a hole, well, pond, or depression deep enough to collect water from subsurface sources. This is a static level; that is, the place at which the

water comes to rest after the well is drilled. Technically, the "water table" is defined as the surface formed by the water in a saturated soil, and for all practical purposes this definition will suffice. Actually, there is some question as to whether local soils are all saturated as high as the static level in a well. There is little doubt, however, that the depth to static water is an excellent gage for determining the point at which drainage becomes necessary. The water table in the Valley is not found as a level surface, but is gently undulated or wavy. In some cases, it appears to change elevation sharply, but these may be considered as exceptions to the average conditions, and are usually caused by a specific local influence. The hydraulic gradient of Valley water tables slopes generally from west to east, except in the vicinity north of LaFeria and Harlingen, where it slopes to the northeast.

Most irrigated Valley lands have a water table near enough to the surface to require additional drainage works. Of the total 552,000 acres irrigated, 386,000 acres have had groundwaters within 8 feet of the surface during the twelve months period ending September 1947. During this same period, areas having groundwaters within 5 feet of the surface varied from a minimum of 110,000 acres to a maximum of 245,000 acres. This area, 245,000 acres, undoubtedly requires immediate attention. Investigations have shown that the magnitude of such areas is entirely dependent upon rainfall and irrigation. In September 1946, after an extended dry period and period of low river flow, and a time when transportation and evaporation were at a maximum, less than 50,000 acres had groundwaters within 5 feet of the surface. After the general rains of late September of the same year, the area so affected increased to 200,000 acres. Based on the rate of recession of groundwaters during the 4 months following, during which time little precipitation occurred, at least one year would have been required, assuming that no rainfall was experienced, for the affected area to decrease again to 50,000 acres. Again in July 1947, after an extended dry period, the area with groundwaters within 5 feet of the surface was comparatively low; 127,000 acres, as compared to the previous low of 50,000 acres in September 1946. In August 1947, heavy rains again occurred. After these rains, the area increased to 245,000 acres as compared to the previous high of 200,000 acres with dangerously high groundwaters. Such data are conclusive but difficult to remember. The significant fact which I hope impresses you, is that each new low in the cycle shows a greater area affected than did the previous low, and each new high shows a substantially greater area adversely affected than did the previous maximum. It is doubtful that the September low of 50,000 acres will ever exist again unless extensive remedial measures are taken to relieve the cause of high groundwaters.

To briefly summarize the extent of this problem over the Valley, I will give you the areas with various depths to groundwater, as they existed several weeks after the storm of August 1947.

0 to 3 feet from the surface, 83,000 acres.

3 to 5 feet from the surface, 160,000 acres.

5 to 8 feet from the surface, 166,000 acres.
8 to 10 feet from the surface, 66,000 acres.
10 feet or greater from the surface, 77,000 acres.

These data represent the most unfavorable groundwater conditions to date. They also reflect the areas to which we must direct immediate attention, as you have been shown that there is no stable point. Today's high will surely be tomorrow's low. The most detrimental groundwater condition experienced in 1947, can well be taken as the most favorable to occur in 1952, unless the cycle is checked and stabilized within desirable limits.

Accumulations of Salts in the Soil

Excessive quantities of salts injurious to plant growth are found in many areas. Areas with such salt accretions correspond to those where high, saline groundwaters exist over extended periods. High groundwaters go hand in hand with excessive salt accumulations. Where groundwaters exist at a safe depth, no appreciable quantities of salt are found.

It is evident that salts in Valley soils originate from the Rio Grande through irrigation. Available data indicate that before irrigation was practiced, Valley soils in a typical area of approximately 155,000 acres averaged only about 0.05 percent of soluble salts. By 1925 this concentration had reached 0.13 percent. In 1945 it was 0.28 percent. This area has had groundwaters from 3 to 8 feet from the surface during periods of normal rainfall since 1945. During periods of excessive precipitation, the groundwaters are at less than 3 feet from the surface over about a third of the area, and less than 5 feet over most of the remainder. These conditions have had a profound effect on Valley agricultural incomes. During the period 1925 to 1945, while salt content of the soil more than doubled, it is estimated that losses in income amounted to $400 per acre. Invested in war bonds, this loss amounts to about $500 per acre for that period. At the present rate of deterioration, a complete drainage system, including tile on 200 feet spacing, the necessary outlet drains, and lateral drains at ½ mile spacing, can be paid for with the sum equivalent to the losses in the past 6 years. It is hoped that property owners who feel that they cannot afford the necessary drainage works will seriously consider those statements.

The amount of soluble salts in Valley soils varies considerably, ranging from a few hundredths of one percent to one percent or more. Minimum salt contents are usually found in areas having light textured soils and water tables well below 8 feet. Soils with medium quantities of salts, 0.2 percent to 0.4 percent, usually have water tables 6 to 8 feet from the surface, and the water itself does not contain a higher percentage of salts than the soil. Soils with high salt concentrations, approaching or exceeding 0.6 percent in the soil profile, usually have or have had groundwaters containing salts generally in excess of 0.6 percent, within 5 feet of the surface. Investigations have shown that in areas where free root zone drainage exists,

no appreciable quantities of soluble salts are found, and favorable crop production has continued. Analyses of salts found in Valley soils indicate that sodium salts rarely exceed calcium and magnesium salts. This characteristic probably explains why most local soils have continually produced under adverse drainage conditions through a long period without having become totally barren. More important, such salt conditions usually react favorably to drainage reclamation. Analyses of salt crusts at the surface indicate a predominance of soluble calcium salts, principally calcium chloride which is readily soluble. In addition, calcium ions are generally considered as having a preservative and restorative effect on the physical properties of soil. Fortunately, no "black alkali" (sodium carbonate) has been found.

The general status of Valley soils with respect to soluble salts content, then, does not present a hopeless problem. The problem is serious, and reclamation will be slow and costly, but, from an economical standpoint, it is feasible and should be vigorously pursued in order that productive ability be not further lowered. From a physical standpoint, reclamation is practical, and, when satisfactory drainage conditions prevail, the seriousness of the salinity problem can be greatly reduced. Here, again, time is important, for increasing salt accumulations and deterioration of soils are accompanied by adverse changes in soil structure which may never be corrected, even after the greater portion of salts has been removed.

Present Operations

This problem has been so termed for want of a more descriptive name. It is a very important problem, however, so I will attempt to define it more clearly by an actual case.

"John Doe," we will call him, lives in another state. He was reared on a farm but has been working in a large city for about 20 years. During this time he saved some money, enough to fulfill a lifelong ambition of owning his own farm. After looking around the country, he decided that the Rio Grande Valley was the place to spend the rest of his life. This was in 1944.

Mr. Doe invested his life's savings in 18 acres of 4 year old orange and grapefruit trees. The soil was fine sandy loam, and the trees looked good. John took no chances in buying this land, because it was sold to him by an old and trusted friend. The friend acted in good faith.

In the spring of 1946, it was still cold where John lived. He and Mrs. Doe thought it would be nice to visit the Valley, inspect their orchard, let their snowbound bones soak up some sunshine, and begin making plans for building a home on the tract. When they saw their place, they noticed several of the young trees were dying. They didn't worry about this and had them replanted. Then the grove looked fine again. Because building costs were still high, the Does went home, planning to return the next spring.

In March 1947, the Does returned to the Valley. Their grove didn't look the same. Many more of the trees were dead. Mr. Doe was very concerned. He inquired among local people and found that the Valley had what was called a "water table." He also found that when a high water table existed, the land became "salty" and trees died. Upon inquiring further, he was told that all one had to do to relieve such a situation was to install a tile drainage system. He found that costs were not excessive compared to his investment in the land. Mr. Doe felt better. He contracted to have the work done by a man who said he could put the grove back in good condition.

At this point the organization with which I am connected asked Mr. Doe if he objected to our making some studies to determine the value of the work. We had no desire or authority to influence the methods or location of the system. Our information would be confidential and available to Mr. Doe alone. He was very pleased and offered his full cooperation.

A study of the soils showed the top foot to be sandy loam, the next 4 feet to be sandy clay loam with only a small percentage of clay. Thus, the top 5 feet were readily permeable. Below these soils were relatively impervious clays for at least 22 feet.

Groundwater studies showed depths to range between 5 and 6 feet from the surface over most of the area. Groundwater movements were found to be toward three well defined points within the grove. Capillarity was at work as indicated by surface moisture over most of the tract.

Soluble salt studies of the soils showed concentrations to be high.

The tiles were placed at a depth of about 7 feet, or about 2 feet in the impervious clay. This depth was used because the contractor had used it successfully in other areas. There was certainly no consideration given to soil textures. While the trench was being dug, there was a very appreciable flow of groundwater into it, indicating that conditions were conducive to rapid and effective drainage reclamation.

After the trenches were completed, the tiles were carelessly laid in one to two feet of muddy water, as the outlet wes kept closed until the system had been placed. There was no way of knowing whether or not alignment was satisfactory. If one tile near the outlet end had been placed off-line, the whole system would be entirely ineffective.

To cap off this series of mal-practices, the impervious portion of the excavated material was used for the initial backfill. If this did not entirely seal the joints between the tile, the method used in backfilling certainly did. The trench was filled by dumping the excavated material into the several feet of water in the ditch. This corresponds to a method purposely used when impervious backfills are desirable, and is known as "puddling."

Since completion, the system has been carefully observed, and groundwater studies have been made monthly. After seven months, the tile line has remained dry, even though there are two feet of saturated soil above; no flow has been recorded at the outlet, and groundwaters have steadily risen. There is obviously no need to check salt contents of the soil. When Mr. Doe visited the Valley last August, he was a thoroughly disillusioned man. Such is the nature of this problem.

It is not to be inferred that such methods are used in every case. There are certainly some well qualified engineers and responsible contractors in the Valley who are capable of doing work of the first order. The fact remains, however, that for each subsurface drain in the Valley that functions properly, there are one or more which do not.

The causes for this are evident. There has been a negligible amount of basic research performed concerning proper drainage practices under local soil conditions. It is clear that methods employed elsewhere are not the complete answer to the Valley's drainage problems. Intensive research is not only desirable but necessary, in order that consultants can be given a course to follow in designing drainage works. This is not an individual problem, but one requiring the concerted effort of all people in the Valley associated with agriculture. We must educate ourselves to turn to reliable professional men and public agencies for the answers. Only in this way can reclamation be effected within the ability of the lands to repay. The Valley cannot afford one drainage system which does not function and later another which does. Each dollar expended must be made to yield results.

There are, of course, many related problems and ramifications to these which could lead to detailed and lengthy discussions not in order at this time. The three named, however, are fundamental, and in their solution lie the Valley's hopes for an agricultural future.

I sincerely hope that I have not criticized, but that these remarks are taken as a frank discussion of present conditions.

I have often been told, locally, that criticism is necessary to bring many people's thoughts concerning drainage to a sound basis. However, criticism that is not constructive is hollow and worthless. For this reason, I present to all people interested in the Valley's agricultural future, a basic four-point program toward solving our drainage problem.

1. Construct in the most rapid, economical, and feasible manner, a system of deep outlet drains. This procedure is fundamental, as surface and groundwaters must be moved out of the area.

2. Simultaneously, and after construction of the outlet drains, diligently pursue a program of lateral drain construction. This will require the closest cooperation between the landowners and their irrigation district officials. Each problem area must be provided with suitable outlets for farm unit drains.

3. Educate. The outlet and lateral drain systems will show a striking improvement in many areas. These improvements will form a nucleus for an educational program whereby landowners can be shown the valuable results of drainage. When the farmers become convinced that expenditures for drainage works will yield increased returns, their participation will be assured.

4. Research. A program of subsurface drainage research is imperative. We should look with skepticism on the individual who guarantees to build subsurface works which will function properly. Little is known as to proper depth, spacing, and type of drains to be provided for best results. Practically nothing has been done to determine the value of pumping from wells to relieve local groundwater conditions. Certain characteristics of Valley soils indicate that this method may prove to be more desirable than drains in many areas. It has recently been shown that bacteria can make water laden soils impervious, thereby reducing the effectiveness of drainage works. Certainly such possibilities need to be investigated along with many others, before successful drainage can be accomplished.

For these reasons, it would appear wise to move slowly on subsurface drainage construction until more facts are established.

I know of no group more qualified than you gentlemen before me to get such action underway. I leave it in your hands. The task is great, but not hopeless.

FUNDAMENTALS OF CHEMICAL WEED CONTROL

By

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The control of weeds by chemical means is not a substitute for other methods of good farming. Neither is it a substitute for other methods of weed control such as by tillage. The new chemicals often make it possible for us to reduce the amount of hand weeding required. In pastures and drill crops they often make possible the control of weeds which we would not be able to handle otherwise. The proper use of chemical weed control materials, which we call herbicides, should now be considered to be a part of good farming methods.

It is important for every grower to understand that there is no shot-gun chemical or no shot-gun 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.

It is especially desirable to have some concept as to why certain chemicals are selective in nature on certain crops. That is, why they kill many weeds without hurting the crop in question. It is also desirable to understand the type of action that nonselective chemicals have on plants. This is the subject that I want to discuss today. For convenience, let's divide the various kinds of chemical weed control agents into several major groups based on the manner in which they act on the plant.

1. The Soil Sterilants

These kill by creating a toxic condition in the soil the length of which depends on the chemical used, the quantity applied and soil and rainfall factors. Those having a long term effect such as the arsenicals, boron and the chlorates are used where a vegetation-free condition is desired. These and certain volatile gases such as carbon bisulfide have been used for the eradication of perennials. To some extent 2,4-D has replaced the soil sterilants for perennial weed control.

Certain chemicals that break down quickly have been used for killing weed seeds or preventing their emergence. Chief among them is calcium cyanamide used for treating tobacco plant beds as a weed-seed killer. This material has also been used for annual weed control in asparagus which has such a deep root system that a toxic condition in the top two or three inches has no bad effect on the crop. 2,4-D has been used experimentally as a soil sterilant. As a pre-emergence spray it kills many weed seeds in the process of germination without hurting certain of the more resistant crops providing seeds are planted at a suitable depth. Soil and rainfall factors also influence the success of pre-emergence sprays of 2,4-D which should be considered still in the experimental stage of development.

2. Contact Herbicides

Many different chemicals have been used from time to time to kill all top growth on contact. These materials are not actively carried into the roots. Small annuals die from one treatment, but perennials are killed only by repeated application. Petroleum oils have been widely used as contact herbicides. Recently certain phenolic compounds applied in oil emulsions have come into use. They have much the same action as oil and in many instances are less expensive. Potato vine killers are contact herbicides, often of a type containing a phenol derivative. Calcium cyanamide applied to small weeds such as found growing in asparagus acts as a contact herbicide if ample dew is on the plant.

The contact herbicides are sometimes used to eradicate winter annual weeds from established perennial crops such as alfalfa. The spray is applied right after cutting during the season when the alfalfa is relatively dormant. Although the tops of the alfalfa are "burned" no permanent damage is done and the small weeds are killed. In one sense this is a selective spraying technique yet all exposed foliage is burned. The contact type of herbicide is used rather than a selective because the maximum kill of small weeds is realized.

Contact herbicides particularly the oils have been widely used on the West Coast for the control of vegetation along highways and ditch banks. In arid sections this is in part a fire control measure.

3. Selective Herbicides

When applied under proper conditions and at suitable concentrations, selective weed killers leave certain crop plants relatively unharmed. These weed killers are useful where a resistant crop is being produced and susceptible weed species are found in the field. Four types of selective weed killers are recognized based on the type of selective action involved.

A. Selectivity based on minimum wetting of the crop and limited absorption of the toxicant because of leaf wax protection.

If foliage is treated when still quite small, grains, flax, peas, alfalfa and certain other crops are difficult to wet by aqueous sprays of chemicals in this group because of their leaf shape and a relatively thick and continuous leaf wax or cutin. That part of the toxicant which does adhere to the plant is not readily absorbed. Sulfuric acid has been used for spraying such crops in Europe and to a limited extent in the United States. In recent years, salts of certain phenolic derivatives have been widely used for the control of mustard and other annual weeds, particularly in western United States and Canada on small grains and flax. Various other compounds used as selective herbicides, also depend on the cutin of the crop plant for their selective action.

B. Selectivity based on the physiological resistance of carrots and related plants to certain petroleum fractions.

Since about 1942, stove oil, Stoddard Solvent and other petroleum fractions have been used for selective spraying of carrots. Parsnips, parsley, celery, and other members of the same family have been treated successfully at certain stages of development without damage to the crop. Just why most small weeds are killed by this treatment while the crops mentioned go unharmed, is not understood. It is evident that the crop plants are thoroughly wet with the oil, so some physiological differences must exist.

C. Selectivity based on differential plasmolysis when sprayed with salt solutions.

Still in the experimental stage is the use of saturated or near-saturated solutions of various salts as selective sprays on beets. Apparently the cells of most weeds are killed by plasmolysis, which is a withdrawal of cell sap by the action of concentrated solutions of soluble salts. Just why garden beets, sugar beets, and certain of their relatives resist this action is not clearly understood.

D. Selectivity based on the physiological resistance of many members of the grass family and certain other crop plants to the herbicidal action of growth regulating substances such as 2,4-D.

These materials so upset the growth of many plants that death occurs. For some reason not well understood, most grasses, a few other crop plants, and certain non-grass weeds do not respond in the same manner. By proper regulation of dosage and time of application, many weeds may be killed without injuring the crop. 2,4-D is the most widely used of all selective weed killers, being used on

lawns and many non-agricultural areas in addition to certain farm crops and pastures.

These then are the important types of weed killers used in agriculture at the present time. There are, of course, some others that do not fit into this classification, for example, those used in controlling water weeds in irrigation ditches. These have sometimes been called the water sterilants. In addition certain materials seem to be actively translocated in weeds and have been classified as translocated herbicides. For example, ammonium sulfamate which is recommended by its manufacturer particularly for certain woody plants including poison ivy. 2,4-D is also translocated and might be put in this group in addition to its place as a selective weed killer.

One of the more recent uses for the contact type of weed killer is the control of all ground cover vegetation in citrus plantings. In California, both oils and the phenolic contact sprays have been used for this purpose. Many factors must be considered before a grower attempts to handle his citrus orchard vegatation by this method and careful experiment should be conducted in the different growing areas.

A tremendous amount of research is under way at the present time in the field of chemical weed control both by experiment stations and by commercial firms manufacturing and distributing such products. Undoubtedly, many new materials and techniques will be developed within the next few years. These of course should be adequately tested at your local experiment stations and by growers in the valley before they are adapted for large scale use. There are certain to be instances in which methods or materials used successfully elsewhere do not pan out in the Valley. On the other hand there may be opportunities to develop new methods of chemical weed control here that will not be too successful elsewhere. I know that your experiment station is interested in your weed control problems and hope that growers can work with the experiment station in finding chemical weed control techniques for your particular area.

THE NON-TILLAGE SYSTEM OF SOIL MANAGEMENT IN THE CITRUS ORCHARD WITH WEED CONTROL BY MEANS OF HERBICIDES

By

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Introduction

Soil management practices comprise the most important part of the citrus orchard management program, since they are concerned with the control of soil moisture and the maintenance of soil fertility—two of the fundamental requirements of successful citrus fruit production, the third consisting of good trees. Among the soil management practices most commonly employed are irrigation—and its counterpart, drainage—fertilization, the use of correctives and amendments, covercropping and tillage.

Thus far, three general systems of soil management have been developed by fruit growers—namely, standard tillage (so-called clean cultivation), permanent sod-culture, and mulch-culture. The distinctive feature of the first system consists in the use of tillage, whereas the two latter systems are characterized by little or no tillage. Until comparatively recently the standard tillage and permanent sod-culture systems of soil management have been those most widely employed in the citrus areas of the United States, the former extensively in California and Arizona and the latter in Florida and the Lower Rio Grande Valley. There has recently developed a new system of citrus orchard soil management which is spreading rapidly in California and Arizona, where it is commonly referred to as the "clean" non-cultivation system. It is without doubt the most important, and the likelihood exists of its becoming the most significant, development in citrus soil management practices in many years.

This system of soil management involves the operation of the orchard without any tillage of the soil but with weed control by means of the use of herbicides or hand-hoeing, or a combination of the two. There is no spring disking, no summer cultivation, no re-preparation of furrows or basins, and no growing of covercrops. It comprises a radical departure from the conventional methods of soil management used in the past and, of course, differs from the permanent-sod system of soil management in that the soil is at all times kept free of weed or plant growth.

History and Current Status

This system of citrus orchard soil management traces its origin to Mr. Frank Hinckley of Bryn Mawr (near Redlands), California, who in 1919 discontinued cultivation altogether in a fine navel orange orchard which was then 27 years old. He merely furrowed out the orchard so as to permit of irrigation, and controlled the weeds thereafter by means of hand-hoeing. At the same time he discontinued the application of animal manures, replacing them with chemical nitrogenous fertilizers. Within two or three years he found that very few weeds were left, and that it was possible to keep them under control by means of hand-hoeing with little labor and effort. Parenthetically, it should be stated that at the present time, twenty-eight years later, the orchard is still in good health and highly productive.

The use of oil as an herbicide to control the weeds seems to have been originated some years later, apparently in 1932, by his brother, Mr. Nat Hinckley, who observed that the use of ordinary fuel oil on weeds along the county roads resulted in their death, even though the usual practice of burning them off after treatment was omitted. He decided to use orchard heater oil as an herbicide in an orchard of his which had a heavy infestation of Johnson grass. His efforts were crowned with success by the virtual eradication of the infestation withn a four-year perod.

Observing the success of the Hinckley brothers in the management of their orchards without tillage, and the control of weeds,

either by hand hoeing or the use of oil sprays, other growers were led to experiment with these methods with the result that within a few years the non-tillage system of soil management with weed control by oil spraying began to spread at an ever-increasing rate. While the exact facts are not known, it is estimated that several thousand acres were under this system of soil management at the beginning of World War II, and there is little doubt that its use would have continued to extend even more rapidly had it not been slowed down by the unavailability of oil during the war period. Since the war many growers have adopted the system, until it is now conservatively estimated that approximately twenty thousand acres are under it. It now exists in all parts of the California and Arizona citrus industries, and has recently spread to some of the deciduous fruit and vineyard districts.

Economics of the System

Recent surveys conducted by the Agricultural Extension Service, based on five years of reasonably extensive experience, permit of a general appraisal of the economics of the new system. Experience indicates that in general the costs for the first two or three years are considerably higher than those of standard tillage or clean cultivation which, while highly variable, average somewhere between $12 and $15 per acre. Once the system is well established, however, the costs are no greater than those of standard tillage, and are commonly less.

The most extensive recent survey, conducted in 1945 and involving 235 records in two counties, showed the average costs for the first year to be $23.43, for the second year $20.67, for the third year $14.52, and for the fourth year $10.80.

The principal variable contributing to cost is the amount of oil used which, of course, varies in relation to the nature and amount of weed growth. This survey showed an average gallonage of 283 for the first year, 243 for the second year, 171 for the third year, and 91 for the fourth year.

Requirements for Effective Weed Control

Experience to date has demonstrated that the first problem is to destroy the natural weed cover, and the second to prevent its reestablishment. The former is best done at the outset by the use of appropriate machinery, rather than by the use of oil sprays. This eliminates the fire hazard, which may be considerable, and is the most economical procedure. To prevent the re-establishment of the weed cover requires spraying before the weed growth has attained a height of four to six inches. Experience has shown that this may require three to eight sprayings of 50 to 75 gallons per acre the first year. If this work is done efficiently, both the oil gallonage and number of sprays required drop off rapidly thereafter. It has sometimes been necessary to spray at intervals as short as 6 weeks during the summer, and once or twice during the winter. It is, of course, exceedingly important to prevent weed growth from going to seed.

In this connection, it has been found that the common weeds in California citrus orchards exhibit marked differences in resistance to oil sprays. With the exception of morning glory, the broad leafed forms are easily killed. Johnson grass, morning glory, and Bermuda grass are much more resistant and their control requires repeated applications and careful work. Nut grass has proven most difficult to control.

Equipment and Herbicides

California experience has demonstrated that power driven sprayers are necessary until the weed growth has been brought well under control, which may require 3 or 4 years, or longer. Thereafter it may be kept under control by hand-spraying or hoeing. Numerous types of equipment are in use, homemade and otherwise, mounted on trucks, trailers, or horse drawn chassis.

For heavy work, generally required during the first two or three years, boom sprayers which cover the middles with a hose attachment on each side for the three rows have proven advantageous and most economical. A driver and two sprayers are used with this equipment and can cover about three acres per hour. Boom sprayers should be equipped with protective shields to keep the oil off the tree skirts.

Pressures of 50 to 100 lbs. have given the best results. Higher pressures cause excessive fogging and poor coverage, and also accentuate splashing on the low hanging foliage. An essential requirement for the use of herbicides other than straight oil is provision for agitation in the spray tank.

The original herbicide employed, and still used to a considerable extent, was orchard heater oil, the gravity of which ranges from 26° to 32°. Ordinary diesel oil is now the most extensively used herbicide. Some growers use them undiluted, while others use half oil—half water mixtures for which the spray tank must, of course, be provided with an agitator. It was early shown that the lower grades of oil are more effective, as well as cheaper.

The present trend is toward the use of oils fortified with toxicants of various kinds, such as sulphur and proprietary weed killers. A commonly used formula containing sulphur is oil 50 gallons, water 50 gallons, and sulphur 5 lbs. Some growers have found this approximately as effective as straight oil but, of course, less expensive. Virtually all of the major oil companies now have proprietary weed killing oils as well as general weed killers, which are used either as diluents in oil, or according to the recommendation of the company concerned. Some of these diluents contain the plant growth regulator 2,4-D.

Recent experience has demonstrated that some of these weed killers used as diluents in orchard heater or diesel oil, or mixed with water, are fully as effective as oil or more so. Unfortunately, for the most part, they are also more expensive. A formula which has given good results is diesel oil 30 gallons, water 70 gallons, plus one quart of a general non-selective di-nitro weed killer. In view of the pres-

ent activity in the field of weedicides, it is almost certain that cheaper and more effective herbicides will displace those now in use.

Effects of the System on the Citrus Orchard

Experience has demonstrated that this new system of soil management may have effects on the soil, the trees, and the fruit, some of which are pronounced and definitely beneficial.

Almost without exception, the physical condition of the soil has improved under the system. It has become more permeable; plowsole, if present, has softened or even disappeared; and lateral spread from furrows has increased. Erosion losses have also been reduced; there is no loose soil to wash away and run-off is less, apparently because of greater permeability.

Thus far, no injury has been observed from the effects of the oil applied to the soil. The amount applied is, of course, exceedingly small, and it either evaporates or oxidizes rapidly. Moreover, the orchards which have been under this system longest have to date shown no injurious effects from the lack of incorporation of organic matter in the soil which the system involves. Tests have indicated no detectable decrease in the organic matter content of the soil.

In many cases tree condition has noticeably improved, the amount and color of the foliage being better, with reduced evidence of minor element deficiencies. In some instances, but not all, yield has improved. In part this may have resulted from allowing the skirts of the trees to grow down to the ground, since it is not necessary to raise them to permit of tillage. It seems probable that these effects are caused by the utilization by the roots of the surface untilled soil layer which is, of course, the most fertile, best aerated, and warmest during the critical spring and fall months.

There is evidence that in some cases fruit maturity has been advanced from one to three weeks. This seems to occur only in seasons of later than average bloom and maturity, having not been noted in early seasons. There are some claims of better fruit quality, but the evidence in support of these claims is not clear-cut or convincing.

Effects on Other Soil Management Practices

From what has been said above, it might be expected that the adoption of the "clean" non-tillage system of soil management would have important effects on other soil management practices. Experience has conclusively proven this to be the case.

Because of the improvement in physical conditions in the soil, which the system nearly always brings about, its effects on irrigation practice are both marked and important, and usually sufficient to require alteration in irrigation practice. The general effect is to require larger heads of water for shorter periods. Where the furrow system is employed, not uncommonly it has been necessary to shorten the furrows by the installation of additional supply lines.

The effects of the system on fertilization practices are also notable, since it involves the abandonment of covercropping and usually sharp reduction in the amount of organic matter applied. Indeed, many growers have eliminated the application of organic matter altogether, with the result that the amount received by the soil is restricted to that provided by the dropping of leaves and small twigs. It should be stated in this connection, however, that thus far at least no ill effects have been observed from the reduction in use of organic matter, which in California in the past has been notably high.

The substitution of spraying for tillage, abandonment of covercropping, reduction in or discontinuance of use of bulky organic matter, and irrigation in permanent furrows or basins—all of which are involved in the adoption of the new system—comprise a radical departure. Its successful use requires new equipment, materials and skills, and the exercise of common sense and good judgment.

Summary of the Possible Advantages and Disadvantages of the New System

Among the advantages the system may provide are the following:

1. Reduced erosion losses.
2. Reduction in water use by the amount required for covercropping, which may be considerable.
3. Reduction in cost of fertilization through the discontinuance of use of bulky organic fertilizers. In California this is considerable.
4. Earlier fruit maturity in some seasons.
5. Possibility of some increase in yield.
6. Savings resulting from greater convenience in certain orchard operations—including picking, loading and hauling of the fruit, pest control, pruning, and operation of orchard heaters. These can all be done more conveniently and sooner after a rain or irrigation.
7. Lower investment in power driven equipment.

Among the possible disadvantages involved in the use of the new system are the following:

1. Likelihood of necessity for modification in the permanent irrigation system.
2. Higher installation cost and maintenance costs for the first few years.
3. The unpleasant and disagreeable nature of oil spraying in hot weather.
4. The fire hazard which exists at the outset if the initial mat of weed growth is not removed or plowed under.
5. Possible tree damage if oil or other herbicides are sprayed on the foliage or collect on and run down the tree trunks.

Recommendations Concerning the Establishment and Operation of the System

Experience has demonstrated that the best time of year to initiate the system is in late spring or early summer, before the weed or covercrop growth has matured and gone to seed. The best procedure consists of the usual spring working of the soil followed by very careful smoothing and leveling and preparation for irrigation. Where conditions permit, the use of broad-base, shallow furrows is recommended. This system provides good distribution of the water, and furrows of this type are most easily maintained free from clogging by leaves, fruit, and other trash. Moreover, they are easier on wheeled equipment. Other methods of distribution of irrigation water in use with the "clean" non-tillage system, however, include standard furrows, spray irrigation, and the flooded-basin system. It is, of course, important that a first-class job be done at the outset with respect to the installation of the system of irrigation, for it must function as a semi-permanent installation.

Once the new system has been initiated, weed growth must be kept under control. New growth should be sprayed while still soft and succulent and before seed formation occurs. It is usually best to spray when the weeds reach a height of four to six inches. Oil should be applied sparingly in amount, sufficient only to wet the weeds without run-off to the soil. One should plan to shift from power-spraying to hand-spraying or hoeing when the weed growth has been reduced to a safe point; this usually requires three to four years, sometimes longer. Other orchard management operations, notably irrigation practice, should be adjusted according to the needs. Experience has shown that the most important precautions to bear in mind relate to the possibility of over-irrigation and injury to the foliage or tree trunks.

Possible Factors Mitigating Against Its Adoption in the Lower Rio Grande Valley

While the new system is undoubtedly giving good results in California and Arizona, and is spreading rapidly, it appears that there are several factors operative in the Lower Rio Grande Valley citrus industry which may mitigate against its adoption there.

The problem of weed control will almost certainly be more difficult in the Lower Rio Grande Valley because of a climate more favorable for plant growth, in that mean temperature and humidity average considerably higher and provide an all-year growing season. Moreover, a certain amount of summer rainfall occurs, though both amount and distribution are highly uncertain. Another factor contributing to this problem is the practical certainty of reinfestation from weed seed carried in the irrigation water. It seems certain, therefore, that weed control in Lower Rio Grande Valley citrus orchards will require more frequent spraying and use of more labor and spray materials.

Another factor which will doubtless mitigate against the adoption of the new system is the fact that the permanent-sod system seems to be so well adapted to grapefruit culture, the cause for which probably lies in the lower nitrogen requirement of this citrus fruit. The permanent-sod system of soil management is, of course, also a non-tillage system and, therefore, enjoys somewhat similar benefits. Moreover, almost certainly it is less expensive, both to establish and maintain.

It is greatly to be hoped, however, that the "clean" non-tillage system of soil management will be given an adequate test in the citrus industry of the Lower Rio Grande Valley. Not until this is done shall we be able to appraise its comparative advantages and disadvantages under the distinctive environmental conditions which characterize the Lower Rio Grande Valley.

SOIL PROBLEMS IN THE VALLEY

By

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Only a few decades ago no one knew of soil problems in our Valley. The land was covered with mesquite, huisache, cacti, grass. When rains fell vegetation turned green and started growing. Long and hot dry spells in between the rains did not matter a great deal. Things stayed much the same. There existed a state of balance between climate, vegetation and soil.

Then man came and removed nature's original vegetative cover. He planted crops, suited for his purpose. He moistened his crops with water from the Rio Grande River. He had great hopes — With plenty of water, plenty of sunshine and good soil, he would produce heavy crops of fine quality all year around.

Here we are now, November, 1947. Our intentions are still the same, but things did not work out as we had hoped. Our crops are not always perfect and plentiful. We realize that we are not altogether on the right track. We have tinkered with the laws of nature, and we have upset nature's equilibrium in an undesirable manner. This has resulted in problems, problems too well known to all of us. Here are only a few of them:

Why do I suddenly have a salt excess in the north part of my orchard? Why are the sizes of my citrus fruit small? Why is the foliage yellow and sparse in the south-east corner of my orchard? Should I irrigate now, or two weeks later? Should I use more water or less? Would an application of nitrogen or perhaps sulphur help? Or will such an application only be a waste?

In the past we have relied too much upon mere *opinions* in solving these problems. If we want to be successful in the future, we must face and understand the *facts* underlying these problems. Which are these facts? How can we understand them?

As we drive along our Valley roads, we notice areas of different crop condition because of what is given by nature—areas of different elevation, or different soil type. Aside from this, however, we notice differences between the land of *different owners*. These differences are often extremely pronounced. The orchard of Mr. Smith, for instance, may show a heavy crop, normally green foliage. The orchard of his next door neighbor, Mr. Jones, shows a poor crop, with light and sparse foliage. Both orchards are level and of the same soil type. The amounts of sunlight, rain, temperatures are the same. *The only difference lies in what these two men have done to their orchards.* Whatever nature has given—heavy or light soil, flat land or sloping—is of basic importance. Within this realm of nature's possibilities, however, the understanding of the individual grower counts very much.

Some of these differences as we observe them on the land of different owners are caused by pathological or insect disturbances. Most of them, however, go back to the soil.

Our trees cannot be productive and healthy unless they are able to get out of the soil what is necessary for healthy growth and production. The organs utilizing the soil for plant needs are the roots. Unfortunately we cannot see them and evaluate the root system as easily as the parts above the surface. This may be the reason why we have not yet learned to sufficiently estimate the importance of a dense or sparse, a deep or shallow root system.

You all know, for instance, that it is easier to grow large fruit on young than on old trees. Why? Because the young trees have a larger root system in proportion to the crown above the surface. As the trees grow older there is no restriction to further spreading of the branches, but the growth of roots into the deeper and tighter subsoil layers of our Valley becomes increasingly difficult.

The grower must never fail to ask himself the questions: "How will this or that cultural program influence root growth? *What soil* condition is required for most perfect root development?"

In the *first* place we must remember that roots are alive. They need *air*. If the air supply is restricted, roots will suffer. *Second*, roots are the only part of the plants through which they are able to absorb water. The vigor and speed of plant growth depends upon the amount of water taken up by the roots. More than 500 lbs. of water must be absorbed to make one pound of citrus dry matter. With the water, minerals necessary for physiological functions are absorbed. *Third*, since only large root systems are able to fulfill their tasks efficiently, the soil must be of a *consistency* in which the roots can grow rapidly. The soil must easily give way to the growing root.

How can we know whether a soil fulfills these important requirements for most perfect root action? First of all it is necessary to realize that soil is not an invariably uniform mass, but that soil is something porous and that the type of porosity is what counts in the life of our plants. To understand the secrets of soil fertility, we must visualize soil in its smaller dimensions—beyond what we can ordinarily recognize with our eyes. The arrangement of the finest particles in the soil is essential.

In a fertile soil the finest soil grains are grouped together into larger crumbs or aggregates. Between these large crumbs we have relatively large spaces—pore spaces. *Large* pore spaces contain plenty of air and free water available for root action, and the growing root can advance with ease. If, however, the large soil crumbs fall apart and the finest single soil grains are independent, the pore spaces will fill up and the result is obvious. Free air and free water are sparse and root growth is retarded because of mechanical resistance.

The arrangement of particles, the inner architecture of the soil, is known to soil science as *"Soil Structure."* A soil of good structure —that is, a soil of large crumbs and large pore spaces—may deteriorate to a soil of poor structure and poor structured soil may be rebuilt to fertile soil of open structure. A great deal of our very best soil research effort is nowadays focussed upon the problem of soil structure—the problem of stability or deterioration of large soil aggregates.

Experiments with growing plants to demonstrate the influence of soil structure are most revealing. Last spring two series of pots containing Valley soils were planted with tomatoes. Series No. 1 grew in soils of normal structure. In series No. 2 the structure had been destroyed by vibrating the pots when wet. All tomato plants in pots from series No. 2 stayed small and yellow, disregarding soil type or addition of plant nutrients. In series No. 1 the plants grew in all cases many times as large. They were much healthier and showed reaction to nutritive treatments.

It is beyond doubt that the explanation *to the behavior of many of our Valley crops can be found in the soil structure problems.* The Valley shows a great variety of soil structure conditions. The tendency towards poor structure is quite natural in our climatic region. In cooler climatic zones the water in the soil pores freezes to considerable depth every year. This widens the pores in a most desirable manner. Here in the Valley we do not have such outstanding soil structure renewer as the frost. Salt crystals in between the finest single soil grains have a tendency to weaken the stability of large soil crumbs. Above all our cultural practices, especially heavy irrigations, have more or less resulted in deterioration of formerly healthy soil structure. Whenever soil is kept excessively wet for prolonged periods its structure will become poor and compact. *Results from excessive wetness are more or less evident in all layers and all parts of the Valley.* The vibration of agricultural implements has also played its part in destroying soil structure. Clean cultivation in the past has interfered with the beneficial structure building effects of organic matter.

The problem now, of course, is *how to rebuild deteriorated soil structure* and how to keep good structure from going bad. Off hand one may think that discing will do the job, since it evidently loosens the soil. As a matter of fact, however, discing is only breaking the soil up into larger clods, not improving the structure within the clods. It does not improve the over all porosity of the soil which is so essential from the stand point of root growth.

A most important factor in rebuilding soil structure in the Valley is *organic matter.* Centuries past, through the soil building history of the earth, vegetation has changed waste land into fertile ground. The structure building effect of the dense root system of a cover crop should not be underestimated. Furthermore, organic matter is food for bacteria. When it is applied to the soil under favorable moisture and temperature conditions, the bacterial population will increase with tremendous speed through the entire mass of the soil. As a result of their life activities, gums and slimes are produced, and while the soil dries out, these materials will glue the finest single particles together into larger aggregates.

If the soil is allowed to stay excessively wet, such rebuilding of soil structure cannot take place. On the contrary these slimy substances will only add to further clogging up of the soil. The beneficial effect of periodic drying out of Valley soils has become evident in numerous instances. Drying out is evidently an important factor recombining soil particles, as well as in stimulating root activity by improved aeration.

While little attention is yet paid to the problem of soil structure here in the Valley, the *excess salt problem* is today recognized in its full seriousness by most growers. Both problems are closely interlinked. When soil pores become small and the soil clogs up, downward movement of water is retarded. Rains and irrigation waters do not wash salts down as freely as in more permeable soils. There is no healthy root action to drink the water up rapidly. The water lingers in the soil. Worse than that, through the fine capillary channels of a poor structured soil water rises, just like coffee rises in a piece of lump sugar. Beware of water which moves upward in the soil, keeping the soil moist to the very surface for prolonged periods. Here on the surface, water will evaporate in high amounts; salts will concentrate. The hotter the sun burns down, the higher will be the rate of evaporation and salt concentration.

The process of surface salt concentration may stop for a while. Rains may wash salts down to a certain horizon. Thus, the masses of soluble salts are moving and shifting at all times. If soil were transparent and the degree of salt concentration indicated by the intensity of—let's say—red color, we would get a most instructive bird's eye view of the Valley's irregular and ever changing salt picture. We would see everything from clear areas to deep red clouds. Sometimes the red would be concentrated near the surface, sometimes in deeper layers. We would notice how much the natural characteristics of the land have to do with the development of the salt problem, but again we would also be amazed at the profound differences caused by different management.

To our trees and vegetables *high salts mean drought.* The higher the salts the more difficult it is for the water to enter into the body of the plant. When salts are very high, plants may wilt long before available soil water is exhausted. To keep them from wilting, we must water before there is a chance for the root system to become properly aerated, before the soil can dry to improve structure. We are thus caught in a vicious cycle and the road back to healthy soil and production is a problem requiring thought and understanding.

In general the grower talks about salt injury only where this injury is plainly visible in defoliation, in dying or dead trees. Hundreds of acres, however, of seemingly normal trees are already, to some extent, affected. Salts are, more or less, excessive in lower layers and water stress occurs at certain times. Trees on such land show more serious defoliation as a result of dry north winds or intense summer heat. Fruit sizing is retarded. It is valuable for the grower to know the salt conditions of his land before salts become actually responsible for killing his trees.

A considerable amount of salt damage could have been, and still can be prevented, by keeping the soil open, by avoidance of excess water in entire fields or limited areas. Where the salt, however, has once reached injurious excess, we are confronted with a problem, which is new and different from our other soil management problems. The question is, *how to reclaim this land successfully and economically to normal fertility?* In only a few cases will a change of cultural and irrigation practices bring about reduction of salts. In by far most of the cases the problem looks like this: *Excessive amounts of salt can only be removed by washing them down below the root zone.* Large amounts of water are needed for this process. Because of lack of subsoil permeability these amounts of water will not freely move into lower layers. They will, therefore, keep the soil of the root zone wet for a long time. Additional salt rise will be the result. We defeat our purpose. The only remedy is to create a condition which will make water flow freely into lower layers. That means, such land must be artificially drained. If drainage cannot be installed because there are no outlets for the water to go to, all we can hope for is to keep salt rise down as much as possible and to keep as many trees alive as we possibly can.

The plain fact that drainage is the only permanent solution of the Valley excess salt problem is not yet sufficiently recognized by all our growers. There is no material available which when applied to the land will tie up the salts. Fertilizer applications on such excess salt land are of very little value. Variations in tree condition are the result of climatic influences, as light rains, lower evaporation. They are only rarely the result of nutrient applications.

When a grower has a chance to tie into suitable outlets for his

drainage water, he is confronted with two problems: *First, how shall I install the drainage system in my orchard, and second, what must I do afterwards in order to get quickest and best results?*

A drainage system must be able to take care of excess salt and excess water now and in the future. Suitable depth, spacing and location of tiles are essential. Among the drainage systems so far installed in the Valley there are already a number which do not seem to function properly. In some cases tiles are placed below impermeable layers. In other instances tiles have been installed properly, but salt wash down has not been effective, because the entire soil mass is in an impermeable condition.

Handling the soil after tiling has very much to do with our success in reclaiming the land. Many soils will require a rebuilding of structure. Their permeability should be improved many times.

The soil should have a chance to dry out completely. That may take considerable time, especially in case of bare land, where there is no plant growth to draw moisture out of the soil. Sulphur or gypsum, and later on the growth of cover crops may be very valuable. More research is needed on sulphur and its importance to permeability in Valley soils. Growers should not frantically purchase thousands of tons of sulphur just to do something. They must have a much greater assurance as to the benefit possible from soil amending materials. If the tiling system works and the soil is permeable, there is no reason why salts could not be flushed down rapidly if sufficient amounts of water are flooded on the land.

Fortunately such important soil characteristics as salt concentration and soil permeability can be measured, enabling us to get closer to facts and to observe trends on which to base future planning.

Fig. 1

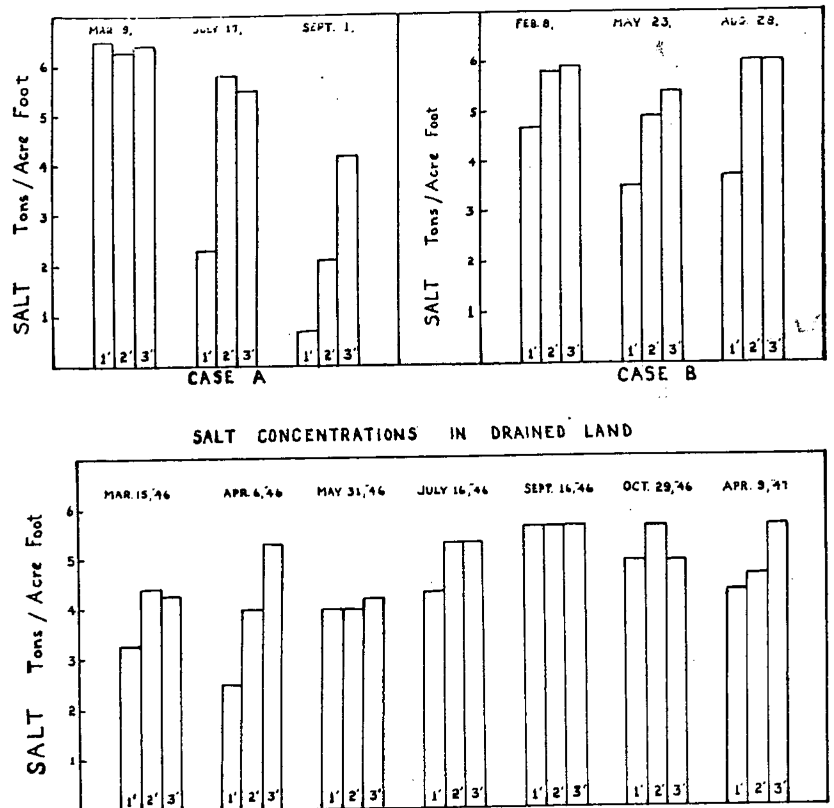


Fig. 1 shows salt concentrations [1] in tons per acre foot in orchards where drainage had been installed. Sampling holes were drilled in all instances at equal distance from one of the drain tiles; and samples taken in all cases from the first, the second and the third foot levels.

Case A: Drainage installed early spring of this year. Salts extremely high to begin with in all layers. Soil permeability improved much during the summer. Salts declined some during the summer, but very much after the heavy rains in early August.

Case B: Same soil type and same depth of tiling as in Case A. Soil permeability extremely poor because of continuous excessive wetness of the entire soil body. No salt decline. Salt situation even worse after, than before August rains.

Case C: Drainage installed two years ago. No appreciable wash down of salts because of impermeable soil layers above the tiles.

[1] Salt readings were made in 3 to 1 water to soil mixture with model RD-15 Solu-Bridge, manufactured by Industrial Instruments, Inc.

Fig. 2

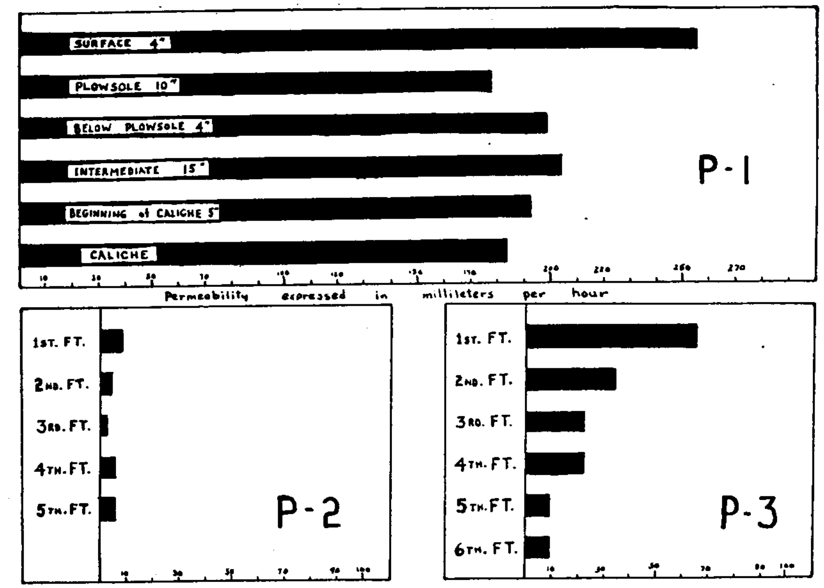


Fig. 2 PERMEABILITY OF VALLEY SOIL PROFILES

Case P-1: Permeability of entire profile good with slight decline in plowsole horizon.

Case P-2: Permeability very poor. Samples were taken from an area where tile drainage was installed, but salt wash down not effective.

Case P-3: Highly impermeable layer at fifth and sixth foot. Salts were found to be accumulating above. Tiles should not be placed below this layer. [1]

Fig. 2 shows the permeability of some Valley soil profiles. Permeability is here expressed as the amount of water in milliliters passing through a standard column of soil in one hour.

One should not think that permeability and soil aeration are only important under extreme conditions and in connection with drainage problems. They are most essential soil factors greatly influenced by daily orchard management. *Air is probably the most serious deficiency in our Valley soils.* If we apply, for instance, *more* water than needed to replenish the water of the root zone of the trees, we interfere with aeration and root growth in lower layers. If we soak the ground with water *before* it is needed, we also interfere with aeration. Such too early watering does not benefit our trees, since trees absorb water with approximately the same ease at any soil moisture content, as long as the moisture content is above the wilting point—that is above the percentage of moisture at which the roots are no longer able to take water from the soil.

[1] Permeability problems may be just as serious in light as in heavy soil types. P-1 represents a sandy loam in the surface, changing into loam and then into clay loam in the third foot. P-2 is a sandy loam in the first foot with clay loam below. P-3 is a medium heavy clay in all layers.

Fig. 3

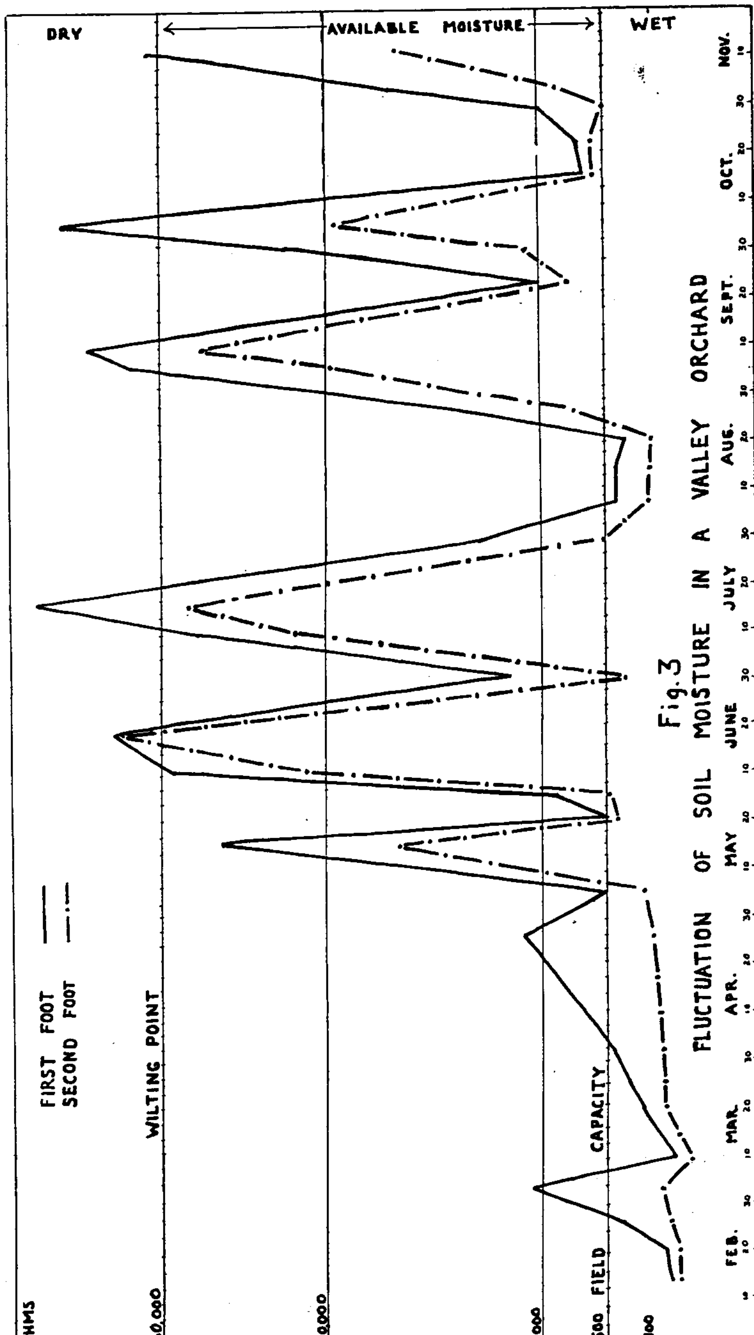


Fig. 3. Fluctuation of soil moisture in a Valley orchard. Note that the low points in the curves indicate wet soil, and the high points dry soil.

Fig. 3 reflects the soil—water house-hold in one of our Valley orchards. There are hundreds of orchards with a moisture condition similar to this one. Periodic moisture determinations were made with the help of the Bouyoucos Gypsum block method. To get the meaning of the curve you must understand that high moisture readings are towards the bottom. The drier the soil, the further towards the top are the readings. At any point above the wilting line the soil is so dry that no water is available to the roots. Periodic moisture readings were taken at the bottom of the first and second foot.

Towards the end of February the owner of this orchard got nervous and irrigated when he should have waited possibly two more weeks. That interfered with aeration. On tight and by nature poorly aerated soils such neglect of aeration may be visible in poorer tree condition for many months. During the hot summer (June, July) the curve shows rapid drying out between irrigations because of increased transpiration rates. During the first part of August the soil stayed wet due to repeated heavy showers.

After the period of showers wes over, the soil dried up much faster than expected. At that time many growers slept upon the laurels of the past magnificent rains and postponed irrigations. That is usually not advisable during the fall months. The foliage of the trees may not show wilting, but the fruit may stop growing because large numbers of roots in the upper soil layer are no longer able to absorb water necessary for fruit sizing.

Fig. 4

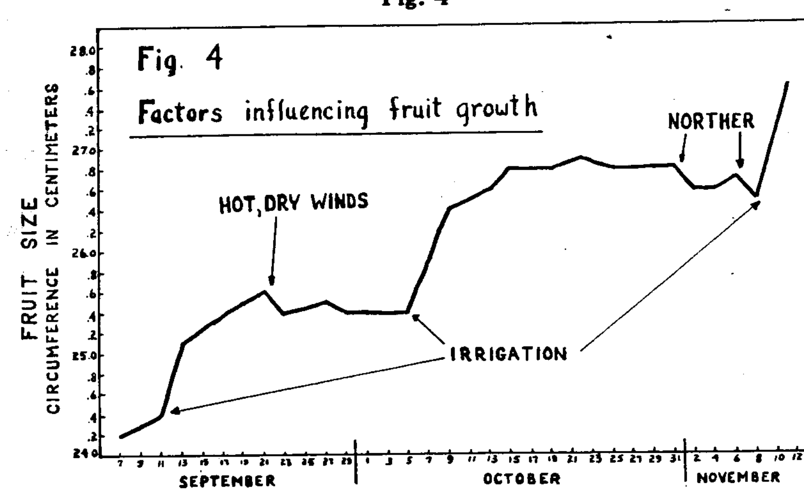


Fig. 4 shows a *fruit growth* picture which is quite typical for the Valley during a hot and dry fall. For about two weeks after an irrigation the fruit grows first fast, then more slowly. Then fruit growth comes to a standstill. The grower hopes for rain, and rain does not fall. During this period hot winds and dry northers will cause fruit to shrink. If the northers are very dry and moisture supply from the roots is scarce, some leaves may even desiccate causing loss of leaves. More frequent, shallow irrigations will pay in sizing up fruit, while too frequent heavy irrigations might cause water logging of lower horizons.

It is most remarkable how uniform such fruit growth curve will turn out no matter which trees and fruit you choose in the same orchard. But measure fruit in your neighbor's orchard, and you will be amazed how different the curve is because of different management.

When growers notice that their fruit is not sizing, they usually apply *nitrogen.* When heavy rains hit the Valley, they think nitrogen is leached out and again they apply nitrogen. Let us see what actually has happened to nitrates in our orchards during last summer and fall.

Fig. 5

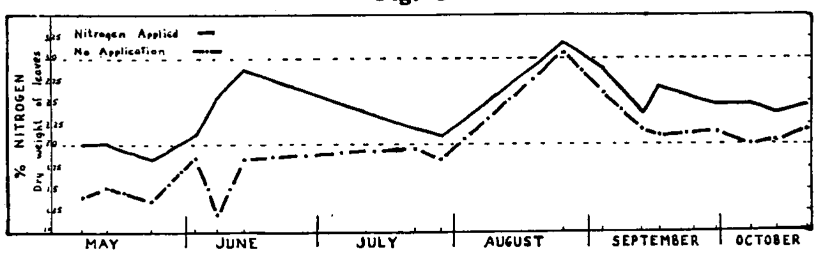


Fig. 5 % NITROGEN IN CITRUS LEAVES

Fig. 5 shows the nitrogen content of citrus leaves [1] in trees receiving heavy nitrogen applications and in trees not receiving any nitrogen application. The nitrogen percentage of all tree parts, except the leaves, is moving more or less at a uniform keel. Whenever available nitrogen is high in the soil, it is normally rapidly grabbed by the trees and stored up in the foliage for later use in the development of leaves, branches and fruit. The curve representing the fertilized trees shows heavy increase of nitrogen from the May application. No such increase is visible in the other curve since no application was made. During June and July followed a long, hot, dry spell and then came the early August rains. During these days of cloudy weather with repeated rains activity of nitrifying bacteria increased so tremendously that trees had a chance to absorb more nitrogen than at any other time of the year.

The art of applying plant nutrients is still in its infancy in the Valley. The problem is not just to apply some fertilizer, but why to apply this or that kind of fertilizer. It is wasteful to pile nitrogen up around trees which suffer from anything else except nitrogen deficiency. It is wasteful to increase phosphate availability where phosphate is stored up in available amounts.

[1] A modified micro-Kjeldahl method was used to make the nitrogen determinations.

On the other hand the possibilities of proper fertilizer applications are not nearly sufficiently utilized. What we can accomplish with nitrogen applications on healthy trees and healthy soils in the Valley is most outstanding. Vegetable growers especially are far from taking advantage of the possibilities from nitrogen and phosphate applications.

As far as minor elements are concerned, we are hanging too much on the shirt tail of Florida experiences. Our soils are much different. Our soils are rich in minerals and very powerful. Adding fertilizer is not like using an automat. You put one nickel in and get one chocolate bar, two nickels and you get two chocolate bars. The happenings in our soils are much more intricate than that. Their study is extremely interesting and of great practical importance to all of us. Over the entire world men are working with soil. No one keeps us from using their methods and findings and applying them fittingly right here on our own soils, together with our own practical experience.

The problem of our soils is, of course, too wide to cover it entirely within the scope of a single talk. I have especially emphasized the problem of structure because it is not discussed nearly enough, and the problem of salts because so many people are interested in it. What I particularly wanted to show is how *all problems are closely interwoven* To evaluate the problems of soil and growth you cannot specialize on one phase and forget the rest. You must be able to see the whole.

Behind everything we observe and experience in our orchards there is law and order. We cannot think of solving our problems unless we understand this order. Unless we work *with* nature and not against her; only then can we hope to again establish a happy balance between climate, soil, plant growth *and* our desire to make this Valley beautiful and prosperous.

FRUIT SETTING AND FRUIT DEVELOPMENT OF AVOCADOS IN TEXAS

By

R. H. CINTRON, *Horticulturist, Hoblitzelle Ranch, Mercedes, Texas*

The information presented on this paper is the result of only one year of observations, a year which might or might not be normal as far as weather and other growing conditions are concerned. The behavior of certain varieties was so evident however, that there is a good chance that they will react similarly in the future.

Observations on Pollination

Within the last twenty-five years, attention has been called to the flowering habits of the avocado, with special reference to flower behavior and its effect on pollination and subsequent fruit setting. Various methods have been suggested to accomplish effective pollination, the most common and widely used being the interplanting of reciprocating varieties. This horticultural practice has been advocated especially in Florida, in spite of the fact that the avocado has a perfect flower, each one capable of producing pollen and developing into a fruit. Notwithstanding the fact that the avocado has perfect flowers, there are pollination peculiarities which under certain conditions of climate might not be always conducive to a normal set of fruit.

The individual flowers do not shed pollen during the full length of the period when their stigmas are receptive to pollen. In general, the stigma matures before the stamens are ready to shed pollen and when these stamens finally mature and shed pollen, the stigma has withered and is no longer capable of being pollinated. Each flower behaves as if it were only female and later only male. This is true of all trees of a given variety—a condition known as synchronous dichogamy. This principle was first discovered by Nirody and later substantiated by Stout and others. The discovery of this synchronous opening and closing, soon led to a further discovery: that each individual flower has two periods of opening and a closed interval between these openings. The length of this closed period differs widely among varieties and in general is greatly altered by conditions of weather.

After a very detailed study of these periods of opening, Stout was able to group all varieties studied into two distinct classes. In group A or class A, he placed those varieties having their stigmas receptive in the morning with another set of open flowers in their second opening, opening and shedding pollen in the afternoon. In class B are all varieties showing a reverse behavior, that is, they exhibit receptive flowers in the afternoon with pollen shed at the second opening generally during the morning of the next day.

If this synchronization were not altered, it is clear that isolated plants, or plants within a variety, or varieties within the same group, would not set fruit unless pollen were available from varieties belonging to a reciprocating group.

Florida growers have been the most enthusiastic exponents of the need of interplanting these two groups. This practice has been going on in spite of several observations by experienced growers who have repeatedly noticed and experienced adequate fruit setting in isolated trees and in solid plantings. Such repeated observations have made many of them skeptical of the need of interplanting reciprocating varieties in spite of the fact that need for it as indicated by flower studies. The practice is still advocated and followed to a large degree in that state. They can point, to be sure, to some cases where fruit setting has been increased by providing the proper pollinator.

California growers, on the other hand, have been harder to convince of this need. They have many solid blocks, especially of the Fuerte variety which have been productive without the apparent need of a reciprocating variety. There, it is not a grower's practice to plan their orchards with that extra problem on their minds.

In California, in Florida and now in Texas, it has been observed that the opening and closing cycles of the avocado flowers are often

upset by violent weather changes. This results in "overlap" of the two sets of flowers. If insects are active and the overlapping period is not too short, considerable close pollination may occur.

While located at Mercedes, and during the winter and spring of this year, your speaker made frequent observations on the flower behavior of the avocado. Mexicans, Mexican-Guatemalan hybrids, Guatemalan and West Indian varieties were represented. In every variety studied, considerable overlapping was observed. This, coupled with a very abundant and active insect life, resulted in a satisfactory set of fruits. It is true that at the Hoblitzelle Ranch where the most detailed observations were made, eleven varieties are growing nearby, some of each of the two groups. The Fuerte and Duke, however, were early bloomers and set fruit during the last week of February, at a time when no other variety was furnishing pollen. Since both varieties belong to the same group, it must be concluded that the set of fruit observed must have been the result of pollination during the overlapping period. In fact, considerable overlap was observed in both varieties. At LaFeria, a planting of Lulas was blooming at a time when the only available pollen (aside from its own), must have been coming from the very tail end of the bloom of three Fuerte trees. The major portion of the planting, however, was blooming when no Fuerte flowers could be found, yet these trees showed a heavy set and to the present time are carrying a good crop.

Recognizing the fact that sudden changes in the weather will upset the synchronous opening and closing of the avocado flower resulting in considerable overlap, and assuming that the changeable weather observed during the winter and spring of this year, represent normal weather changes for the Rio Grande Valley, it can be concluded that under our conditions, deficient pollination will not be a major factor in fruit setting.

We must recognize a difference in the ability of a variety to set and the ability to hold and mature a reasonable portion of the young fruits. In the light of this year's observation, our problem with certain varieties will not be a pollination problem or one of fruit setting. The problem will be that of getting the young fruits to stay on the trees and growing to maturity.

Several factors have been recognized as contributing to excessive shedding of young fruits. Two factors are of paramount importance. Unfavorable water relations, especially a moisture deficiency, will cause abundant dropping. We are eliminating this factor as a cause of unfruitfulness of some varieties because in a planting consisting of several varieties all trees were watered identically and in every respect each tree was treated in the same way. Yet some varieties dropped all their fruits while others matured a good crop. Sudden heat waves especially when the fruit is small, will also cause excessive shedding.

Mexican varieties here will set in February, while other varieties of the West Indian and Guatemalan groups will set in March and April. The mean temperature during March was 67.3 degrees with maximum and minimum averages of 80.4 degrees and 54.2 degrees respectively. The mean temperature for April was 76 degrees with a maximum and minimum average of 86.1 degrees and 65.9 degrees respectively. These averages, however, do not present the entire picture. From the fourth to the tenth of April, the maximum temperature was in the lower 90's. Strong drying winds were prevalent during this period. Excessive dropping in most cases up to 100%, occurred in the Edranol, Ryan, Helen and Leucadia varieties. In May the average of the maximum temperature was 96 degrees with several real hot days and strong drying winds. The Nabal dropped every fruit during the first hot days of May. The Duke, Jalna, Fuerte, Lula and many West-Indian seedling trees, did not suffer much and any dropping observed can be considered normal. It is apparent, therefore, that some varieties are more sensitive than others to dry hot winds. Guatemalans and Guatemalan-Mexican hybrids appear to be affected the most. The Fuerte, a supposedly Guatemalan-Mexican hybrid, did not behave as other hybrids. These facts must be recognized if an intelligent selection of varieties for this Valley is to be made.

The Nabal, a Guatemalan variety, and the Ryan a Guatemalan-Mexican hybrid exhibited a very peculiar behavior. During their blooming period both varieties shed their leaves to an appreciable degree. Vegetative growth was resumed very soon after the fruit was set. Soon after this, an excessive shedding of young fruits was observed. It cannot be determined with certainty if the dropping was due to the high temperatures while the fruit was small or to a partial starvation of the tree due to an excessive demand from the vegetative organs. It should be pointed out here that varieties which were able to mature a good crop did not defoliate appreciably previous to fruit setting.. Also puzzling is the fact that the Leucadia variety, a supposedly Mexican, was able to retain its foliage during the blooming period, yet very early they dropped their fruits altogether. Its reaction is not that of a typical Mexican. Likewise, the fruiting habits and character of growth of the Lula, suggest a West-Indian Guatemalan hybrid and not a Guatemalan-Mexican cross it has been considered up to the present time.

Fruit Growth and Development

Under Rio Grande Valley weather conditions, fruit growth and development is very rapid. The Mexican varieties which normally set fruit in February, will attain maturity as early as the middle of June. Fuertes will begin maturing late in August. Ryans can be picked in October. Both varieties have large sizes by this time. West Indian seedlings will attain maturity and very large size in six months. Hot days and warm nights all through the summer, keep the fruit growing all the time.

It is discouraging to find, however, that while the fruit is growing at such a rate, oil formation is not keeping pace with fruit growth. Periodical oil determinations conducted as the fruit approached and attained maturity, showed in general that oil content is very low. This is true for West Indian as well as for selected Mexican and

Mexican-Guatemalan hybrids known to be high in oil when growing under California conditions, for example.

This low oil content in fruit physiologically mature, eliminates the practicability of using the oil test as a measure of maturity. In other words, if the fruit softens properly and drops from overmaturity while the oil content is still at a very low level, some other practical and easy method to test maturity must be found.

Table I presents data on four Mexican Varieties tested at different periods. Tests started July 14th when the writer obtained a Bauch & Lomb refractometer for this purpose. These tests continued while fruit was still available.

TABLE I

OIL FORMATION IN THE DUKE, MIDDLETON, BENEDICT AND JALNA VARIETIES OF AVOCADOS

	Percent Oil			
Date of Test	Duke	Middleton	Benedict	Jalna
June 15	4.10x			
July 11	4.50x			1.3x
July 14	6.10	5.5	9.72	5.24
July 25	7.20	5.6	10.60	6.12
July 17	7.22			7.47
Sept 5				10.60
Sept 24				10.62
Nov. 8				11.20

(x) Tested by the Texas Research Foundation, Renner, Texas.

It is evident from a study of this table that these varieties will not develop enough oil when maturing under our conditions.

Table II presents data for the Fuerte variety. It can be seen that up to the present time this variety is not developing oil to a satisfactory level in spite of the fact that the fruit is completely mature. This particular variety is still available and oil determinations will continue. It will be interesting to follow the formation of oil as the fruit develops through cooler weather.

TABLE II

OIL FORMATION IN THE FUERTE VARIETY

June 19	1.33x
July 14	3.70
July 25	5.55
Aug. 17	6.17
Aug. 28	7.70
Sept. 5	7.92
Sept 16	8.12
Sept. 24	9.17
Nov. 8	11.82

(x) Tested at the Texas Research Foundation, Renner, Texas.

Three West-Indian seedlings were also tested at different periods. As expected, their oil content was low, the highest showing 7.51% oil. Lula was tested March 24th, 1947, after being on the tree for fully twelve months. Under Florida conditions this variety will have between 8 and 12% of oil. Here it showed 7.75 percent. Ryans were also tested March 24th. It also had been for twelve months on the tree. That analysis showed 16.3% oil. Under California conditions, this variety averages 25% oil. It was also observed that under Texas conditions, avocado varieties not only will show a low oil content, but also the picking season is greatly shortened. The fruit drops very fast with approaching maturity and must be picked at very short intervals and during a short season. This is especially true of all Mexican and West-Indian varieties. Of the varieties observed, only Guatemalan-Mexican hybrids such as the Lula and the Ryan and to some extent the Fuerte, will stay on the trees for a longer time.

Summary and Conclusions

There is evidence to support the belief that under our conditions, there is enough overlapping to insure selfing of the avocado flower. There is no apparent need, therefore, of interplanting reciprocating varieties.

Fruit drop is very pronounced in certain varieties in some cases making them entirely unsatisfactory. Guatemalan varieties seem to be affected the most. In view of this fact, it is doubtful that the better types of straight Guatemalan varieties will ever be fruitful enough to be considered desirable for this region.

All varieties representing the three types of avocados, West Indian, Mexican and Guatemalan show low oil content when grown under our condition. It appears in general that high oil content is more a response to low mean temperatures during fruit development than a specific varietal characteristic.

All observations point to the belief that due to the low oil content of most varieties when grown under our conditions, the oil test will not be practicable as a measure of maturity. Some other method must be found to accomplish this need.

DIVERSIFICATION OF ORCHARD CROPS OF RIO GRANDE VALLEY

By

J. ELIOT COIT, *Coit Agricultural Service, Fallbrook, California*

It was hardly necessary for me to come from California here to suggest that when the new acreage of grapefruit now being planted in this valley comes into bearing, you may have a surplus. In fact, I have been told that there is a surplus now. Evidently greater diversification of orchard crops is needed. I have been asked to present my ideas with respect to what extent the growing of other tree crops is practicable, which crops may be best suited to environmental conditions here, and for which there may be a reasonable market demand. These are rather large questions for a nonresident to answer. A good

deal of research and investigation will be necessary before the right answers may finally be arrived at. My remarks, therefore, are to be taken simply as suggestions.

After looking over the list of orchard crops which may hold some promise, and having in mind the limitations imposed here by the Mexican fruit fly regulations, I can think of at least three crops with definite possibilities. These are Mexican type limes, papayas, and avocados. I do not believe that any one, or combination of these, can be developed into an industry comparable in volume with your present grapefruit and orange industry. However, if some lands can be diverted to them, to that extent may the pressure on the present grapefruit market be reduced.

Mexican Type Limes

While the lime is a specialty item, and is handled and marketed quite differently from lemons, there has long been a good demand for fresh lime drinks as a thirst quencher, particularly in summer. Lemons can be substituted for limes for certain uses only; such, for example, as a garnish for sea food dishes and in hot and cold tea. Lemon juice is not satisfactory for use in carbonated mixed drinks, either hard or soft. Here the lime is supreme and finds its place beside the "fizz-bottle" in every bar. The lime must be squeezed fresh for each drink in order to provide that distinctive aroma of lime oil from the rind.

Because of climatic conditions there is great difficulty in getting Mexican type limes up to good size and maturity in either California or Florida in summer when the demand is greatest. Therefore growers in California have turned to the less desirable Bearss and Florida growers are producing the Tahiti lime. But demand of the trade is still strong for Mexican type limes. I will not take time here to go into all the interesting reasons why. Many millions of pounds of Mexican limes are imported each year, chiefly from Mexico. They grow in many parts of that country and are of good size and quality in summer. Dealers in the United States would prefer to buy limes in this country because of the difficulty in getting Mexican growers to grade and pack them uniformly, and also because of inadequacy of transportation facilities in Mexico. A packing-house is maintained at Laredo for the regrading and packaging in small paper cartons of these limes, many carloads of which arrive days or even weeks behind schedule.

Another and ominous handicap in handling limes from Mexico is the fact that Black Fly (*Aleurocanthus woglumi*), an extremely devastating citrus pest, has become well established in Mexico. It is now found at several places in central Sonora, and has recently been reported at Valles near Tampico. In Cuba and elsewhere this pest has been controlled by biological means, but in Mexico, on account of climatic conditions, introduced parasites have so far failed to give control. We may expect, any day, to have Mexican limes either quarantined out of this country, or we may have to subject them to fumigation or other treatment at the border. This will not only mean more expense and delay, but may seriously injure their marketability.

Mexican type limes thrive in this valley and produce good sized fruit. The main picks come in June to September which is the season of greatest demand. This past July, I took samples back to show to the Manager of Calavo Growers who stated to me that they were quite satisfactory. The chief function of Calavo is to pack, distribute and market California avocados. Limes and some other sidelines, such as Florida avocados, are distributed in summer, when the volume of California avocados is not sufficient to keep the employees and distributing facilities throughout the country fully occupied.

But before you can fully grasp this opportunity to grow and sell 10 to 15 million pounds of limes a year, the subject should receive considerably more study and investigation. I see that you can grow three kinds of limes; thorny, thornless, and a form called "limon" by Mr. Ballard. For the sake of uniformity of product you should find out which is best for all purposes and make that standard. In picking limes here it has been customary to pull them rather than clip them. Is that really best for keeping quality? The market prefers limes to be green in color. How should they be treated here to retard decay and enable the green color to be retained for a longer time? What standards should be adopted with respect to acids and juice content?

It is true that the lime tree is more tender to cold than grapefruit and some sections of the Valley may be found better adapted than others. It is my understanding that the lime is not attacked by the fruit fly and that they may be harvested all summer. Abrasions caused by wind injure the appearance of limes and you may find the thornless variety less affected, or you may find it advisable to provide windbreaks. Soil types best adapted; irrigation, fertilization, rootstocks and cultural methods, all should be investigated. If these problems are vigorously attacked and solved, I see no reason why the production of Mexican type limes may not become a profitable industry here.

PAPAYAS

For many years papayas have been grown here in a small way for home use in yards and gardens. When planted on light soils and given good care, they yield well. I have eaten fresh papaya in many parts of Mexico as well as here, and in my judgment the quality of fruit produced here compares very favorably with that grown in Mexico. Grown from seed, the plants begin maturing fruit in about fifteen months, or in much less time if the seeds are planted in a greenhouse in fall and planted out as good-sized plants in spring. Seed is cheap and plentiful. Because of the short time needed to mature the crop, a relatively small amount of capital is necessary.

Papayas are quite tender to frost and are very likely to be injured or killed by cold occasionally. But this is not too serious because they may be replanted and brought to bearing so quickly. On poorly subdrained heavy soils the plant is subject to root rot, and the fruit is often attacked by the anthracnose fungus which causes spots on the skin. It should be possible to control the latter after experi-

menting with fungicidal sprays. The market demands a small sized roundish fruit, and the variety question should not be too difficult of solution.

The principal reason why more papayas have not been produced in the Valley is the lack of marketing facilities. In my opinion there already exists a certain amount of demand in the markets throughout this country. Americans are increasing their travel in foreign tropical countries where they get acquainted with, and learn to appreciate the good qualities of the papayas. Thousands of our young men and women saw military service in the tropical lands of the Pacific where many of them learned to like papaya. These ex-service people are now back at their homes scattered all over this country. No doubt they will buy papayas when they are available in their local markets. The selling price of papayas is high enough to warrant shipment by air-freight to all our principal cities.

While bi-products of other fruits are not usually as profitable as fresh fruit, there are, in the case of papaya culls and surplus, interesting possibilities such as liquid juice, evaporated and powdered juice, and certain drugs and chemicals which are derived from the papaya fruit. Quick freezing papaya also offers much promise.

In past years some papayas from Hawaii have reached the Pacific coast cities, but due chiefly to transportation delays, the quality was so poor that this business has not grown. Calavo Growers of California has all the necessary facilities of distribution and the trained personnel to handle this business. They probably would be interested in handling papayas as an additional side-line, especially in summer and fall when avocados are not plentiful. In my opinion papaya culture has considerable promise in this valley.

AVOCADOS

Over the years a good many avocado trees have been planted in this valley. Most of them have died out, but a few here and there have lived, and some have grown well and borne fruit. No one seemed to know why such a large proportion of the trees failed. In the summer of 1941, Mr. Karl Hoblitzelle asked me to plan and supervise a good sized experiment to find out if avocados can be grown commercially here, and if not, why not.

At first the variety question seemed most important. The only place I knew of where 600 first class budded trees of eleven different varieties could be obtained was Armstrong Nursery in California. All these were on Mexican root-stock as that is used exclusively in California. These trees were carefully selected and shipped to Mercedes in November, 1941. Due to war restrictions on travel, I was not able to visit them again till January, 1947. During this interval I was in frequent correspondence with Mr. Morris Allen under whose care they were being grown.

Many of these trees died out rather promptly. Some of them grew well and today are large trees for their age. The most successful trees were those planted on well drained sandy soils. The ones which failed were mostly those on heavy, poorly subdrained soils. We now feel that one thing has been sufficiently demonstrated, and that is that it is useless to plant avocados on heavy soils.

In the beginning Mr. Friend of the Experiment Station here told me that, in his opinion West Indian root-stock was best for this valley. But we could get none on that stock for comparison purposes. Observations made last January and again in June by Dr. Cintron and myself, of various bearing trees scattered through the valley, appear to confirm Mr. Friend's opinion. Trees will grow well on Mexican stock as shown by the trees now on the Hoblitzelle ranch. Other trees on West Indian stock grow just as well and apparently are less subject to leaf tip-burn. We are now growing trees here on West Indian and Guatemalan stocks. We plan to mound the soil above the bud-unions for several years in order to protect these more tender stocks from cold.

Since Dr. Cintron has been employed by Mr. Hoblitzelle, he has taken special interest in the avocado experiment and much valuable data has been compiled. He is now top-grafting some trees to many additional varieties from California, Florida and Puerto Rico. He is also experimenting with nursery propagation, irrigation methods, soil management, disease control, etc. He has made extensive observations on avocado flower behavior. Using a refractometer, he has tested the fruit for oil content during its development. He is on this program to report to you some of his observations. I may say here, however, that due to local climatic conditions, several of our California varieties fail to develop normal oil content before maturity. Most varieties, so far tested, bloom heavily and set excessive amounts of fruit, but some of them drop it all before maturity. Anthracnose decay of the fruit is very serious, and with some varieties repeated sprayings with bordeaux have failed to control it.

Of the older bearing trees observed in the valley, the Lula seems to be a healthy grower and bears fair crops of fruit which is little affected with anthracnose. The Lula is grown commercially in Florida, but I know of only one or two trees in California. It is supposed to be a seedling of Taft, which is a pure Guatemalan. I think this must be an error as it has every appearance of being a hybrid between Guatemalan and West Indian. We plan to test the Itzamna, and any other promising similar hybrids which may be brought to our attention.

The Valley growers owe appreciation to Mr. Hoblitzelle for his generosity and altruism in authorizing and financing this comprehensive avocado experiment.

Before the avocado can become a commercial crop here, there are a number of additional problems which will have to be solved by investigation and research. It is not easy and will take time. If we are finally successful and produce an avocado of good marketability, I think the logical thing would be to form a cooperative packing association to handle limes, papayas, and avocados. The distribution and marketing requirements of all three are similar. It would seem to be economically advantageous for these fruits to be marketed through the same facilities.

A SEARCH FOR NEW ROOTSTOCKS FOR AVOCADOS

By

H. B. GRISWOLD, *President California Avocado Society, President United Avocado Growers, La Habra, Caliornia*

Before describing possible new scources of rootstocks for avocados, it will be necessary to review the past experience with rootstocks in California. At hand were the commercial varieties and miscellaneous seedlings stemming from these varieties. It was only natural that seeds from these trees should supply the nurseryman with rootstocks.

Commercially produced avocados fall into three recognized groups or races: West Indian, Guatemalan and Mexican. In addition there are hybrids between these races having intermediate characteristics. In California we grow only the Guatemalan, Mexican and hybrids of these two. The West Indian race is too tropical in its requirements and it not adapted to the sub-tropical climate of Southern California.

It is now standard practice to use the pure Mexican race seedlings for rootstocks. These have proved to be the best of the locally available seedstock. They are vigorous growers and the most hardy of the races to cold. The Guatemalan race seedlings have been used to a limited extent but have demonstrated no advantages over the Mexicans. Their greater susceptibility to frost has stopped their use. Hybrid seedlings such as from the Fuerte variety have sometimes been used but they show great variation in vigor and the nurserymen do not like them as they make an uneven stand in the nursery row.

The California avocado industry would have been satisfied with its present Mexican stocks if it were not for the increasing menace of a root rot called avocado decline. This condition results from oxygen starvation in the root zone and the resulting destructive activity of a fungus *Phytophthora cinnamomi*. The majority of our avocado orchards in California are on clay soils through which water percolates slowly. Heavy winter rains or bad irrigation practice cause periods of water logging and the resulting oxygen starvation promotes root decay. Once the *P. cinnamomi* fungus, which appears to be widely distributed, is active in the roots the tree slowly dies over a period of several years. Replanted avocado trees will not grow where a declined tree has been removed.

Interest has been stimulated in finding a possible decline-resistant rootstock. Among the local sources none has proved promising, the Mexican seedling being still the best available.

In October 1946 this writer and Carl Crawford of Santa Ana, Calif., visited Wilson Popenoe, director of the Pan-american School of Agriculture in Honduras. We had a long standing mutual interest in the avocado. Wilson Popenoe took us to see wild primitive forms of the avocado growing in the cloud forest on nearby Mt. Uyuca. Here in a wet jungle at 7000 feet were huge old avocado trees growing on heavy soil saturated with water from the over one hundred inches of seasonal rainfall. These trees were vigorous and healthy with no signs of decline. We were greatly impressed with the possibilities of trying these or similar types as rootstocks in California.

When we returned to California we discussed these possibilities with Dean Robert Hodgson of the University of California and others and it was determined to secure as many forms of these primitives as feasible for test as rootstocks. To carry out this project a special committee of the California Avocado Society was formed. Several expeditions have been made to acquire avocado plant material in Mexico and Central America.

One form of primitive avocado is widely distributed in the subtropical mountain forests of Mexico and Central America. We have found this form between 7000 and 9000 feet elevation at Mt. Uyuca, Honduras; near Tecpan, Guatemala and in the Mt. Orizaba region of Mexico. This wild form is classed as *Persea Americana* which classification also included the two commercial avocado races: Guatemalan and West Indian. It is our belief that this primitive form is the progenitor of both the West Indian and Guatemalan races of avocados. The early Spaniards found both races on the mainland, the Guatemalan in the highlands and the West Indian on the tropical coast line. The Spaniards are known to have introduced the so called West Indian race to the West Indies where they were not previously found.

The wild *Persea Americana* is a large upright tree with non-anise scented leaves. They bear small, green fruits about 1½ inches in diameter mostly all seed with very little flesh. The skin is medium thick. They bloom in the spring and mature their fruit about twelve months later.

An extensive search was made for the wild form of the Mexican race avocado which is classified as *Persea drymifolia*. Tracing through the Mexican markets it was found that the most primitive type fruits were in the Mt. Orizaba area. Back in the mountain valleys at about 5000 feet we found growing almost exclusively primitive forms of these Mexicans. These trees were large spreading specimens obviously accustomed to open spaces. Both the leaves and the fruits were very strongly anise scented. Some fruits were too bitter to eat while others had a delightful flavor and had local market value in spite of their diminutive size. The fruits were less than an inch in diameter, black in color and with large seeds and little flesh. The skin is very thin and fruits are eaten skin and all.

They were always found in association with the local inhabitants and definitely are not found in the mountain forest ringing the valleys where the wild *Pers a Americana* is to be found. We believe these primitive forms to have been indigenous in these mountain valleys

and to have been engulfed by the Indian culture. They are no longer to be found in the truly wild state except as escapes.

We also found other wild Perseas in the mountain forests of these regions. These are not true avocados but closely related forms and might be possible root stocks.

This plant material is being gathered in California as fast as government restrictions will permit. It will take many years to complete tests. Progress will be announced through the pages of the California Society "Yearbook". If any of these primitives prove to be valuable as rootstocks they will eventually be available to the avocado industry.

Fig. 1. The aguacatillo, a primitive type of avocado, found in mountainous regions of Honduras, Guatemala, and southern Mexico at elevations of 7000 to 8000 feet. Note the small size of the fruit in comparison with the pocket knife shown.

ORGANIZATION OF THE TEXAS CITRUS ADVISORY COUNCIL

By

C. L. SKAGGS, *Chairman Citrus Advisory Ccuncil*

I was requested by your Program Chairman, to tell you something about the organization of the Texas Citrus Advisory Council; as to its operations to date, and what we propose to do for the citrus industry. Before getting into a discussion of the setup of the Council I think it is well that we should review some of the conditions that lead up to the necessity for such a Council.

I am one of the oldtimers in the Valley, having been here since December, 1923. You will therefore know that I have observed the progress of the citrus industry in this area. I have observed it, not only from a banker's viewpoint, but I have been actively engaged in the production of fruit since I set my first trees in April, 1924.

Notwithstanding the fact that the industry was still quite young we ran into production and marketing difficulties during the depression of the early thirties. The difficulties were so great that fruit was sold below the cost of production, and in an attempt to have orderly marketing, two efforts were made to solve the problems, by the adoption of Federal and State Marketing Agreements, both of which were unsuccessful in stabilizing our markets. Subsequent to that time we had the lush War years, during which time, everybody made money in spite of themselves, instead of because of themselves. This was particularly true with the citrus growers of the Valley. New people came into the industry and a great many of us whose memory was short, concerning the marketing difficulties of prior years, were guilty of planting every additional acre that we could, completely forgetting that history usually repeats itself. The same policy was pursued in Florida, the result being that we still have, in Texas and Florida, literally hundreds of thousands of young trees that have not yet come into bearing. The unfortunate part about the situation is that a great many of the trees were planted by people who never had any intention of keeping them until they came into bearing, but on the contrary, expected to dispose of them at a handsome profit, and leave the problem of marketing the fruit to people who have been and will continue to be in the business of growing and marketing fruit as a means of livelihood. Who is to blame for the situation is of course beside the point, but it does present a grave problem to us, which will require the best thinking and our best efforts to solve.

It is unfortunate that our self interest is often the cause of many of our troubles. Again, unfortunately, our own self interest is outweighed by our selfish interests when we attempt to take advantage of the situation and beat the other fellow to the high markets, when we know full well that such a policy is against the best interest of the industry and will eventually be against our self interest, rather than for it. This selfish interest is evident throughout the industry; by growers, canners and fresh fruit shippers, independent and cooperative, alike. Every year we see a rush to dispose of our crops first and we are not willing to heed the advice of those who know best about marketing conditions, when they caution us to ring pick and ship only large sizes and mature fruit that the market will absorb. The result is, that notwithstanding the general prosperity and heavy buying power that exists in the Country now and has existed for about seven years, when prices for nearly everything else are at all time high peaks, we have again run into marketing difficulties.

About a year ago, when we had the first serious drop in our prices, everybody began thinking about remedies. Our State Commissioner of Agriculture, J. E. McDonald, decided to appoint a group of Valley men who could work together and perhaps solve a portion of our problems. He appointed a group of approximately 25 Valley men and asked us to get together and see what could be done to solve

the industry's ills. The group met, and after giving thoughtful consideration to the personnel of the committee, we decided that the Council, should be composed of a cross section of the industry, giving proper thought and consideration to a committee representing different segments of the industry. It was finally decided that the Council should be made up of twenty-eight men with each member having an alternate, to be composed as follows: 7 growers who market their fruit through cash buyers and independent fresh fruit shippers; 4 growers who market their fruit principally through cooperative associations; 5 members representing independent shippers and cash buyers of citrus fruits; 2 members representing cooperative shipping associations; 1 member representing independent cooperative canners; 3 members representing independent cash buyer canners; 1 member representing independent cooperative fresh fruit shippers and 4 members representing Valley-wide business interests, not directly associated with either of the foregoing groups. I was elected to serve as Chairman, Paul T. Vickers of McAllen, Vice-Chairman and Stanley Crockett of Harlingen as Secretary-Treasurer.

The Council has since been incorporated as a non-profit organization. It is my opinion that the membership represents a highly satisfactory cross section of the industry, and from careful observation of the committee at work, it is my belief that the decisions and actions of the committee are going to represent their best thought and unselfish action, and that its recommendations should be received and considered as being in the very best interest of the industry as a whole. Obviously there are a great many men in the Valley who are not on the committee, who could be of valuable service to it in its deliberations, but as I said before, I do believe that the Committee as presently constituted does represent a good cross section. The by-laws as adopted, provide for a revolving membership. Each year the terms of approximately one-third of the membership will expire, which will make it possible to have new members and new ideas from year to year. Alternate members are welcome to attend all meetings and enter into all discussions, but do not have a vote, except in the absence of their principals. The actions, the decisions and recommendations of the Committee are therefore a result of the best thinking of 56 men who are vitally interested in the citrus industry.

Through the cooperation of Mr. Hart T. Longino of the Federal Inspection Service, Mr. L. E. Pratt and Commissioner McDonald of the State Department of Agriculture, collection of inspection fees were discontinued during the later part of last season and the shippers voluntarily continued to pay the 2c per box fee, which was turned over to the Advisory Council, to be used for the benefit of the industry in whatever way seemed best to the Committee. The Committee immediately put to good use a portion of the funds: First, by a grant of $5,000.00 to the Texas Experiment Station to supplement the funds supplied by the State and Federal Governments in the study of root stocks and soil salt conditions as presently conducted by Dr. Wm. C. Cooper at the Valley Station. An additional $7,500.00

was allocated for the use of the Federal Marketing News Service, which was scheduled to be discontinued, had it not been for this allocation of funds. An appropriation was made to pay the expenses of some of the out of State speakers who are appearing on the program of this Institute. There is still a considerable balance in the Treasury, to be used for any good purpose which will benefit the industry.

At the last meeting of the Council held on Monday, November 17th, we heard Dr. S. E. Jones, Vice-Director of the Texas Experiment Station; Dr. G. W. Adriance of the College Staff, and W. H. Friend, Director of the Valley station, concerning the difficulties they have encountered in the proper promotion of citrus research, because of a dreadful lack of sufficient funds. They were invited to appear before the Council to tell about the work that has been done and the work that they propose to do, and to determine what, if anything, the Committee and the industry could do to be helpful. A suggestion was made by Mr. Hugh Rouw of Edinburg, an independent shipper and member of the Council, that the shippers and canners of the Valley should and he believed would, be willing to again pay an assessment equal to one cent per box, which would be a direct cost to the shippers, but indirectly a cost to the growers.

Assuming 25 boxes per ton, this would be an insignificant cost of 25c per ton to the industry. The U. S. Department of Agriculture has estimated our current crop is in excess of thirty million boxes. A one cent per box donation, would, within a comparatively short time, create a fund of approximately $300,000.00, which would come into the hands of the committee, to be used for research on production and marketing, advertising, and other problems. Directors, representing the different segments of the industry were requested to contact their organizations and be in a position to report to the committee at its next meeting, to be held on Monday, November 24th, as to whether or not their respective groups would cooperate in such a move. There is a definite feeling that some such program will be worked out.

I must call to your attention, that the Citrus Council is a purely voluntary organization, without any authority to levy such a fee or tax, upon the growers and shippers, but the payment of this one cent per box must be on an entirely voluntary basis. If you think such a plan has merit, and would have the support of the growers and the industry as a whole, now is a good time to contact the members of the Council and urge the adoption of such a program.

Some people may ask why such an enormous amount of money is needed. Yesterday on this program Dr. Hayward, Director of the Federal Laboratory at Riverside, California, gave us some idea of the heavy cost of research, and the time involved in working out a great many problems. As a matter of fact, our own Texas Experiment Station Staff, which is a division of A. & M. College at College Station, requested of our last Legislature, an appropriation of approximately $300,000.00, which was their idea as to the amount

needed to carry on the proper research work. They received approximately 50 thousand.

I have already told you that the committee acts only in an advisory capacity and they have no authority to make any sort of rule or regulation that will bind anyone, but in order to be effective, it must have general support of everybody interested in the industry. The committee may make some mistakes, but it is my belief that it can, with your cooperation, do a lot of good for the industry. It is composed of busy men who are giving a lot of their time, without any hope of direct personal reward, but receiving only the satisfaction of having done something for an industry that needs support. Its success or failure will depend upon the almost unanimous cooperation of everyone. In any event, it will take time, so if progress seems slow, do not be too quick to criticise. I hope that the industry will accept the Council as its spokesman which will make it more effective when approaching the State and Federal governments concerning industry problems.

The Council meetings are open to the public and we shall at all times welcome any helpful and constructive suggestions.

ROOT DISTRIBUTION STUDIES IN CITRUS

By

H. E. HAMPTON, G. W. ADRIANCE, C. C. EDWARDS,
T. E. WRIGHT, G. W. OTEY and G. R. WILLIAMS

Although root distribution studies have been conducted with apple, peach, and other fruit trees, little work has been done to determine the relation of soil conditions and cultural practices to the distribution of citrus roots. The investigations reported here were undertaken with the hope that the findings would be of value in planning experiments involving fertilizers, soil amendments, cultural practices, irrigation and drainage. Because of the importance of Marsh Seedless grapefruit, this variety was chosen, and the study was limited to 12-16 year old trees.

Preparation of Excavations

Locations were selected to reflect a variety of conditions. The soils ranged from sandy loams to heavy clays, and from well-drained to poorly-drained. Some of the trees are in orchards which have always been basin irrigated and cultivated with heavy disks. Others are in orchards which have been irrigated by the sprinkler method for periods of 2-4 years and the weeds have been controlled by means of either a mower or a stalk cutter. Two of the orchards have not been cultivated (nor intentionally irrigated) during the past ten years. A total of 93 trees have been used in the study.

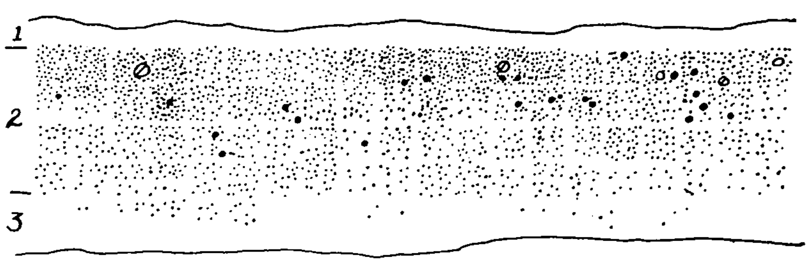
Holes were dug in two locations with respect to the trees. In one case, the excavation was dug under and along the extremities of the branches, being ten feet long, two feet wide and to a depth greater than the deepest roots. In the other case, the excavation extended radially from the trunk to several feet beyond the spread of the tree.

Variation in Root Depth

At several locations the roots of the trees were limited to the upper two feet of the soil, while at others the maximum depth at which live roots were found in this study was about six feet, although deeper citrus roots have been reported. The depths to which the roots had penetrated were dependent upon two principal and related factors, the nature of the soil and the height of the water-table.

Several of the locations were on heavy, dark-colored clay soils which are very plastic and tough when wet and crack badly upon drying. Because of increased density and compactness with depth, the pore spaces in these soils are very minute at lower depths and do not permit proper aeration and ready penetration of roots and water. At every location on these soils, the roots were found limited to the surface layers, the trees stunted and dying-back, and production low. The distribution of the roots of a tree representative of those growing on heavy soils is shown in Fig. 1. No water tables were encountered at these particular locations, possibly because irrigation water is more likely to evaporate at the surface than to penetrate and accumulate at lower depths. The color and other features of the soil indicated poor aeration. Although the trees showed pronounced deficiency symptoms, it was noted that they were no more likely to be affected with scaly-bark or gummosis than trees growing in more favorable locations.

LOCATION NO. B.V. 1



1. 3-4" Plowed surface composed of dark gray finely cloddy clay, very plastic when wet.
2. 22" Dark gray, tight, very dense clay, very slowly permeable, deep cracks form on drying.
3. Light brown crumbly moderately permeable clay.

Fig. 1. Root distribution of a tree representative of those growing on heavy, dense soils.

At a location in an orchard typical of those having restricted root systems because of high water-tables, the soil from 23-51 inches

below the surface was found to be saturated with water and free water stood in the excavation at 51 inches on the day that the distribution of roots was determined. That citrus roots cannot grow and function freely in soil layers which are saturated with water is evident from this study. As shown by the graphic presentation in Fig. 2, no large roots and only a few feeder roots of this tree which is representative were found below a depth of two feet. No roots extended below 39 inches. Almost all of the trees which have restricted root growth due to saturated soil layers were found chlorotic, were dying back, and a large portion of them exhibited evidence of scaly-bark and gummosis.

LOCATION 15 A - R.F.

1. 0-8" Medium gray sandy clay loam, compact brittle when dry.
2. 8-23" Brownish - gray clay loam, crumbly and friable.
3. 23-39" Light brownish - gray crumbly clay to clay (increasing clay with depth), few lime concretions, layer saturated with water.
4. 39-46" Light gray clay, plastic but rather crumbly, containing numerous lime concretions, saturated with water.

Free water surface at 51 inches.

Fig. 2 Root distribution of a tree representative of those growing on soils having saturated layers near the surface.

Citrus trees can not grow vigorously or yield well when root penetration is restricted. Nutrient uptake must necessarily be limited under these conditions because of the lack of root surface for absorption. Furthermore, the concentration of salt in the soil will affect water uptake. As the supply of nutrients in the surface soils is depleted or the nutrients rendered less available by the addition of salts, the tree is likely to show decline in vigor.

The roots of most higher plants are unable to live and few can function properly in the soils saturated with water. Numerous investigators have pointed out that the roots of fruit trees do not grow normally nor absorb nutrients efficiently when the oxygen supply is limited. The colors and other physical features of the soils as well as saturated soil conditions, indicated inadequate aeration, and it is doubtful if the few live roots encountered in the wet layers were active. Most of them, in fact, appeared to be in various stages of deterioration.

Lateral Distribution of Roots

It has been observed that many citrus growers broadcast fertilizers and soil amendments like sulfur under the branches of the trees, while others broadcast or drill the materials in the middles between the trees. The question as to which is the correct practice naturally arises, and the observed variations in placement indicate an incomplete knowledge of the rooting habit of citrus trees.

Obviously, fertilizers should be applied in the region of the greatest concentration of feeder roots. The result of previous root distribution studies pointed to the possible destructive influence of cultural practices on the feeder roots located in the top few inches of soil, which are the roots most likely to be active in the absorption of the nutrients added in the fertilizers. Although it is generally known that the feeder roots of trees are usually most abundant beyond the branches, deep cultivation may destroy sufficient roots to greatly impair nutrient uptake and contribute to tree decline. Deep disking could be especially damaging to trees whose root systems are already restricted because of tight or water-saturated soils.

A study to determine the distribution of roots from the trunk of the tree outward under different cultural practices suggested itself. Locations reflecting three conditions were selected, (1) orchards in which bordering and deep tillage have been practiced continuously, (2) orchards which have not been bordered or deep tilled for ten or more years, and (3) orchards which formerly had been bordered and disked but which have been sprinkled and mowed for the past two to four years.

Although the number of excavations studied were too few for a complete understanding of the full range of conditions, the root distribution pattern obtained under each set of conditions was so consistent that the following discussion seems warranted.

Bordering and deep tillage operations destroy the surface feeder roots as shown by the graphic presentation in Fig. 3 (A). At this location, which is representative, the roots were restricted to the upper 36 inches of the soil. Relatively few roots were alive in the third foot because of the saturation of that layer with water. The soil under the tree had not been disturbed in tillage operations and roots were growing immediately under the surface, but the use of a border machine and a heavy disk had materially decreased the total volume of feeder roots by destroying those in the plowed layer in the middles between the trees.

In orchards where bordering or deep cultivation had not been practiced for ten years or more, the feeder roots in the upper 18-inch

layer of soil were distributed very uniformly. Although the distribution of roots was charted only to a depth of 18 inches, roots were found nearly as numerous in the lower layers as in the surface. Considering the lack of care, the trees were in remarkably good condition. That the roots of citrus trees are able to compete successfully with those of bermuda grass and other weeds is evidenced by the presence of tree roots in the immediate surface of the soil. As shown in Fig. 3 (B), the greater concentration of feeder roots was found beyond the spread of the branches.

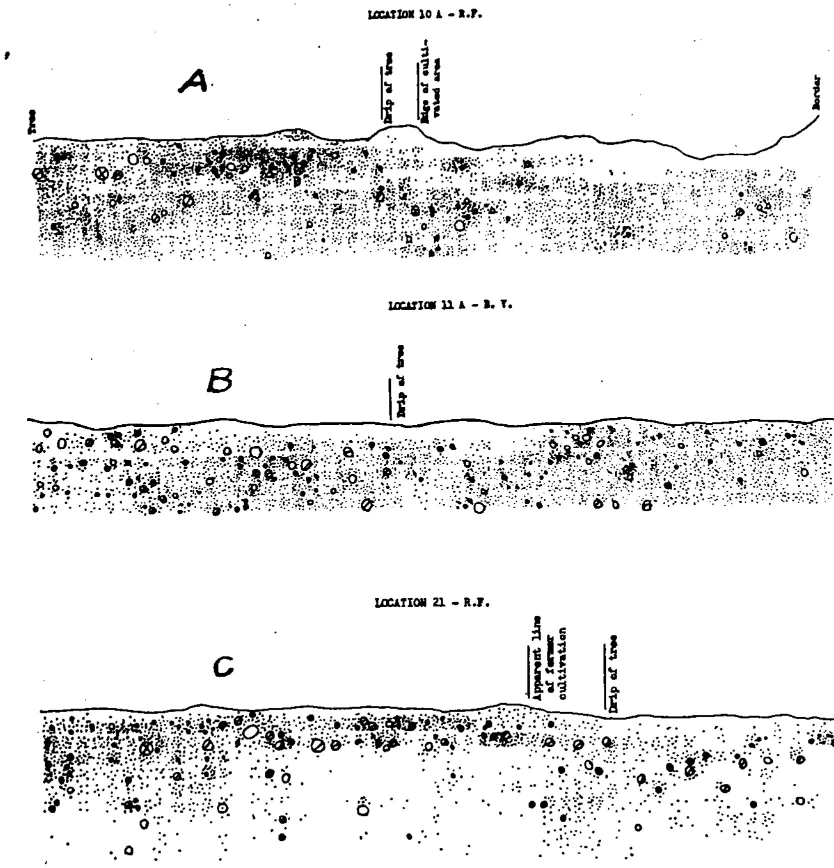


Fig. 3. Distribution of surface roots radially from the trunk to the middles between the trees. The tree is on the left of the diaagram in each cut. (A) Diagram showing the lateral distribution of the roots of a tree representative of those in orchards which have been bordered and deep tilled. (B) Representative of the root distribution in an orchard which has not been tilled for 10 or more years. Examination was to a depth of 18 inches only. (C) In an orchard which has not been bordered or disked in 3 years.

It appears from this study that the main portion of the surface feeder roots of citrus will be located beyond the tree spread if they are not destroyed by tillage operations. The decline of citrus trees is very probably hastened by the deep cultivation commonly practiced, which kills the roots in the top several inches of soil while rising water-tables destroy them from below. Grapefruit trees have been found whose root systems actually occupy vertical zones of less than 18 inches. The trees, as might be expected, were in very poor condition.

At locations in orchards which have not been bordered or deep tilled for periods of 2-4 years, the lateral distribution of roots was found to be intermediate between the first two described. There was some evidence that feeder roots had developed in the surface following the cessation of deep cultivation. The root distribution of a tree which is representative is presented in Fig. 3 (C). The soils appear to be taking up water more readily, and measurements indicate lower water-table levels in orchards where these data have been taken. Yield records indicate improvement in the condition of the trees following the change to the present practice.

Conclusions

That many soils of the Valley are not suitable for citrus production is well known. Two of the reasons for the lack of vigor and productiveness of citrus trees are emphasized in this work. It is obvious that soils which have heavy, poorly-drained surface and subsurface layers should be avoided. Soils which appear to be permeable in the upper part may be actually impervious due to tight layers several feet below the surface. Slow drainage and the over-use of water results in water saturation and the destruction of the deeper roots and thereby injury to the tree. The damage caused by surplus water is critical and its removal a problem.

Impermeable layers have been found from a few inches to several feet below the surface, and the depth may vary considerably from place to place in the same grove. The ineffectiveness of many drainage systems is due to the slow migration of water to the tile. There is unquestionably a need for studies relating soil characteristics to water movement. The information is essential for the installation of successful drainage systems.

The lack of roots in the upper soil layers in bordered and deep-tilled groves indicate the injurious nature of these practices. The deep disking of orchards which have a saturated layer within three feet of the surface appears to be particularly damaging. The use of mowers and stalk cutters in the control of weeds is increasing, although these implements have some disadvantages. To avoid the injurious effects of deep tillage, the use of a light-weight disk, adjusted to cut only 2-3 inches deep, has been suggested for checking weed growth.

Citrus growers have experiencd varying results from the use of fertilizers and soil amendments. Fertilizer investigations should consider placement as well as amounts and forms of nutrients. The

observations made during the course of this work indicate that perhaps the method of application should vary with the cultural and irrigation practices.

Observations made during the course of these studies indicate a possible fallacy in the methods commonly used for determining the height of water tables. The common practice is to bore a hole of convenient size to a depth of several feet and after a period of time measure the distance to the free water surface.

In the excavations which were prepared for these studies, the soils in which water tables existed were found to be saturated with water for considerable distances above the free water surface. The thickness of the saturated layer varied with soil conditions but ranged from 18-36 inches. Inasmuch as few healthy roots were found in the saturated layer, the height of the effective water table should be considered as the top of the saturated soil and not that of the free water surface. In fact, the term water-table usually refers to a saturated soil layer. The root systems of the trees in many Valley orchards are obviously more restricted than we commonly think.

FERTILIZER EXPERIMENTS WITH CITRUS AT THE VALLEY EXPERIMENT STATION

By

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Conducting fertilizer experiments with perishable crops is probably the most disheartening problem to be faced by a research horticulturist. When this work is limited to cold-tender fruit trees, which are subject to attack by insect pests and diseases that are capable of inflicting great damage, the odds in favor of uninterrupted continuity of results are greatly lowered. In the light of our present knowledge of "hidden" deterioration diseases such as scaly bark of grapefruit and oranges, it seems likely that some of the differences in yield seemingly due to differential fertilizer treatments may have been due to factors other than nutrition. We know that the variation in yield between individual trees in a seemingly uniform block of a commercial orchard is frequently as much as 25 percent for a single crop year. This disparity between yields of individual trees increases as time goes on and the orchard has weathered a few major freezes, a hurricane or two, an outbreak of red scale, or an epidemic of gummosis. Premature decline of some trees due to virus disease and soil salinity add to the woes of the horticulturist who undertakes a long-time orchard-sized project with orange or grapefruit trees. When the job is completed, the best answer that the investigator can give is the result for the one type of soil with the orchard managed according to a system which may be outmoded at the time the experiment is completed.

This gloomy picture is not painted to discourage the ambitious young pomologist who sets out to solve a practical problem in plant nutrition, but to point out some of the pitfalls which should be avoided; and to show the fallacy of passing snap judgment based on results which are more fancied than real.

It is practically impossible for any one institution to work out the fertilizer requirements of all kinds of crops on all of the soil types common to a region such as the Lower Rio Grande Valley. Much of this orchard or field testing of materials and methods must be done by the growers themselves. It is important, therefore, that the public spirited growers who are interested in the advancement of the science of plant nutrition, know a few of the fundamentals on which experimental procedures are based. First of all, one should start with a uniform lot of trees, on a reasonably uniform piece of land. Second, he should use relatively few treatments or methods; and these should be decided upon only after careful deliberation and consultation. Third, he should repeat these treatments at random, so as to have at least six plats of each treatment. And last, but not least, he should realize that "accuracy is the essence of science", and treatments should be applied and yield records recorded with as much precision as seems practicable for this type of work.

Fertilizer Work with Grapefruit, 1925-1933

The Weslaco station purchased a fairly uniform 10-acre block of four-year-old grapefruit trees (started from California stock) in 1924. A fertilizer test was initiated the next year. This was about as good a block of four-year-old grapefruit trees as could be obtained, and it produced an average yield of approximately 200 boxes per acre in its fourth year. Then came the sleet storm of December 1924, followed by another in 1925. These calamities were followed by a red scale epidemic in 1927 and a flood that same year; then came the freeze of 1930, followed by the hurricane of 1933 and the experiment was terminated. We made the usual mistake of starting out with too many treatments and too few replicates. During the first five years, we were unable to detect any differences in yield among the different plats of trees which could be attributed to different soil treatments. However, from 1930 to 1933 the cumulative results of the fertilizer applications began to show up. It was from these early experiments that we arrived at the conclusion that nitrogen is the element of primary importance in the nutrition of Valley citrus trees; and that split (spring and summer) applications gave better results than a single (spring) treatment. Also, it was from these tests that we arrived at the conclusion that certain soil correctives such as sulfur, gypsum and iron sulfate have a favorable effect on Valley grapefruit trees.

Reclamation Studies with Grapefruit Trees

As early as 1927, we became aware of a water induced decline (chlorosis) of grapefruit trees which affected relatively young (seven-year-old) trees. After correcting the seepage conditions responsible for the damage, a series of tests was set up to determine what soil treatment and management practices would speed up the recovery of water-damaged citrus trees. These experiments seemed to justify the conclusion that soil applications of sulfur will correct a type of chlorosis of grapefruit which is characteristic of trees on water-damaged land.

These studies also yielded the information that soil or foliage applications of iron sulfate will aid in correcting water induced chlorosis. Frequent, light (2-inch) irrigations were found to be better than occasional heavy (6-inch) irrigations in speeding up the reclamation process. The liberal feeding of decadent (water-damaged) trees was also found to be beneficial in speeding up recovery. We do not claim that sulfur and iron sulfate will neutralize alkali and salt; but the accumulated experience indicates that these correctives, along with proper fertilization and irrigation practices, will enable the owner of water-damaged trees to hasten their recovery after the seepage has been stopped and subsoil drainage has been provided.

A Study of the Potash Needs of Grapefruit Trees

Preliminary studies conducted with relatively young grapefruit trees from 1925 to 1933, indicated that nitrogen was the most important element in the fertilizer program under Valley conditions. A test was started in 1933 in a uniform block of eight-year-old grapefruit trees, using 10 pounds per tree (700 pounds per acre) of 10-30-10 fertilizer as a base. This complete fertilizer was compared with the standard treatment of five pounds per tree of 20-0-0 (10 pounds of 10-0-0) and with 10 pounds per tree (700 pounds per acre) of 10-30-0. Four years experience showed that potassium was not important in the nutrition of grapefruit trees of full bearing age, under the conditions of this experiment. These results were anticipated, as an analysis of the soil in this orchard at the start of the experiment, showed that the phosphorus and potassium reserves were sufficient for at least 25 crops of fruit. This experience left us with the feeling that our suggested basic treatment of one pound of nitrogen per tree per year was a safe and sane fertilizer practice for owners of bearing grapefruit trees to follow.

Fertilizing Hurricane Damaged Trees

The hurricane of September 1933, damaged the above-ground portion of millions of Valley citrus trees; but the torrential rains which accompanied and followed the blow, raised water tables to dangerous levels and left many trees with greatly restricted root systems.

An experiment, started in the spring of 1934, in a block of fourteen-year-old grapefruit trees, showed that nitrogen was the critical element needed under these conditions. Nitrogen from ammonium phosphate-sulphate (16-20-0) was slightly better than nitrogen from cyanamid or sulphate of ammonia, or in combination with phosphorus and potash in the form of 10-30-10 fertilizer.

Complete Versus Incomplete Fertilizers

Following the 1933 hurricane and its attendant water damage to millions of Valley citrus trees, growers were in a receptive mood for propaganda from fertilizer salesmen relating to the rejuvenation of weak trees with so-called complete fertilizers.

A small experiment was started in 1936 in which 5-15-5 fertilizer at the rate of 20 pounds per tree per year was compared with half this quantity of 10-30-10 fertilizer and with comparable money values in 16-20-0 and sulphate of ammonia. One block of 15 trees in this experiment received no commercial fertilizer during the eight-year period, but did receive 100 pounds per tree per year of sorghum hay, which was disked into the soil. At the end of the eight-year period, the accumulated yield data showed that the trees which received 5-15-5 fertilizer at the rate of 20 pounds per tree yielded, on the average, two tons per acre per year less than those which received a comparable money value in sulphate of ammonia (approximately 15 pounds per tree) and five tons per acre less than the block which received 16-20-0 at the rate of approximately 10 pounds per tree. The trees which received the 100-pound application of sorghum hay each year during the eight-year experiment, produced considerably more fruit (two tons per acre per year) than the trees which received 20 pounds of 5-15-5 fertilizer each year. In this test we again have an indication that nitrogen is the hub around which the fertilizer program for Valley grapefruit trees should be built. The rather outstanding performance of the trees which received nitrogen and phosphorus in an available form (ammonium phosphate) indicates that this combination is worthy of further investigation under a wide variety of conditions.

Fertilizer Experiments with Orange Trees

Until 1945, all of the orchard testing of commercial fertilizers at the Valley Experiment Station was conducted with grapefruit trees. In the spring of 1945, an experiment was started in a block of four-year-old Hamlin orange trees which had been developed for use in nutrition studies. Nitrogen alone at various rates and at different seasons is being studied in these tests. It is too early to form any conclusions from this work, but it is interesting to note that the trees which received the most nitrogen have produced the most fruit during the past two seasons.

In three other blocks of young orange trees, phosphorus in varying amounts is being compared with nitrogen alone and with phosphorus and nitrogen in combination. This work is being conducted with Hamlin, Joppa and Valencia orange trees.

Summary of Results

We do not claim to have the answer to the nutrition problem as it affects the growth, fruiting and longevity of Valley citrus trees, but we do believe that we are on safe ground when we recommend the use of sufficient nitrogen to replace that removed by annual cropping, and phosphorus of an available type to supply the amount removed by average fruit crops. The addition of bulky organic matter such as sorghum also appears to have an imperfectly understood beneficial effect on the performance of old grapefruit trees. It is also quite obvious that the proper use of soil correctives such as sulfur, gypsum and iron sulfate will expedite the recovery of water-damaged trees, provided the unfavorable water-soil relationships are corrected.

Fertilizer is not a cure for the various types of citrus tree decline common to the Lower Rio Grande Valley; but the intelligent use of commercial fertilizers and soil correctives in conjunction with good orchard practices should enable orchardists to produce more fruit at less cost per orchard unit.

A PRELIMINARY REPORT OF WORK AT CAMPINAS, BRASIL, ON TRISTEZA DISEASE OF CITRUS

By

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In September, 1946, work was started at Campinas, Brasil, on the disease of citrus known as tristeza, with the hope of contributing information on the nature of the disease, its method of spread, its host range including susceptible scion-stock combinations, and on control. This work was initiated, and is being continued, as a joint cooperative project between the Instituto Agronomico of the State of Sao Paulo, Brasil, and the Division of Fruit and Vegetable Crops and Diseases of the United States Department of Agriculture. This paper reports the progress of the work during the first year.

Economic Importance and Symptoms of the Disease

In South America tristeza appeared first in Argentina about 1932. In Brasil it was found first in the Paraiba Valley in the State of Sao Paulo in 1937 and within a period of 10 years it spread to all of the major citrus-producing areas of the country and has killed or rendered unprofitable a high percentage of the trees of the standard varieties of sweet orange on sour orange stock.

On bearing trees first signs of the disease usually appear on one side of the tree and soon spread to all parts of the top. Leaves are slightly bronzed, or otherwise discolored, and more brittle and leathery than those of healthy trees. In some cases there is a distinct yellowing of the midrib, the midrib and lateral veins, or even the entire leaf. Soon many of the older leaves fall. Lateral buds start growth and produce short, weak shoots with small leaves. Usually the first year after the disease appears the tree blossoms heavily and sets a large crop of fruit which is very conspicuous when ripe, partly because of the sparseness of the foliage. Trees decline rapidly in vigor. Twigs die back from the tips and sprouts are produced from the main limbs. Yields are drastically reduced after the first or second year and the trees are of little value.

Transmission Tests

Experiments have been made to transmit the tristeza disease from affected plants to healthy plants of known susceptible scion-stock combinations, both in the field and in the greenhouse, by various methods available for such transmission.

Field Tests

In the first test for transmission of tristeza to nursery trees, 20 trees of the variety Bahianinha on sour orange stock were selected from a nursery near Limeira and planted in plots near Campinas, October 31, 1946. Ten of these trees were inoculated November 20, 1946, by placing 2 buds from diseased trees into each plant. The trees were reinoculated December 18, 1946. The 10 trees remaining were held as checks and were not inoculated. All of these trees came from a nursery in an area where tristeza was prevalent and it was recognized that some of the trees may have been infected before inoculation. One of the check trees began to produce yellow leaves by January 15, 1947, and showed other symptoms characteristic of tristeza. By June 1 all of the 10 inoculated trees and 3 of the check trees showed rather marked symptoms of tristeza. All of these diseased trees blossomed and 9 of the 10 inoculated trees set fruit which matured in September. The 7 healthy-appearing trees on October 1 were considerably larger than the inoculated trees, had normal foliage, had blossomed sparsely, and had set no fruit.

In a second field test trees of the varieties Barao, Seleta, Pera do Rio, Abacaxi, Parnasia, Serrana, Campista, Lima, Coronel, Mangaratiba, and Bahianinha were obtained from a nursery near Santa Rita the early part of December, 1946, and planted at Campinas. At the time the trees were selected tristeza was only just beginning to appear in the area around Santa Rita and it was thought that most of the younger trees should be free of the disease. All of the trees were on sour orange stock. One-half, or more, of the trees of each variety was inoculated with buds from diseased trees January 18, 1947, and reinoculated April 9, 1947.

By the first of May, or approximately three and one-half months after the first inoculation, some of the inoculated trees of the variety Barao began to produce symptoms characteristic of tristeza. About a month later some of the inoculated trees of the variety Seleta began to show abnormal coloration of the foliage. Symptoms characteristic of tristeza appeared on other varieties until by October 1, as indicated in table 1, most of the inoculated trees of all of the varieties except Abacaxi, were obviously abnormal. These abnormalties consisted chiefly of stunting of the trees, production of various shades, types and degrees of yellowing of the foliage, dropping of the leaves, and profuse blossoming. Leaf cast was severe on some of the trees of the varieties Barao and Mangaratiba and was especially severe in the case of the inoculated trees of the variety Coronel. Leaf dropping was followed by the production of many weak auxiliary shoots. With the exception of one tree of the variety Coronel which lost most of its leaves, blossomed heavily, and was obviously diseased, none of the check trees of any of the varieties have shown symptoms characteristic of tristeza.

Table 1

Table 1. Results of inoculation of nursery trees in plots at Fazenda Santa Eliza, Campinas, with buds from diseased trees.

Variety tested	Number of trees used in test	Trees inoculated: Number	Trees inoculated: Number diseased	Trees used as checks: Number	Trees used as checks: Number diseased
Bahianinha*	20	10	10	10	3
Barao	25	15	10	10	0
Seleta	25	15	13	10	0
Pera do Rio	20	10	9	10	0
Abacaxi	10	5	0	10	0
Parnasia	10	5	5	5	0
Serrana	10	5	4	5	0
Campista	10	5	5	5	0
Lima	10	6	4	5	0
Coronel	10	5	5	5	1
Mangaratiba	10	5	3	5	0
Bahianinha	5	5	5	--	--

* These trees were planted October 31, 1946, and inoculated November 20, 1946, with buds from diseased trees; they were reinoculated with buds from the same source December 18, 1946. All other trees were planted the first week in December, 1946, and inoculated January 18, 1947, and reinoculated April 9, 1947. The above records were taken October 1, 1947.

Greenhouse Tests

An extensive series of transmission tests has been made in greenhouses screened to give a considerable degree of protection against insects. Most of these experiments were made with small plants 4 to 24 inches tall growing in pots. Each of the small plants used for inoculation was produced by grafting a sweet orange top on a sour orange root when the plants of sweet and sour orange were only about 3 inches tall.

Inoculation with Twigs and Buds Since all virus diseases are transmissible by graft, the first attempts to transmit the tristeza disease were made by grafting twigs and buds from diseased plants onto healthy plants. In one of these tests, small healthy plants were approach-cleft-grafted to twigs of diseased trees growing in barrels in the greenhouse. After a contact period of about 30 days the diseased twigs were severed just below the point of union with the healthy trees and allowed to continue to grow on the inoculated plant. Of 28 trees inoculated in this manner, 21 have shown definite symptoms of tristeza. Of 10 trees grafted with twigs of healthy seedling orange plants, none has shown symptoms of disease.

In a modification of the method of inoculation just described, twigs were taken from diseased trees and approach-cleft-grafted into the stems of healthy trees. The cut ends of the twigs from the diseased trees were kept in vials of water until union was complete and then severed just below the area of contact with the inoculated tree. This method of inoculation has given a relatively high percentage of infection with twigs from known disease sources and little or no infection from certain other sources.

Several experiments have been made in which buds from diseased trees were placed in the stems of healthy plants. So far this method of inoculation has given a very low percentage of infection when used with small potted plants.

In all cases of infection in these experiments in which inoculations were made by the grafting of diseased tissue to healthy plants, symptoms have begun to appear in periods varying from 30 to 90 days. Usually first signs of the disease appear in the youngest leaves. These are somewhat more yellow than normal and soon growth is retarded and the older leaves of the plant become pale, pale yellow, or yellow. The degree of yellowing varies greatly with different plants, but the degree of stunting is more or less uniform. Some plants have remained yellow and stunted for more than four months; others have produced some additional growth with more or less normally colored leaves that are smaller than those of healthy plants. Leaves have fallen from some of the more severely affected plants.

Inoculation with Insects Small citrus plants composed of sweet orange tops on sour orange roots have been inoculated with most of the species of insects with sucking mouthparts that have been found feeding naturally on citrus plants in the plots at Campinas, and with certain other species of insects that have been induced to feed on citrus plants. These insects have consisted of 5 species of leafhoppers, one species of whitefly, and 6 species of aphids, including the black citrus aphid of Brasil, *Aphis citricidus* Kirkaldy.

Only plants that were inoculated with the black citrus aphid have shown symptoms of yellowing and dwarfing characteristic of tristeza. In all experiments in which this aphid was transferred from diseased to healthy plants in large numbers, a high percentage of the inoculated plants has later shown symptoms of the disease. Usually the inoculated plants began to produce yellow leaves at the growing tips about 30 to 60 days after inoculation. Growth was much retarded and the plants showed various degrees of yellowing. In some cases the older leaves turned bright yellow in color and some leaves dropped. In other plants yellowing was less marked and in some cases the leaves were only slightly paler than those of normal plants. A few plants of this latter type have produced new shoots with small leaves more or less normal in color. Check plants infested with approximately the same number of aphids from healthy plants have remained normal in all cases. In some of the earlier experiments the check plants are now 3 to 4 feet tall, whereas the inoculated plants are pale to very yellow in color and average only about 12 inches tall.

These results with the black citrus aphid of Brasil are similar to those obtained by Meneghini [1] in tests with this insect. The evidence now available seems sufficient to justify the conclusion that the black citrus aphid, *Aphis citricidus*, is an agent of transmission of the tristeza disease in Brasil.

Inoculation with Sap from Diseased Plants. In tests of transmissibility of tristeza by means of juice, sap was pressed from young succulent shoots of orange trees that had been diseased for more than two years and which showed marked symptoms of tristeza. The juice was then used immediately to inoculate small rapidly-growing orange trees. The inoculations were made by rubbing the juice over the surface of the leaves that had been sprinkled with an abrasive before inoculation. Forty trees were inoculated in this manner and 10 trees were retained as checks. Five months after inoculation no symptoms characteristic of tristeza were evident on any of the inoculated or check trees.

Attempts have been made also to transmit tristeza to annual plants by means of juice inoculation. Obviously, if a type of annual plant susceptible to infection and producing marked symptoms, could be found, such a plant would be extremely useful in further studies on the tristeza disease, particularly in the determination of the presence of virus in different species and varieties of citrus on which no evidence of infection has so far been recognized and in detection of early stages of infection in trees of sweet orange on sour orange stock. However, although some 50 species and varieties of annual plants have been tested, none has shown abnormalties that have been attributed to the tristeza virus.

Test for Seed Transmission. All of the seedling plants of both sweet and sour orange used thus far in the work on tristeza at Campinas have been produced from seeds from diseased trees or from trees that have been exposed to infection over a considerable period. A total of over 1100 plants composed of sweet orange seedlings grafted on sour orange seedlings have been prepared. Some of these have been inoculated by grafts or by the black citrus aphid and have shown the disease, but only after a reasonable period of time following inoculation. More than 325 plants, however, have been held as checks or have been inoculated by juice, by dodder, or by means of insects that appear not to be vectors of the virus. Only one of these plants has shown symptoms characteristic of the tristeza disease. This plant was not inoculated. Symptoms have persisted for more than four months but it has not been determined by inoculation tests that the plant carries the virus. It should be emphasized, however, that even if this plant proves to be infected, this cannot be accepted as conclusive proof that the virus was transmitted through the seed since possibility of accidental infection by aphids is difficult to avoid in tests of this type, and more evidence must be available before definite conclusions may be reached. From the results obtained thus far it

[1] Meneghini, M. Sobre a natureza e transmissibilidade de doenca "tristeza" dos citrus. O. Biologico 12:285-286. 1946.

seems probable, however, that the virus is either not transmitted through the seeds of sweet and sour oranges tested or, at most, it is transmitted through a very low percentage of such seeds.

Additional and more extensive tests are now under way to obtain further evidence on the problem of seed transmission. For these tests seeds were collected from trees of the variety Pera in advanced stages of disease. Sour orange seeds were harvested from trees on their own roots showing no obvious symptoms of tristeza but surrounded by badly diseased trees of sweet orange. The seeds of the two varieties of oranges were planted in flats. When the seedlings attain sufficient size the sweet orange seedlings will be grafted onto the sour orange seedlings and the resulting plants will be watched for appearance of symptoms of disease. Symptoms of tristeza should appear in plants of this combination if the virus is carried through the seeds of either the sweet or sour orange which give rise, respectively, to the scion and stock of the test plant.

Scion-Stock Combinations Susceptible to Tristeza [2]/

All trees of the varieties Pera, Bahia, Bahianinha, Barao, and other sweet varieties of orange, when grafted on sour orange stock, seem to be susceptible to tristeza. The disease has been reported also on mandarin on sour orange stock. In tests of different types of stocks being conducted at the Citrus Experiment Station at Limeria, Brasil, by Senor Silvio Moreira, trees of the variety Pera on grapefruit stock are dwarfed and show symptoms more or less characteristic of tristeza. The trees, however, have not declined so rapidly as trees of this variety on sour orange stock. Certain varieties of tangelo on sour orange stock also appear to be susceptible to the disease. However, a strain of the variety Sampson appears to be resistant. Trees of Marsh Seedless grapefruit on sour orange stock also show symptoms characteristic of those produced by tristeza.

The common varieties of sweet orange in Brasil when grafted to sweet orange, rough lemon, Rangpur lime, sweet lime, ponderosa lemon, "cravo" tangerine, citron, and trifoliate orange have been resistant. However, citron and trifoliate orange have proved to be of little value as stocks.

Although certain scion-stock combinations seem to be required in order to have trees show symptoms so far recognized as characteristic of tristeza disease, it has seemed reasonable to suspect that certain types of citrus trees, both on their own roots and on various types of so-called immune stocks, might be capable of harboring the virus which causes the disease, and thus might serve as sources of infection without showing symptoms of the disease.

[2]/The authors are indebted to Silvio Moreira, Chief of the Department of Horticulture of the Instituto Agronomico, Campinas, Brasil, for information on varietal susceptibility, and for the privilege of making observations on the effects of tristeza on trees on different stocks in the extensive stock tests at Limeira.

To obtain information on the possible host range of the virus an extensive test is being conducted in which as many as possible of the different varieties and types of citrus trees growing in areas where they have been exposed to infection over a period of years, are being tested for presence of the virus. Inoculations by buds, by twig grafts, and by aphids are being made from each source. Thus far transmission of the disease has been obtained from an unidentified citrus tree on its own roots, from the "cravo" tangerine on its own roots, and from the Pera variety of sweet orange on Rangpur lime. None of these three types of trees showed the severe types of symptoms recognized as charactristic of tristeza. Transmission has been obtained also from grapefruit trees on their own roots that showed marked yellowing of veins and yellowing of the entire leaf in the case of some of the twigs produced during periods of rapid growth. It seems evident from these results, therefore, that the causal virus is not limited to trees that show symptoms, such as those that occur on trees of sweet orange on sour orange roots, but may occur in at least certain trees on their own roots or on stocks other than sour orange, in which no symptoms or only questionable symptoms of the disease have been recognized.

Tests of Stocks for Resistance

Experiments are being made at Campinas in which all of the available varieties and types of citrus and citrus relatives are being tested for their reaction to tristeza disease when used as stocks for sweet orange. Thus far seeds of 125 varieties and types of citrus and citrus relatives have been forwarded to Brasil by F. E. Gardner of the U. S. Subtropical Fruit Station at Orlando, Fla. These seeds were germinated in flats and at present plants of 119 types are growing in nursery rows and will be budded to sweet orange, probably in January. After the sweet orange buds have grown into shoots they will be inoculated with tristeza. Later the trees will be planted out 3¼ feet apart in rows 6½ feet apart in locations exposed to further infection by tristeza and watched for appearance of symptoms of the disease. This test in the course of a few years should furnish valuable information on the degree of resistance to tristeza of a large number of citrus types when used as stocks for standard varieties of sweet orange.

Summary and Conclusions

The evidence now available seems ample to justify the conclusion that tristeza disease of citrus in Brasil is caused by a virus which can be transmitted from diseased to healthy plants by means of buds or twigs and by means of the black citrus aphid, *Aphis citricidus*. The virus probably is not juice transmissible and as yet there is no conclusive evidence that it is transmissible through seeds of diseased plants.

Probably the chief natural agent of transmission of the disease in Brasil is the black citrus aphid. This insect occurs abundantly on the new growth in the spring and, despite the fact that it appears to be a very inefficient agent of transmission when compared with vectors of certain other virus diseases, it probably has been responisble for most of the spread of the disease in Brasil.

Tristeza causes severe damage to all varieties of sweet orange, to mandarin, and to certain varieties of tangelo when these types are on sour orange stock. There is evidence also that it causes severe injury to sweet orange on grapefruit stock and to grapefruit on sour orange stock.

In addition to these types of trees on which definite injury is produced, the virus occurs in certain kinds of citrus trees in which no symptoms have been detected. It has been recovered from an unidentified citrus seedling on its own roots, the "cravo" tangerine on its own roots, and from the Pera variety of sweet orange on Rangpur lime stock, none of which showed symptoms of the disease. It was recovered also from a seedling grapefruit tree on its own roots that showed a type of yellowing of leaves of rapidly growing twigs. These preliminary results indicate that the virus may be rather generally distributed in the various kinds of citrus trees of Brasil.

CITRUS TREE DECLINE IN THE WINTER GARDEN AREA

By

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A malady which usually occurs only after citrus trees are ten years or older has appeared in the Experiment Station plantings of this age at Winter Haven, Texas. This seems to correspond to what was called citrus blight by Rhoads (1936) and "spreading decline" by Suit and Ducharme (1947). This was reported in Florida as early as 1883, according to Rhoads.

Rhoads describes "blight" as a chronic wilting of foliage of part or all of the affected tree. The trouble ordinarily does not develop until trees are 12 to 14 years and older and bearing heavily. It seldom attacks younger trees. "Trees may exhibit a more or less decided wilting and curling of foliage during dry periods for at least several months or a year before chronic wilting becomes apparent. The initial stage is indistinguishable from wilt exhibited by trees suffering temporily from drought except that it usually is localized on one part of the tree. Ultimately the wilted leaves lose their normal sheen and become dull and lifeless. Affected trees show a strong tendency to develop an abnormally heavy bloom characterized by abnormally small and weak blossoms which set very little fruit. Despite years of trial, no known method of treatment, including irrigation, has succeeded in effecting a permanent recovery of citrus trees that have once developed a genuine case of blight."

Photographs published by Rhoads correspond to the decline occurring at Winter Haven, Texas. The trees progressively die out in groups and the disease appears to spread like a root rot from the original infected tree or trees.

At Winter Haven, Texas, the disease first appears as a single affected tree and slowly spreads out from this tree as a center. The first noticeable symptom is a dull green appearance of the leaves often in only one segment of the tree. Defoliation of the affected part of the tree is gradual and the younger growths die back. This is later followed by sucker growth from the scaffold limbs and main trunk which may continue as long as four years before the tree dies completely.

Examination of the roots of diseased trees show the trouble to be correlated with the death of the small feeder roots. Later, when the tree dies, the larger roots have a strong, sour smell coming from the decayed bark. No definite pathogen has so far been found to be associated with this root decay.

In the Experiment Station planting of 554 trees 10 years or older there are 49 areas of infection which have killed 46 trees and infected 42 others. Similar areas occur in some older orchards in Dimmit county on both trifoliate orange and sour orange. Most of the plantings in Dimmit county are less than 10 years of age which probably accounts for the decline not being more extensive at this time. Of the 46 trees that have died in the Experiment Station orchard only 4 were infected at less than 10 years after planting.

Rhoads has indicated that the so-called blight disease is not transmitted by budding in Florida. At Winter Haven we have used buds from declining trees without noticeably transmitting the disease on budded trees for as long as 6 years later.

Swingle and Webber (1896) state that the rootstocks appeared to have little effect on blight incidence. Rhoads (1936) does not consider that enough different rootstocks have been grown in the same orchard to get a reliable estimate of susceptibility. It appears to occur with equal frequency on sour orange and bitter-sweet orange stocks. It also occurs on grapefruit and sweet orange stocks but seedling trees are less susceptible. Rough lemon appeared to be more resistant. However, the "spreading decline" of Florida definitely infects rough lemon according to more recent reports. The results presented in this paper show a large variety of stocks to be susceptible.

Experimental Results

A record of the citrus plantings from 1931 to 1937, inclusive, is given in Table 1. This considers only trees that are ten years old or more and, therefore, the total number considered in some combinations is too small to have any significance.

So far the following stocks have shown susceptibility to decline at Winter Haven, Texas: Carrizo, Cunningham, Morton, Rusk, Savage and Uvalde citranges, Sacaton citrumelo, Meyer lemon, Ichang lemon, sour orange, trifoliate orange and an unknown shaddock. The data show trifoliate orange as very susceptible, 27% infected trees of 258 planted. It should be pointed out that these trees are several years older than those on other stocks.

At present the following stocks have not shown decline symptoms where 10 or more trees are recorded: calamondin, citrangequat, and Rustic citrange. Possibilities of resistance are indicated by Glen citrangedin and Changsha tangerine. Sacaton citrumelo has only one tree with a satsuma cion that has shown decline symptoms out of 29 budded trees ten years old or more with various cions, and only 2 out of 40 on Rusk citrange have shown decline symptoms.

Table 1. Citrus Rootstock Decline in budded trees 10 years or older
September 1947.

Rootstocks	Oranges & Misc.		Satsumas		Grand Total		
	Number of trees	Number decline	Number of trees	Number decline	Number of trees	Number decline	Decline percent
Calamondin	1	0	10	0	11	0	0
Carrizo citrange	1	1	4	0	5	1	20
Changsha tangerine	1	0	1	0	2	0	0
Citrangedin, Glen	3	0	3	0	6	0	0
Citrangequat, Thomasville	9	0	2	0	11	0	0
Citrumelo, Sacaton	23	0	6	1	29	1	3
Cunningham citrange	20	2	48	4	68	6	9
Kansu	1	0	0	0	1	0	0
Meyer lemon	3	0	3	2	6	2	33
Morton citrange	6	2	9	3	15	5	33
Rusk citrange	15	0	25	2	40	2	5
Rustic citrange	1	0	10	0	11	0	0
Savage citrange	1	0	39	5	40	5	12
Sour orange	7	0	9	2	16	2	12
Trifoliata orange	69	19	189	51	256	70	27
Uvalde citrange	19	3	7	0	26	3	12
Ichang lemon	0	0	3	0	3	0	0
Shaddock	6	1	0	0	6	1	16

Discussion

The citrus plantings at Winter Haven, Texas, are too recent to have developed definite information on resistance of all the stocks under test. Most of the stocks reported in this paper should be tested further together with other promising citrus rootstock varieties such as other citranges, citrangequats, citrangedins, rough lemon, mandarins (including Cleopatra), tangelos, shaddock, Eremolemon, Rangpur lime, and sweet orange varieties. These and many other varieties are being tested as citrus rootstocks extensively in the Lower Rio Grande Valley, Florida and California.

The trifoliate orange rootstock was used extensively enough in these plantings to leave no doubt as to its susceptibility to the decline. Since the trifoliate orange has been found to be resistant to tristeza in Brazil by Bitancourt (1943), we can conclude that the Winter Haven decline is different from tristeza. Tristeza is also known to be transmitted through budding as Bennett has just reported and it is concluded to be a virus disease. Quick decline, a disease similar to tristeza, has also been shown to be transmitted by budding as reported by Fawcett and Wallace (1946) and Wallace and Fawcett (1947). The Winter Haven decline has not been transmitted by budding. This indicates that the Winter Haven decline differs from tristeza or quick decline and is probably not a virus.

It is believed by the author that the Winter Haven decline and the similar Florida spreading decline may be an infectious soil disease caused by a weak parasite attacking trees when they reach full production and have less resistance. However, there is no actual evidence to support this theory at this time.

Summary

Present available information on the citrus decline at Winter Haven, Texas, shows trifoliate orange, Cunningham, Morton and Uvalde citranges and sour orange root stocks to be definitely susceptible to the disease. Indications of possible resistance are shown by calamondin, Thomasville citrangequat, and Rustic citrange.

Further years of observation and testing will be necessary before any conclusions can be made concerning the cause of the decline disease at Winter Haven or of the resistance of various rootstock varieties to the disease.

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CITRUS MARKETING PROBLEMS

By

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When you folks invited me down to talk to you, I had some misgivings about trying to analyze the marketing problems of the citrus fruit industry at a time when the current market is somewhat unpromising. On the other hand, progress is often made as a result of necessity. Most of us are inclined not to worry about the future so long as the present holds no cause for alarm. So I would like to talk to you a few minutes today about the citrus industry largely from the viewpoint of an outsider or one who has been following the development of the industry from long range.

My interest in the activities and problems of the citrus industry in Texas and elsewhere has always been rather keen. During the years prior to the war my work was largely concerned with the marketing of citrus fruit and I maintained an active interest in the affairs of your industry. Then came the war and like many others my work was suddenly changed. During the years that I spent in the air forces I was completely disassociated from the citrus industry. I didn't see or hear or talk about citrus fruits until I returned to the Department last year.

Since I returned it has been my privilege to spend some time in and to travel throughout the several citrus producing areas of the U. S., and to talk to citrus growers and shippers and distributors. I must admit that what I saw and heard was amazing. The citrus industry had undergone a complete physical revolution during that five-year period. New plantings everywhere and more trees being planted, new processing plants turning out more and more products, new equipment and facilities on every hand. And most important, until recently everyone was highly optimistic about the future of the citrus industry. We are living in a new age, I was told, and times have changed. And the citrus industry was not alone in that belief for we heard the same tune from many quarters. But the tune has changed and now we find ourselves asking each other a lot of difficult questions.

One of the questions which always arouses a good deal of interest is "What is the future of the citrus industry?" And I am speaking of the entire citrus industry of the U. S. because I don't think we can segregate one State from another. All areas are competitive and all have similar problems when it comes to marketing and merchandising their products. I doubt if we can answer that question completely, but perhaps we can develop some rather concrete and reasonable views.

Let's start with a brief review of what has been happening in the citrus industry during the past decade. Without using a lot of figures, let's take a quick look at what's been happening to production, how the fruit has been used, and something about prices.

You are all generally familiar with the amazing growth of the citrus industry. A good comparison to keep in mind is that citrus fruit production has doubled every 10 years during the past four decades. In Texas your primary interest is grapefruit. Production of grapefruit has jumped from 30 million boxes in 1937 to more than 60 million boxes today. By and large the increase in Texas has been greater than for the U. S. as a whole. But lately the increase has become less pronounced and today Texas is producing about 40 percent of all U. S. grapefruit. Florida is your big competitor and they likewise have experienced an increased production. When it comes to oranges, your production in Texas has nearly trebled in the past 10 years, but you have encountered fewer problems in marketing of your orange crop.

Much of the increased production of citrus fruit has been used for processing. This is especially true for grapefruit. Ten years ago we were processing about one-third of all our grapefruit, whereas today nearly one-half of all grapefruit goes to market in cans. In Texas you have rather consistently increased your sales of fresh grapefruit and processed the remainder. In Florida there has been very little increase in the sales of fresh grapefruit and nearly two-thirds of the crop has been processed. The processing of oranges has increased tremendously especially in Florida. But here in Texas you have found it more profitable to market your oranges as fresh fruit.

Now what has been the result of all this? What has happened to prices and returns to producers? On-tree prices for Texas grapefruit averaged $7.00 per ton for the five prewar years, a period which incidentally was the low point in the history of the industry. During the war years the price averaged nearly $26.00 a ton. However, since the war, prices of grapefruit have declined sharply and are at a relatively low level at the present time. Prices of oranges have shown a similar trend although not as pronounced as for grapefruit. The citrus industry has gone from rags to riches and back again in the span of a few short years.

From the foregoing, it can be seen that production has increased steadily; that the major portion of the increase has gone into processing; that prices to producers during the war were more than three times the prewar level; and that current prices have receded to a point comparable with the prewar years. Any industry that expanded its output as rapidly as the citrus industry is bound to encounter serious trouble in disposing of its product, and some readjustments are likely to be necessary.

Apparently many people were misled by the high prices during the war. Demand seemed unlimited and the biggest problem seemed to be one of producing more fruit. Prices were so favorable that the trials and tribulations of the thirties were soon forgotten. You didn't need to sell fruit; it became a matter of allocating the supply. The citrus industry was making money—a lot of money, and how to spend it became a problem. You worried about shortages of material at times but the biggest complaint seems to have been price ceilings, set aside orders, and numerous regulations or measures taken by the Government to further the prosecution of the war.

The war served as a stimulant that relieved the pain of the pre-war years. The effects of the stimulant have worn off rather rapidly. So now we are looking for a new stimulant. But let's be careful. We haven't forgotten the experiments tried in the late thirties, both here and elsewhere, to maintain prices. Right now, as usual, there are many solutions being offered to maintain the economic well-being of the industry and the nation. We need new ideas, good, sound ideas, of course, but we must be able to distinguish the good from the bad.

It seems to me that there is no single remedy for our ills, no simple expedient to rescue us from this "sea of troubles." I think we should recognize this fact and start pooling our efforts in order to get the best and quickest results. Many a battle has been won by uniting forces, all pointing toward the same goal. It's when we are in distress that the need for working together becomes most apparent. A British historian has put it very aptly. He wrote: "It is evident that many great and useful objects can be obtained in this world only by cooperation. It is equally evident that there cannot be efficient co-operation if we proceed on the principle that they must not cooperate for one object unless they agree about other objects." In other words, we don't have to agree on everything before we cooperate on matters concerning which we do agree. An appreciation of the problem and a willingness to apply basic principles will go a long way toward pursuing a sound course of action.

The citrus grower is interested primarily in price. He has a big investment in his grove and equipment. He can influence production to some extent to be sure, but the size of the crop is largely out of his power to control. He is interested in price—not necessarily the price to the consumer or the price to the jobber, but rather the price to the grower. It's the price of the fruit on the tree that governs whether he makes a profit or a loss. In the price of the fruit to the producer lies a most important factor in keeping the industry on a reasonably even keel. If returns to the producer after paying expenses are at a high level, planting of new trees continues to increase. Call it what you will, profit or interest on investment, but when a business is profitable, an increase in output can be expected. That's what's been happening in the citrus industry, in Texas and elsewhere. If it were not so we wouldn't see the millions of young trees, and more going in.

The point I want to emphasize is that the industry can't be on a sound basis if prices are such as to encourage new plantings, yet at the same time complaint is made that the prices which stimulated the plantings, are too low. We must recognize the influence of one upon the other. In other words, any action which maintains prices at too high a level is bound to stimulate more and more plantings which will produce more and more fruit. There are those who advocate rigid controls over plantings as well as the disposition of the crop, but I doubt if such measures would avoid the issue very long.

It should be recognized that there are definite limits within which prices may be stabilized over a long period of time without upsetting the basic balance between supply and demand. In a free and competitive market, price is the mechanism which equates demand against supply. Any influence which alters either the supply or the demand of a product can be expected to result in a change in price. It might be well to consider how the demand and supply of citrus fruits can be influenced or affected.

Let's consider the marketing situation from the standpoint of what you or I would do if we owned or controlled all the fruit. Before the season starts we know how much fruit is going to be produced in all areas of the U. S. We also know something about the quality of the crop, the size composition, the varieties, and about when the fruit will start moving to market. How should the total supply of fruit be handled or how should the crop be marketed to the best advantage of the producer? It seems to me that there are several things which can be done which will directly or indirectly have an influence upon the supply and the demand for the product.

One thing we can do is give the consumer a uniform, high-quality product. Average quality won't do because the average is made up of some very good fruit and some very poor fruit. I suppose you are tired of hearing about this matter of quality. As long as I can remember we have been hearing the pros and cons of marketing quality fruit. But you must satisfy the consumers if you are going to keep them buying and eating your fruit. Take a look at some of the grapefruit which arrived in terminal markets early this season—and every season. I don't need to describe it; you know the eating quality of early season grapefruit. And the first few cars sell at good prices, but the edge is soon worn off the market. You can be sure that immature or off-quality fruit does not bring repeat customers. The same applies to canned fruit and juices as well as to fresh fruit. We should keep off the market that fruit which does not meet the standards of high quality and uniformity. You have little or no control over the production or the amount of fruit available, but you *can* do a great deal about the quality of the product you give the consumer.

A great deal remains to be done in the field of selling and merchandising. Most of us assume the job is done when the fruit is packed and shipped. But there is still a long way to go before it reaches the consumer's table. Perhaps we can blame our troubles partly on the war. Many of us got into some bad habits during those years. Selling seemed to be no problem. And under price ceilings there was little or no reward for quality, consequently, it was easy, and perhaps profitable, to forget about a quality pack and to put more effort into moving a larger volume of fruit. A good friend of mine remarked recently that we need to unlearn a lot of what we learned during the war. We need more downright salesmanship and modern merchandising to push the sales of citrus fruit and products. Are we getting citrus fruits into every remote area of the country and every conceivable outlet; is it available regularly and of the quality the consumer wants. And more important, do we have anyone who is actively promoting and selling citrus fruits to the consumer. It seems to me that we need to do more in the way of convincing the consumer of the value of citrus fruits. This presents a real challenge to the industry and can only be done by united action.

The matter of efficiency in handling and marketing fruit should not be overlooked. We should take every possible measure to cut the costs and improve the efficiency with which fruit is handled from the time it leaves the tree until it reaches the market. During the war years we didn't have to be efficient because profits were good and margins were large. Under present day conditions, economic operation is essential if the industry is going to be able to supply the market with a quality product at prices consistent with a large volume operation. Many shortcuts have been made, many improvements have been accomplished, but economy must be a watchword.

The matter of new products and new uses continues to be a fertile field for investigation. If we produce more fruit than can be marketed at a profit to producers, it is logical to look for new products and new uses. The citrus industry has developed many new products and by-products during the past 10 years. This was a case of necessity. It had to find new outlets in order to dispose of the ever-increasing production. Further research in this field should be pushed forward aggressively. A few new products have appeared on the markets. Frozen juices, concentrated juices, powdered juices, citrus beverages, etc., are new methods of getting citrus fruits to the consumer. During the war there was a great interest in concentrated juices to conserve shipping space. Great Britain received 10,000,000 gallons of concentrated orange juice under the Lend-Lease program for distribution to children. This program is being continued in Great Britain and that government continues to purchase concentrated orange juice in the U. S. The subject of research cannot be overemphasized and we cannot afford to overlook any possibilities of expanding and increasing our potential markets.

The need for additional research in the field of agriculture was recognized last year when Congress passed the Research and Marketing Act. This legislation provides for research into the basic laws and principles relating to agriculture. Work has begun under this program with the funds which have been made available for this year. Under this research program, the industry plays an important part. A system of committees has been established to serve in an advisory capacity concerning the type of research program which should be undertaken. You have three members here in the Valley on the Citrus Fruit Advisory Committee. It is their job to help draft the research program for citrus fruits. Several projects have been approved and are already under way. The outlook is encouraging and much can be accomplished by continuous and systematic research.

We should not overlook the possibility of developing new foreign markets. At the present time the outlook is not promising. Embargoes, exchange restrictions, dollar shortages, and unstable cur-

rencies have made it extremely difficult to develop or hold our export markets. But in spite of all this, our exports of citrus fruit have been relatively good. Canada continues to be a good market and our exports to the west have increased. Last year you made a substantial sale of grapefruit to Great Britain with favorable results. I hope you continue to explore this and other foreign markets. It is well to remember that there are a lot of people in the world who have never seen an orange or a grapefruit. It may be that in order to develop foreign markets it will be necessary to sell at prices lower than the domestic market, at least for a few years. This type of activity will require the industry to organize itself to do an effective job.

It is recognized I believe that some adjustments will undoubtedly be necessary. We are living in a dynamic society where change is the order of the day. Swings of the economic pendulum cannot be stopped. Perhaps it is possible to retard or delay the change, but sooner or later the day of reckoning is at hand. You have had a good war record and did an outstanding job. You did what the market demanded. You turned out more and more fruit products. But we must think about tomorrow and what tomorrow will bring.

It is extremely difficult to outline specific proposals which, if carried out, would solve our many perplexing problems. Economic changes cannot be developed on that basis. It is going to require a long-time program and will take a lot of hard work on behalf of growers and everyone connected with the citrus industry. Opportunity and not defeat should be our watchword, opportunity to demonstrate the same kind of initiative and perseverance that has been demonstrated in building this great industry. We look forward to a tomorrow of peace and prosperity but we know full well there can be no peace in a world that is not well fed. There can be no prosperity in a nation whose farmers are not prosperous. With this in mind, let us work together to put this industry in shape for whatever tomorrow may bring. In this endeavor the Department stands ready to assist in solving the many problems which come before the industry.

DEVELOPMENTS IN CITRUS PRODUCTS

By

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I wish to thank your Program Committee for this opportunity to meet with you to discuss developments of mutual interest and importance to the citrus industries of Texas and Florida.

Our interests are so close that there are more things on which we should work together than there are on which we should compete. When I see evidence of antagonistic competition between one citrus section and another I am reminded of a story told about two Scotchmen, who, although they were honest and conscientious, were victims of such intense rivalry that they submerged their own interests to strike at one another. They were getting along in years,—so the story goes;—their Guardian Angels became concerned about this rivalry which was the only blot on their records. Finally, it was decided to send Sandy's Angel to remedy the situation. Sandy woke to find the Angel by his bed. The Angel said: "Sandy, we are concerned over this fussing and fighting and feuding between you and MacTavish. I have been sent to tell you that you can have the fulfillment of any wish as a Christmas gift, with the provision, however, that whatever you wish, MacTavish will get just twice what you do." Sandy appeared stumped, but not for long. He replied: "Then I'll tell you what I'll ask: *loss of the sight of one eye.*"

The real competition for citrus fruits and products is not between sections, but between citrus and other foods. When it is realized that more of a *single brand* of soda pop is sold per year than the juice of *all* oranges and grapefruit produced in the United States we see how foolish it is to waste our energies battling one another. We should join forces in energetically promoting the sale of *all* citrus fruits and products. The facts are all on our side. Soda pop is simply acidulated, flavored, colored and carbonated sugar-water. It is a pleasant thirst quencher with no food value except its sugar content. Orange and grapefruit juices are even more pleasant thirst quenchers with an equivalent sugar content, *plus* indispensible minerals and vitamins which are deficient in the diet of more than half the people of this country. The juice from all the oranges and grapefruit we grow is equivalent to only one-third of our *Minimum* nutritional needs. Moreover, the price of canned citrus juice is actually lower than that of the soda pop! We stand convicted of being poor salesmen if we cannot sell an equivalent quantity of a superior product at at least an equal price!

There are of course reasons for recent market reverses. Real progress had been made in expanding citrus markets, but we were lulled into a sense of false security by heavy demands during the war years. We lost sight of the necessity of skillful, energetic, cooperative effort to keep demand increasing at the same rate as supply.

My guess is that we must find something better than hoping that a freeze or a hurricane will destroy a lot of fruit,—*for somebody else!* It won't be safe to depend upon Chance or the Whims of Nature to see us safely through marketing increased production of fresh and processed fruit in quantities now in prospect.

I do not intend to imply that there is some simple solution to the problems which lie ahead. I will not place myself in the position of the fortune teller, consulted by a handsome and fashionably dressed lady. After gazing into his crystal ball, this fortune teller came to three conclusions: First, he needed ten dollars. Second, the lady looked as if she could afford a ten dollar fortune; and third, it would be a mistake to give her a cheap fortune at such a price. "Madame," he said, "I see a brilliant future for you. You are going to marry a tall, dark, handsome and wealthy gentleman. With him you will travel widely and be received with honor, hospitality and acclaim. That will be ten dollars and are there any questions?"

The lady sighed deeply, fished a ten dollar bill out of her purse, and replied: "That is worth ten dollars, but I do have one question: 'How am I going to get rid of the little worry wart I married five years ago' "?

Anyone offering a panacea for all the ills that can befall a citrus market will have a few questions to answer. On the other hand, there is nothing to be gained from pessimism. There is a fable told about two frogs who fell into a can of milk. One, a croaking pessimist, sized up the situation, observed the steep sides of the can and the lack of a base for hopping, said: "The situation is hopeless," gave up and drowned.

The other frog, an optimist, said: "I'll swim as long as I can and perhaps something will happen." He swam and swam until he churned the milk. He climbed on the floating lump of butter and hopped out of the can to resume his career, winning mention by Dale Carnegie for his adventure.

If all of us do the best we can *and* inform ourselves of *all* the facts, we can hope for a sound foundation upon which to establish orderly and profitable marketing of fruit and products. Knowledge of all facts often aids in clarifying problems. As an illustration: I was puzzled to hear of a baby born in Cincinnati. This infant did poorly on every formula tried by the attending doctors till they finally resorted to elephant's milk. On this food the baby thrived and, in fact, gained fifty pounds within a month. I was amazed until I learned that it was a baby elephant.

To insure the profitability of growing citrus fruit, all that is necessary is to keep supply less than demand, by controlling supply so that it never exceeds demand or by stimulating demand so that it develops faster and stays ahead of supply.

Having stated the problem and the answer, it is necessary to confess that this is the answer in the back of the book, which doesn't explain *how* the problem is to be solved. That is the hard part, and is a phase which I hope to keep in mind in discussing developments in citrus products.

III

Texas and Florida, sharing the problem of extending marketing through summer and fall months when fresh fruit is not available, turned to processing. Two-thirds of the grapefruit and one-third of the oranges are marketed in processed form. When canners are paying low prices for fruit, it is easy to blame processors for poor returns, but without processing, the difference would have been that chaotic marketing conditions would have forced us to tackle a more difficult task long ago. We must either divert and destroy fruit when necessary to keep production less than demand, or we must stimulate demand sufficiently to keep it slightly in excess of supply if we wish to avoid situations in which growers fail to secure the cost of production. I do not hold much hope for the first method unless we have unified control of marketing for all areas. The problem of stimulating demand is an ever changing one requiring flexibility in cooperative and competitive application of skillful plans.

Avenues for extending markets include:

1. Development of new products of greater appeal or utility.
2. Improvement of existing products to increase popularity.
3. Promotion of the exceptional nutritional properties and bargain value of citrus fruits and products.
4. Development of export markets.

Discussing these avenues in detail:

1. **Development of new products:**

One of the most promising is frozen concentrate, in which fresh, raw juice is concentrated to one-fourth its original volume at very low temperatures. In our plant the juice will be concentrated in four minutes at a temperature of sixty degrees Fahrenheit, then quick-frozen to a creamy consistency, filled in cans, sealed and hardened at ten degrees below zero. It is then distributed in frozen condition to home consumers or to hotels, restaurants, drug stores, etc. When mixed with four volumes of water, the water thaws the frozen concentrate, the frozen concentrate chills the water and the reconstituted juice is ready to serve. In blindfold tests this product was preferred to freshly squeezed juice in every test made in kitchens and laboratories of eastern institutions. Concentration permits savings in container, storage and shipping costs which tend to offset the cost of handling in a frozen state.

Other new products which we are undertaking to develop and market include high juice content beverages. Most so-called orange drinks contain less than five per cent of juice. Almost none contain more than fifteen per cent. We have developed bases to yield beverages with twenty-five to fifty per cent juice content; and these are finding acceptance

Other processors and state and federal laboratories are demonstrating many possibilities in the field of new products, and further developments may be expected.

2. **Improvement in existing products:**

The principal citrus product is canned juice which has been greatly improved by deaerating, deoiling, completely inactivating enzymes and rapidly heating and cooling. The next steps in this process of improvement will be cooling the product to lower temperatures before casing and storing at temperatures below 80°F.

3. **Promotion:**

The third method for extending markets for fresh fruit and products is promoting the nutritional importance of citrus fruits as a basic food for which no other food can be satisfactorily substituted. We have been most negligent in this field in which the sale of citrus fruit and products can be most effectively stimulated at least expense. This negligence has been costly.

Advertisements in leading journals circulated to hospital dietitians promote mixtures of citric acid, sugar, yellow color, flavoring oil, and ascorbic acid as satisfactory substitutes for citrus juices. This advertising implies that these products contain appreciable quantities of juice, but the label reveals less than two per cent. Although these products bear the seal of approval of the American Medical Association, they can only do harm if *substituted* for citrus juice. I have called this to the attention of the Federal Trade Commission, but the industry needs an effective nutritional promotion program which will actively combat such injurious and unfair competition.

To illustrate how a small investment may pay big dividends in this field, while in a grocery store in a Florida town, the manager came up to me and asked: "Aren't you the man who talked to our Civic Club three months ago on the nutritional importance of citrus juice"? When I admitted my guilt, he told me that his sale of canned juice had immediately tripled and this lead had been maintained.

Our organization published a little booklet describing the nutritional importance of citrus fruit. The reception was so good that an improved, simplified, and illustrated booklet containing more information on this subject is now in process of publication.

The National Canners deserve credit for a campaign which publicized the fact that properly canned citrus juice doesn't lose a significant portion of its food value within a year.

The California Fruit Growers Exchange sponsored a colored motion picture for exhibition to the medical and nursing professions. In this film, made in University laboratories, two sets of guinea pigs were subjected to major surgical operations. Both sets had received identical diets with the exception of the inclusion or exclusion of orange juice. The picture revealed conclusively how wounds healed rapidly and strongly in animals receiving orange juice and slowly and improperly in animals denied this food. This has been shown to more than a hundred thousand professional people and is an outstandingly effective educational picture, free from advertising, excepting its simple message of the necessity of citrus juice for proper healing of wounds. Yet how many hospitals include ten ounces of genuine citrus juice in the diet of every surgical patient?

If time permitted I could talk for hours presenting authentic scientific evidence of the importance of oranges and grapefruit in daily diets. Here in Texas Dr. R. J. Williams at Austin and Dr. Florence I. Scoular at Denton are among the scientists who are making important contributions to our knowledge in this field. The Handbook of Nutrition of the American Medical Association contains statements like the following: "One of the worst of the many bad food habits of Americans is the excessive use of carbonated beverages . . . . The trouble mainly comes from lack of fruit in diets, especially lack of citrus fruits." Doctors Wilder and Keys could not be paid to make such statements unless they had solid reason for believing them true. Yet the citrus industry has no promotional agency for publicizing these facts effectively and for combatting unfavorable publicity, which may be widely circulated as was the interpretation of tests of lemon juice on teeth, the enamel of which was defective. The implication was that citrus juice might be injurious to teeth when the truth is that citrus juice in adequate quantities is indispensable to the development and maintenance of healthy, caries-resistant teeth.

4. Development of Export Markets:

We of the citrus industry have a challenge and an opportunity. How we shall meet it remains to be seen. At the moment, it presents itself in the form of an opportunity to promote the sale of citrus juices and concentrates in the food relief program for Europe. Next month or next year, it will be something else, but the subject with which I wish to conclude my discussion is why citrus juices and concentrates should be included in any food assistance program by the U. S. Government for European countries.

Your speaker was asked by the Florida Citrus Commission to serve on a committee to gather information to be used by representatives of all citrus areas in an effort to secure allocation of funds to include the juice and concentrates from 15,000,000 boxes of oranges and grapefruit in purchases for European relief. There has been a carry-over in canned grapefruit juice for two seasons with the result that prices of citrus juices have been forced down to a level which will not return the cost of production to growers. If the juice from ten million boxes of grapefruit and five million boxes of oranges were taken out of American markets this year, several important results would be secured.

First: it should make it possible to stabilize the marketing of fresh fruit and products for two years at prices which would return production costs.

Second: this would result in increasing employment and income taxes from the citrus and related industries which would more than pay the cost of the project.

Third: it would result in the manufacture of feed products (citrus pulp and citrus final syrup) which would replace 2,000,000 bushels of scarce grains for cattle feeders at a saving of forty per cent or $1,365,000.

Fourth: it would contribute needed food elements to our less fortunate good neighbors in western Europe.

Fifth: it would be a contribution to our major responsibility: compelling admiration for our system of government by proving that it is possible to develop a sound economy under it.

Considering some of these factors in detail:

Economic and diplomatic considerations favor the inclusion of citrus fruits in the government's program. Experience has demonstrated that it is impossible to purchase friendship, admiration, loyal-

ty or esteem with gifts of food or materials, or with military assistance. In planning our relief program we may advantageously consider how Sweden and Switzerland have managed to be favorably considered without resorting to gifts or military aid. These countries have commanded universal respect because they adjust themselves to maintain a stabilized economy under changing conditions. They export commodities which they can produce advantageously in excess of home requirements, maintaining a favorable balance of trade. They import or keep at home things needed there, and as a result have been able to keep industry and agriculture, capital and labor in balance without resort to artificial expedients.

In the Balkans, three billion dollars worth of U.N.R.R.A. gifts from the United States were used to alienate the recipients, demonstrating that following the path of least resistance can injure our position instead of benefitting it. It will take skillful, energetic application of intelligent plans to accomplish the objects of the Marshall Plan, or any other that may be devised by our Government.

If we wish to protect the ideals which we defend so ably and expensively in battle, we must earn the admiration of the world for our accomplishments in applying those ideals at home. We cannot serve the interests of the people we feed, of our own pople, or of the system of government which we consider best, if we export by gift or sale commodities which are in short supply and hold onto the things that are surplus.

Supplies of grain, meat, fats and steel are notoriously short. It is wise to survey the agricultural situation, determine which foodstuffs are available in excess of current consumption, and figure which of these can be most advantageously substituted for commodities in short supply in feeding the people we want for friends in other countries. While it is important to consider the wishes of the recipients of the gifts, we can render a disservice if we allow their wishes to be the sole determining factor in deciding what foods shall be supplied.

European countries can grow grains and while they may not have all they want or need and while we should supply them with as much as possible without upsetting our own economy, we should not fail to consider other factors which relate to this problem. So long as grains are short here, Europe should be encouraged to produce as much grain as possible at home. We should consider the possibility of supplying nutritionally important basic foods which the recipients cannot produce and which we have in excess of current consumption.

Among these foods is grapefruit juice of which there was a carry-over from the 1946-47 season. As a result of this carry-over, canned orange and grapefruit juice prices have been depressed to figures that will not return costs of producing the fruit, placing growers in a disastrous position, the prices of grain, meat, labor, fertilizer and other commodities being what they are. Grapefruit is one of the basic citrus fruits for which no satisfactory substitute is known. If the juice from fifteen million boxes of grapefruit and oranges (637,500 tons) could be taken out of American markets, the balance of the American citrus fruit crop could be marketed at prices that would return production costs.

Probably both single strength juice and concentrated juice should be included in the program. While an eighty per cent saving in shipping and container costs results from concentrating the juice, it is necessary to have potable water, mixing facilities and trained personnel to reconstitute the juice. This means that concentrated juice will be of greatest acceptability in large distribution centers and single strength juice for rural communities.

Comparing the calory content of citrus juice and grains, wheat has approximately 1600 calories per pound, single strength sweetened juice about 260 calories per pound and concentrated juice (65° Brix) has approximately 1,200 calories per pound.

A gallon of sixty-five Brix concentrate supplies 12,000 calories. The shipping weight is only eleven pounds and a gallon can probably be moved from eastern ports for less than twenty-five cents.

In addition to a high caloric value, citrus juices are the richest available food sources of three important food factors: Vitamins C and P, and Inositol.

Vitamin C. The importance of this vitamin is so generally recognized that it need not be detailed here, except to refer to its importance for normal, healthy teeth, gums and bones and proper healing of wounds and fractures and resistance to infections. C. G. King, Director of the Nutrition Foundation, volunteers the statement that citrus juice is the *ONLY* dependable source of this vitamin, because it is so unstable in other foods that it is destroyed before the food is consumed. In England, during the war, concentrated orange juice was supplied to nursing and expectant mothers and to children under five and despite abnormal war-time conditions and limitations in hospital and medical facilities, death in child birth and infant mortality dropped to an all time low and child health reached an all time high.

Vitamin P. (*Citrin*), is the correlating, supplemental factor without which the full benefits of Vitamin C are not possible. It relates to the health of the smallest blood vessels, the capillaries, which in turn determine the health and tone of all body tissues.

Inositol is one of three substances which is capable of preventing liver damage on unbalanced diets such as are generally prevalent in aggravated form in Europe.

Citrus juices are not only the richest available sources of Inositol and Vitamins C and P, they also contain valuable quantities of Thiamin, Niacin, Riboflavin and Folic Acid, vitamins of the water soluble "B" complex, essential to avoid anemia, pellagra, dermatitis and debility. These vitamins are moderately deficient in

American diets and grossly deficient in Europe. The juice from fifteen million boxes of grapefruit could contribute importantly to alleviating this deficiency.

In addition to these essential vitamins, citrus juice contains naturally balanced minerals. Anyone who has seen the results of so-called "Minor" element fertilization in Florida citrus groves can realize that if these minerals are essential in the health of trees, they are of even greater importance in human nutrition.

IV.

In closing this discussion of the importance of including citrus juice products in government relief purchases, unless the unbalance between supply and demand is corrected by some means, the prospects are:

Growers may lose $7,500,000 on production costs of fruit allowed to fall to the ground and a considerably larger sum because of poor returns on the balance of the crop.

Citrus industry labor may lose $3,500,000 in wages because of wasting this fruit.

The feed industry may be deprived of 84,000,000 pounds of dried citrus pulp and 42,000,000 pounds of citrus final molasses which would replace 2,000,000 bushels of scarce feed grains at a saving of $1,500,000 to cattle feeders.

Loss of income tax to the federal government from growers and employees may easily exceed the cost of this program which should place the citrus industry upon a sufficiently sound foundation to work out its marketing problems by stimulating demand to the point where it will absorb the production of the industry at prices which will cover production costs.

Summarizing these points:

It would be a repetition of previous mistakes to use purchases for European relief to unbalance our own economy, when they can be advantageously employed to improve our domestic economy while aiding in the development of future markets for American commodities.

Citrus juice products could supply important food elements desperately needed by undernourished people of Europe.

Not only would the citrus juice products replace scarce grains, but feed by-products from the advocated program would replace 2,000,000 bushels of additional grain at a saving of forty percent to feeders.

Increases in employment plus income taxes, plus savings in feeding costs might reimburse the government for the entire cost of the program.

Support for such a program by the citrus industries of all areas and by every American citizen is warranted.

COLD STORAGE STUDIES WITH TEXAS CITRUS FRUIT

By

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Those of you who attended the 1946 Citrus Institute may recall that I stated then that we felt there were commercial possibilities in the cold storage of Valley grapefruit and oranges as a means of supplying southwestern markets during the summer months when freshly harvested citrus fruits are not available from the Texas producing areas. It was also stated at that time that a program of experimental work was being inaugurated to determine the feasibility of storing part of the spring crop for summer marketing.

The first season's work on this project has now been completed. Results given in this report must be considered as preliminary as further work should reveal additional facts and may somewhat modify the findings of a single season. Some previous work on the cold storage of citrus fruits has been done in the Rio Grande Valley. As reported by Friend and Bach [1] of the Valley Experiment Station, cold storage trials were made during the 1930-31 season with several varieties of Valley grapefruit and with Valencia oranges. The marketing of Valley grapefruit at that time was accomplished principally during the period December 1 to March 1 with the result that the goal of cold storage studies was somewhat different in those days than it is at the present time when our normal harvesting season extends to June 15, and even later in some seasons. Those early storage experiments were designed to determine the possibility of storing fruit for sale in March, April, and May, whereas the experiments described in this report were conducted in the hope of finding methods whereby citrus fruits could be held in cold storage for sale in July, August, and September.

In the 1930 experiment Friend and Bach harvested grapefruit at intervals from December 22 to February 20. On the basis of harvestings made during this period they reported that grapefruit was held in satisfactory condition for 8 to 10 weeks at a temperature of 45°F., and that the Duncan variety was more satisfactory for cold storage than the Marsh Seedless. Valencia oranges were found to hold up well at 32°F. for periods up to 20 weeks. They further reported that grapefruit picked on February 20 did not keep as well in cold storage as fruit picked in December or January. Some results were also given on the effect of different soil types and different fertilizer treatments on the keeping quality of the fruit.

Experimental Methods

In selecting the harvest dates for experimental fruit in the present work, it was felt that as July through September was the desired marketing period for the cold storage holdings the pickings should be made as late in the season as it was possible to secure sound fruit.

[1] Friend, W. H., and W. J. Bach. Storage experiments with Texas citrus fruit, Texas Agr. Exp. Station Bul. 446, 1932.

April first and early May were selected for grapefruit harvest, the first date being before the date of required heat sterilization and the second date coming during the period when compulsory heat sterilization would generally be in effect.

As Valencia oranges are generally considered to reach full maturity somewhat later than Marsh Seedless grapefruit the picking dates for Valencia oranges were set at mid-April and mid-May. Orchards from which the fruit was harvested were selected at points relatively close to the packing and storage site for convenience. All of the Marsh Seedless were harvested from a block of 16-year-old trees in the Primera section. Trees in this block were in a good state of vigor, carried a moderately heavy crop, and had received regular nitrogen fertilizer and adequate water for a number of years past. The Valencia oranges were secured from an orchard of 15-year-old trees in the Adams Gardens section. These trees were also in good vigor, carried an average crop of good-sized fruit, and had received better than average care.

All of the fruit was packed through a regular commercial packing house as it was felt that commercial handling methods should be used insofar as practicable in the experimental study. However, as a supplement to the regular packing house procedure certain treatments were applied which would not generally be a part of commercial practice. These treatments were based on present knowledge of decay control as developed by experimental work in Texas and in the other citrus-producing areas of the United States.

Supplementary treatments included fungicidal dips and fumigants prior to packing, chemically treated wrappers at packing, and treatments with nitrogen trichoride gas after packing. The treatments before packing were as follows: (1) Borax solution dip, 6%, 110°F., 30 seconds; (2) nitrogen trichloride gas, 0.1 to 0.15 p.p.m. 4-hour exposure; and (3) a combination of the borax dip followed by nitrogen trichloride. In each case an untreated lot was used as a check.

All experimental fruit was wrapped and packed in standard two-compartment boxes. Three types of tissue wraps were used including untreated, Diphenyl, and Alpha, the last two being patented types of chemically treated wraps which are presumed to have value in checking the development of rot-producing organisms. After packing, certain lots were treated with nitrogen trichloride at 0.1 p.p.m. for 4 hours at warehouse temperature.

At each picking of both grapefruit and oranges the fruit was harvested before noon, treated the same afternoon, packed that evening, and placed in cold storage on the following morning. Storage temperatures used for grapefruit were 32°-34°F., 38°-40°, and 46°-50°. Only the two lower temperatures were used for oranges. Under the conditions of commercial storage used the temperatures were not closely controlled and there were some periods when they ran slightly above or below the stated range. Humidity also varied somewhat, ranging from the low to the high eighties measured as relative humidity.

All of the grapefruit was examined after 8 to 9 weeks in cold storage. All lots that were in reasonably good condition at this time were repacked and returned to the cold storage chamber. A second complete examination of this fruit was made at approximately 6 weeks after the initial examination and the lots that were still in fair to good condition were held for re-examination after 3 days at room temperature.

All oranges of the mid-April picking were completely examined after 16 weeks' storage, again after 20 weeks' storage, and finally after 3 additional days at room temperature. Oranges harvested in mid-May were examined after 12 weeks, 16 weeks, and 3 additional days at room temperature.

Results, Grapefruit

A storage temperature of 46°-50°F. was more satisfactory for grapefruit than either of the two lower temperatures. After the first picking had been stored for 8 to 9 weeks the average proportion of fruits affected with pitting was 13.7 percent at 46°-50°, 94.1 percent at 38°-40°, and 47.9 percent at 32°-34°. Furthermore, most of the pitting found at 46°-50° was of the mild type (less than 15

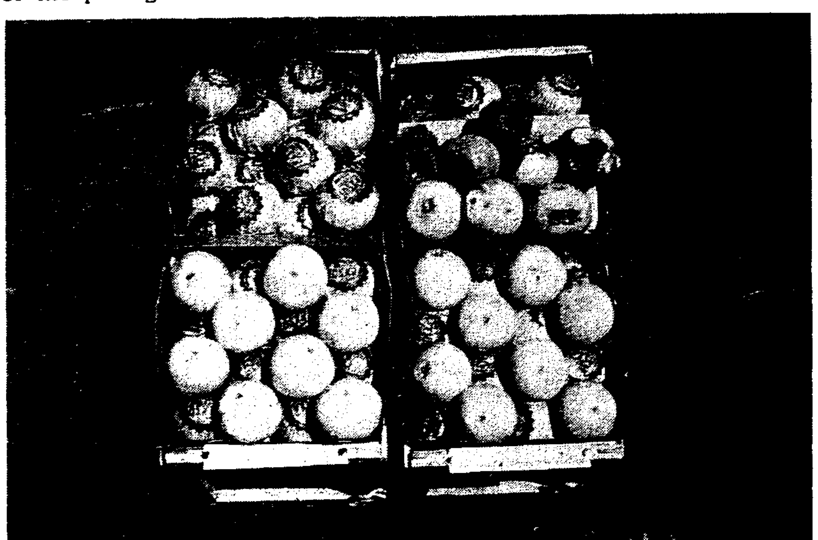

Fig. 1. Marsh Seedless grapefruit harvested April 1, 1947. Picture taken after 2 months storage at 50°F. Box at left, treated with borax dip and nitrogen trichloride before packing and 6 weekly treatments with NC13 during storage. Box at right untreated before packing but received 6 weekly treatments with NC13 during storage. Box at left contained no decay, box at right showed 8 rotten fruits. Note freedom from pitting and stem ageing. Both lots in untreated wraps.

percent of the surface affected), while at the lower temperatures a large proportion of the fruits were affected with moderate to severe types of pitting. The relative condition of lots from the second picking was about the same but a somewhat greater percentage of the second picking was affected by pitting after 9 weeks' storage at 46°-50°.

The amount of grapefruit decay found after 8 to 9 weeks' storage in general was least at the highest storage temperature used. The first picking showed an average of 1.9 percent decay after 8 to 9 weeks' storage at 50°F., 4.6 percent at 38°, and 0.8 percent at 32°. After the same interval the second picking showed an average of 1.6 percent decay at 50°, 4.3 percent at 38°, and 4.9 percent at 32°. The increased decay in the second picking stored at 32° was largely a result of the development of some physiological internal breakdown which increased susceptibility of these fruits to rot organisms.

Ageing at the stem was found at all storage temperatures but appeared to be somewhat more prevalent in fruit stored at 50°F. than in that stored at lower temperatures. An accurate determination of this was difficult as the stem ageing was often masked at the lower temperatures by severe surface pitting.

Treatment of the fruit before packing, with hot borax solution, nitrogen trichloride gas, or a combination of the two resulted in decreased decay for the 8 to 9 weeks' storage. Untreated fruit of

Fig. 2 Marsh Seedless grapefruit harvested April 1, 1947. Picture taken after 2 months storage at 38°F. Both lots treated before packing with borax dip and nitrogen trichloride gas. No treatments during storage. Box at left packed in untreated wraps. Box at right packed in Diphenyl wraps. Note amount of pitting developed in 2 months at 38°F.

the first picking showed 4.2 percent decay at the end of 8 to 9 weeks' storage at 50°F., while fruit receiving the combination of borax dip and nitrogen trichloride gas prior to packing showed only 0.3 percent decay. At 38° the decay figures were 7.7 and 0.7 percent respectively, for the untreated and the double-treated fruit; and at 32° the two lots showed 1.7 percent and 0.5 percent. Fruit of the second picking showed the following results after 9 weeks of storage: at 50°, untreated 4.2 percent decay, treated 1.8 percent; at 38°, untreated 6.5 percent, treated 0.5 percent; at 32°, untreated 7.7 percent, treated 3.8 percent. Fruit treated with either the borax dip or nitrogen trichloride alone also showed less decay than the untreated lots, but neither of the single treatments was as effective as the dual treatment.

In most cases the amount of decay developed in grapefruit stored for 8 to 9 weeks was less in Diphenyl wraps than in untreated wraps, but this was not entirely consistent. Fruit in Alpha wraps showed less decay in some lots and more decay in other lots than comparable fruit packed in untreated wraps. The evidence obtained does not indicate that Alpha wraps significantly affected the incidence of decay in stored grapefruit under the conditions of this experiment. At 38° and at 32°F. the proportion of fruits affected with pitting and the severity of the pitting were greater in lots stored in Diphenyl wraps than in those stored in untreated or Alpha wraps. At the 50° storage temperature, where surface pitting was less serious than at the lower temperatures, the data do not indicate that the amount or severity of pitting was consistently affected by the type of wrapper in which the fruit was stored.

Grapefruit harvested on April 1 maintained quality and condition during cold storage better than fruit harvested on May 7. After 8 to 9 weeks' storage at 46°-50°F. the first picking averaged 13.7 percent pitting, 12.1 percent stem ageing, and no surface scald. After a comparable storage treatment the non-heat-sterilized fruit of the second picking averaged 31.5 percent pitting, 32.9 percent ageing at the stem, and 34.4 percent surface scald. Dessert quality also deteriorated more rapidly in the later-picked grapefruit.

Treatments with low concentrations of nitrogen trichloride at intervals during storage at 46°-50°F. resulted in reduced incidence of pitting, ageing, and scald; but since it was necessary to remove the lots from the cold storage room for the gas treatments there is a possibility that periodic temperature changes rather than the gas treatments were responsible for the beneficial results. This phase will be more fully investigated during the current season.

Texture and dessert quality of the grapefruit from the April 1 picking were maintained very well for 8 to 9 weeks at 50°F. After 14 weeks' storage much of the first picking was of acceptable quality but flavor had deteriorated somewhat. After 3 additional days at room temperature most of the fruits had an overripe or stale flavor. The second picking lost dessert quality more rapidly in storage, so that after 8 to 9 weeks in storage at 50° the dessert quality was only fair and after 13 weeks the flavor was poor. Fruit from the second picking that was heat sterilized prior to packing lost quality more rapidly than the fruit packed without heat sterilization.

On the basis of these results there does not appear to be much promise for the successful storage of grapefruit for marketing very far into the summer season. The fruit that was harvested on April 1 maintained prime quality only until about mid-June, and fruit picked in early May had lost quality and developed a considerable proportion of unmarketable fruit by the first week in July. However, some leads were developed which with further experimental work may make it possible to maintain marketable quality in grapefruit over a longer storage period. Meanwhile the results secured may be of some benefit to those who wish to hold grapfruit for periods of 1 to 2 months to smooth out marketing and to relieve temporary oversupplies which develop almost every season.

Results, Oranges

The data indicates that 38°-40°F. was somewhat better as a storage temperature for Valencia oranges than 32°-34°. Fruit of the first picking after 16 weeks of storage at 32° averaged 10.4 percent pitting, 26.0 percent stem ageing, and 3.9 percent decay, while the fruit stored at 38° for a comparable period averaged 4.0 percent pitting, 24.3 percent stem ageing, and 4.4 percent decay. After 16 weeks' storage at 32° fruit of the second picking showed an average of 21.3 percent pitting, 20.3 percent ageing at stem, and 4.2 percent decay. Stored at 38° for the same period oranges of the second picking developed 16.0 percent pitting, 32.5 percent stem ageing, and 3.1 percent decay. After 20 weeks' storage some brown stain was apparent on oranges stored at 32°; and when the various lots were held at room temperature for 3 days after 16 or 20 weeks of cold storage, decay usually increased more rapidly in the fruit that had been stored at 32°.

While a considerable number of oranges showing pitting were found in most lots, especially those from 32°F. storage, the pitting was very largely of the mild type with only 1 to 5 small pits per fruit. Such pitting probably would have little effect on the marketability of the fruit. On the other hand, a large proportion of the oranges showing stem ageing were considered to be unmarketable since the brown, sunken areas around the stem varied in diameter from one-quarter inch to one inch and were very unsightly.

Neither the borax dip nor the nitrogen trichloride gas treatment before packing was consistently effective in reducing storage decay of oranges. The combination treatment using both borax and nitrogen trichloride did result in consistently lower percentages of decay after storage. However, the data indicate that pre-packing treatment with nitrogen trichloride, either alone or combined with the borax dip, increased the percentage of pitting and stem ageing found after 16 to 20 weeks of cold storage.

Chemically treated wraps (Diphenyl and Alpha) reduced the average percentage of decay found in oranges at the final examination in every case, in comparison with untreated wrappers. In addition, somewhat less pitting and stem ageing were found in fruit wrapped in treated paper than in that in untreated paper, but this tendency was not entirely consistent. After 16 to 20 weeks of cold storage and 3 additional days at room temperature there was in every case more marketable fruit in the lots that had been stored in treated wraps than in those in untreated wrappers, and in most cases marketable fruit was at least 10 percent higher in the lots stored in treated paper. Alpha wraps showed a somewhat better average of marketable fruit than did Diphenyl wraps.

A single treatment with nitrogen trichloride after packing reduced decay in every case, in comparison with untreated lots. However, such single treatment showed little effect on the subsequent development of pitting and stem ageing in storage.

On the basis of these results it appears that Valencia oranges that were carefully selected and handled could be held successfully up to 16 weeks in storage at 38°F. Under ideal conditions losses from decay should be slight. Further investigational work is needed, however, on methods of reducing the incidence of such physiological disorders as surface pitting and ageing at the stem. The data indicate that Valencia oranges harvested in mid-May held up in storage as well as those harvested in mid-April, which suggests that Valencias might be harvested for cold storage even later than the last date used for these tests.

THE CITRUS BLACK FLY

By

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The native home of the citrus black fly, *Aleurocanthus woglumi*, is in southeastern Asia. It was first found by Maxwell-Lefray in India during 1910. Since then, it has been found as a major citrus pest in the West Indies, Cuba, Canal Zone and Mexico. The black fly was reported in 1935 as causing damage to citrus at El Dorado, Mexico. Since then, it has spread to Empalme, which is approximately 270 miles from Arizona and 700 miles from the Lower Rio Grande Valley of Texas. During the 1946-47 citrus season, this pest was reported at Valles, Mexico, near Tampico. This infestation is only 270 miles from the Lower Rio Grande Valley of Texas. In other words, we here in the Valley have the same probability as Arizona in having trouble with this pest in the future.

The citrus black fly, an Aleyrodid, is closely related to the citrus white fly. The adult is similar in size to the citrus white fly. The body of the citrus black fly is dark brown in color, while the wings have a bluish-black appearance. The eggs are laid on the under side of citrus leaves. At first these eggs are white in color; then they gradually change to black. The larval stage lasts from 45

to 113 days, the length of time depending upon the temperature. Further work is needed to determine the exact number of generations per year. This insect sucks the sap from the leaves. As the black fly is very prolific, it can severely damage a tree in a short period of time. Black flies numbering in the thousands have been found on a single leaf, according to Woglum and Smith (3). Black flies feeding on citrus result in a failure of fruit setting and in degeneration of the tree. Citrus is the black fly's favorite host, and it has been found in large numbers on mangos and coffee plants.

When the black fly first appeared in Cuba, a number of parasites and predators were imported. According to Clausen and Berry (1), the lady bird beetles did not prove very effective in controlling this insect. On the other hand, a parasite known as *Euretmocerus serius* was very effective in reducing black fly infestations. After one year, survey work showed that this parasite parasitized between 72 and 78 per cent of the black flies, which was considered good commercial control.

Attempts have been made to control the citrus black fly in Mexico with *Euretmocerus serius*. This parasite was imported in 1943 to the Colima area and was soon established. Here the parasite destroyed as much as 64 per cent of the black flies, but the black flies were so numerous that the trees were still severely damaged. Only an occasional parasite was found in the Los Mochis area during the dry season where repeated attempts had been made to introduce this beneficial insect. This is due to the fact that *Euretmocerus serius* works efficiently only during an extended rainy period.

Since the black fly is only 270 miles away, citrus here in the Valley has a chance of becoming infested. The quarantine and inspection services should be watching for this pest. However, the author believes that this insect may become established eventually, even though the inspectors are constantly watching. Once established here, this insect will become a major citrus problem because of the lack of prolonged rainy periods which are needed for the establishment of efficient control with the parasite *Euretmocerus serius*. As mentioned before, the lady bird beetle predators are of little value. So, in case the black fly eventually does become established here, we have two choices of control open: (1) work with the proper Federal and State Experiment Stations in finding parasites and predators which will do the job under our weather conditions; and (2) if no efficient parasite or predator can be found by the time of the initial black fly infesation, we will have to resort to insecticidal control. Insecticidal control is expensive, and what's more, we may create new insect problems on citrus by destroying the natural balance between the beneficial and harmful insects.

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A PRELIMINARY REPORT ON THE TEXAS CITRUS ROOTSTOCK INVESTIGATION [1]

By

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In September 1946 work was started at the Valley Experiment Station, Weslaco, Texas, on the problem of finding suitable rootstocks for the Rio Grande Valley other than sour orange stock. The tristeza disease has been very destructive to certain citrus fruits on sour orange rootstock in parts of South America. The work was initiated and is being continued as a joint cooperative project between the Texas Agricultural Experiment Station and the U. S. Department of Agriculture. This paper reports the progress of the work during the first year.

Nursery Planting at Weslaco

One hundred seedlings each of 49 varieties of citrus (see table 1), grown from seed planted on January 20, 1946, at the U. S. Subtropical Fruit Station, Orlando, Florida, were shipped to Weslaco, Texas, in September, 1946, and were transplanted in nursery rows at the Valley Experiment Station. The seedlings of each variety were divided into four lots of 25 plants and were planted in randomized replications in the 3/5 acre nursery area. The plants were spaced 18 inches apart in rows 3 feet apart.

The seedlings of all varieties survived the winter without noticeable cold damage. Growth was most rapid in the shaddocks, limes, lemons, and sour oranges and was least rapid in the trifoliate oranges. The entire nursery, except the very small plants, was budded with Red Blush grapefruit [2] on May 20, 1947. Plants not having a growing bud were re-budded on August 20, 1947. The seedlings were partially girdled above the bud three weeks after budding. The seedling top was trimmed slightly at intervals of two or three weeks. Experience has shown that at certain seasons of the year the practice of pruning back the seedling top to near the bud union before much wood is formed by the grapefruit scion often results in the death of the plant. Leaves on the new shoot of the grapefruit bud become chlorotic, the stem becomes brown and necrotic, and finally the plant dies. It is suspected that this is a salt effect.

1/ This investigation was supported in part by a grant to the Texas Agricultural Experiment Station by the Texas Citrus Advisory Council.

2/ Webb strain taken from 12-year-old trees of George Crockett, Weslaco, Texas.

A record of observations made in early November 1947 on these budded rootstocks is shown in table 1. Growth of the grapefruit scion top was based on estimates made for each individual plant as to whether it was large, medium, or small. Actual measurements were not feasible as a supporting stake plus the stem of the seedling top frequently made it almost impossible to get at the trunk of the grapefruit scion with a measuring tape. The large size represents trees of an estimated scion caliper of one-half inch or greater, which were considered ready for transplanting to the orchard. In the medium category were trees in which the scion had been topped at 24 inches and had formed a head, but the caliper of the trunk was less than one-half inch. Classed as small size were trees in which the scion was less than two feet high. The fourth class represented seedlings with either dead or dormant buds.

The various sour orange rootstocks, with the exception of Natsu Mikan, produced the largest trees in the nursery row under the particular conditions of this experiment. Practically all were either large or medium size. It is not yet known for certain, but all sour orange varieties may be susceptible to tristeza. Terra (3) reports that the Florida sour orange and the Bigardier sour orange are susceptible to tristeza in Java.

Tristeza-resistant rough lemon and Rangpur lime (1) as rootstocks produced many large and medium-sized trees under the conditions of this experiment. The high percentage of dormant buds was the factor that prevented the rough lemon from making a better growth record in the nursery. This response of the rough lemon is similar to that observed with this variety by several nurserymen in the Valley.

The Cleopatra mandarin, said to be resistant to tristeza (3,2), produced much smaller scion tops than did the sour orange varieties under the particular conditions of this test. There were no trees in the large category and most were in the small class. The record of other mandarin rootstocks, including the Dancy, Satsuma, Sunki, Ponkan, Chu Koa, and Clementine, was similar to the Cleopatra. The King, the Umatilla, and the Calamondin produced more vigorous scion growth than the other mandarins mentioned above. The Temple produced a high percentage of variant seedlings (all appeared to be hybrids) and is not promising as a commercial rootstock for the Rio Grande Valley.

The tangelo varieties differed considerably in the effects on growth of the grapefruit top during this particular test period. The Yalaha, Suwannee, Orlando, Sunshine, Minneola, and Pina produced much less scion growth than the Williams, Thornton, Watt, and Sampson varieties. The latter four varieties induced growth only slightly less extensive than did the sour orange varieties.

The record of the sweet orange, grapefruit, and other types of rootstock under test is seen in Table 1. None of these varieties induced growth comparable with the sour oranges. The two trifoliate oranges produced the poorest record. The leaves on the seedlings were chlorotic during the entire period of the test. Necrotic brown areas appeared on the leaves and abscission usually followed shortly afterwards. Many of the shoots began dying back from the tips. The few grapefruit buds that were induced to "stick" usually put out a short shoot which had chlorotic leaves and usually died back to the bud.

Table 1. Observations on the Rootstock Test with Red Blush Grapefruit at Weslaco, Texas. (Seed planted 1-20-46, transplanted 9-15-46, budded 5-22-47 and 8-20-47, observations made 11-13-47).

Rootstock Variety	Size of Grapefruit Top: Large	Medium	Small	No bud	Chlorosis Record for Seedlings [1]
Sour Oranges					
1. Florida sour orange	22	70	5	3	-
2. Oklawaha sour orange	12	72	12	4	-
3. Bergamia (Bergamot orange)	28	58	10	4	-
4. Sauvage sour orange	39	49	9	3	-
5. Bittersweet	20	51	13	16	-
6. Natsu Mikan	0	48	26	26	-
Sweet Oranges					
7. Florida sweet seedling	2	49	40	9	*
8. Hamlin orange	3	62	21	14	*
Grapefruit					
9. Duncan	0	19	31	50	**
10. Leonardy	1	44	40	15	-
Shaddocks [2]					
11. Siamese	0	21	36	43	*
12. Thong Dee	3	34	26	37	-
Lime-Lemon Group [3]					
13. Rough Lemon	26	32	14	28	-
14. Rangpur lime	23	41	19	17	*
15. Lakeland limequat	0	4	50	46	-
16. Tavares limequat	0	30	27	43	*
17. Lempum	3	19	40	38	***
Mandarin Group [4]	23	41	19	17	-
18. Cleopatra mandarin	0	38	54	8	-
19. Dancy tangerine	0	33	46	21	-
20. Satsuma	0	17	28	55	-
21. Sunki	0	52	33	15	-
22. Ponkan	0	37	30	33	-
23. Chu Koa	0	51	43	6	-
24. Clementine tangerine	3	46	33	18	*
25. Temple	2	34	37	27	-
26. King	1	73	9	17	-
27. Umatilla tangor	4	64	23	9	*
28. Calamondin	8	63	19	10	-
29. Kalpi [5]	1	38	40	21	-
30. Yalaha tangelo	0	10	58	32	**
31. Suwannee tangelo	4	27	50	19	**
32. Williams tangelo	14	68	17	1	-
33. Watt tangelo	14	62	22	2	-
34. Sampson tangelo	6	64	22	8	-
35 Pina tangelo	2	54	34	10	-
36. Minneola tangelo	4	51	30	15	*
37. Thornton tangelo	17	60	20	3	*
38. Sunshine tangelo	0	31	46	23	-
39. Orlando tangelo	0	38	35	27	**
Trifoliate Group [6]					
40. Trifoliate orange-small flowers	0	0	16	84	****
41. Trifoliate orange-large flowers	0	0	13	87	****
42. Citrangor No. 43728	0	20	70	10	*
43. Citrangequat No. 48050	0	0	40	60	-
44. Citrangequat No. 48032	0	10	63	27	-
45. Citrumelo No. 4475	0	7	69	24	***
46. Citrumelo No. 4561	0	17	42	41	-
47. Citrumelo No. 4482	0	0	48	52	***
48. Citrumelo No. 4606	0	15	40	45	***
49. Citrumelo No. 4478	0	4	18	78	***

[1] See text for meaning of Symbols.

[2] Also known as pummelos.

[3] This group includes various natural and controlled cross hybrids of which either the lime or lemon is, or is suspected of being, one of the parents.

[4] This group includes mandarins, tangerines, tangors, tangelos, and several natural hybrids of which the mandarin is suspected of being one of the parents.

[5] Suspected of being a hybrid of **Citrus macroptera** with the common Philippine mandarin (Swingle (4, p. 439)). Known as Webber's Philippine hybrid.

[6] The trifoliate orange and controlled crosses between that and various citrus species.

A record of chlorosis observed in the nursery stock of the various rootstock varieties is given in the last caption on the right in table 1. In general, where chlorosis was observed in leaves of the seedling stock it also appeared in the leaves of the grapefruit scion. This, however, was not consistent for all plants. There was considerable variation in this respect in the various plants within a variety. In all instances chlorosis was accompanied by necrotic brown areas. It should be recalled that there were four replicate plantings of each rootstock variety and these were randomized in the test area in order to minimize the effect of differences in the soil. If chlorosis occurred on seedling plants of any of the four test lots it was indicated by the * sign. The symbol * * indicates that it occurred in all four plantings, and the symbol * * * indicates occurrence on every plant. The symbol * * * * indicates the severe cases such as those where the trifoliate orange rootstock was used. The symbol - indicates no chlorosis.

It is seen that the seedling sour oranges, as a group, showed no chlorosis. The seedling Cleopatra, Dancy, Satsuma, Sunki, Ponkan, Chu Koa, Temple, and King mandarins showed no chlorosis; the Clementine mandarin, however, showed chlorosis. The weaker-growing tangelos showed chlorosis, while the more vigorous group was free. Four out of five citrumelos showed * * * chlorosis while one variety showed none. The rough lemon was free of this trouble.

Seedling Plantings in Various Parts of the Valley

In consideration of the fact that there is a great variation in the type, profile, water table, and salinity of the Rio Grande soils on which citrus is grown, an extensive grower cooperative series of rootstock plantings was initiated this year. Seed of 127 varieties of citrus and citrus relatives, sent to Texas by the U. S. Subtropical Fruit

Station at Orlando, Fla., was planted in seedbeds at the Valley Experiment Station at Weslaco, Texas, in January 1947. The seedlings were dug in October 1947 and were transplanted to five different locations in the Valley.

The locations selected for these plantings were Mission (Ray Goodwin), Elsa (Engelman Products Company), Monte Alto (Rio Farms, Inc.), Harlingen (Ben Chambers), and Bayview (San Roman Nursery). The U. S. Department of Agriculture will enter into a cooperative agreement with each of these growers in which the U. S. Department of Agriculture agrees to furnish the seedlings while the grower agrees to bud and grow the nursery stock and make permanent field plantings of the stock under the supervision of the cooperative rootstock project of the U. S. Department of Agriculture and the Texas Agricultural Experiment Station.

The 127 rootstock varieties included in these tests are shown in table 2. There were not sufficient seedlings available of some varieties to make plantings at all locations. Only 30 varieties were planted at all five locations; 9 more were planted at four locations; 13 at three locations; 21 at two locations; and 52 at a single location.

There were from 40 to 60 plants in each planting of the various varieties. Half of these are scheduled to be budded with Red Blush grapefruit and half with Valencia orange. It is anticipated that the final orchard tests will consist of 12 budded trees of Red Blush grapefruit and 12 of Valencia orange on each of the rootstock varieties.

Complete records on the characteristics of the soil in the various locations are now being made in cooperation with Mr. Raymond Cowley, soil scientist of the Texas Experiment Station. In general, it can be said that the top soil of the various locations varies from fine sandy loam to clay loam. The subsoil, lime content, salinity, and water table vary greatly between locations.

Salt Tolerance Tests

The chlorosis observed in the nursery stock of the Weslaco planting was suspected to be a symptom of salt injury. This is not definitely established, however, as chlorosis can be induced by a number of factors other than high salinity. The electrical conductivity of an extract of the saturated soil (a measure of salinity) was determined from soil samples taken at several locations in the nursery in July and October of this year. The conductivity was in all cases below 2 millimhos (1400 parts per million) which is generally considered to have no effect on plant growth except on highly intolerant plants (5).

In order to evaluate critically the salt tolerance of the various citrus rootstocks, salt tolerance plots have been set up, patterned after a technique developed at the U. S. Regional Salinity Laboratory, at Riverside, California. These salt tolerance tests are made in soil plots that are uniformly salinized with salty water. The plots

are 14 x 14 feet square, are level, and have a 6-inch dyke around them so as to make them impounding basins.

The plots are brought to the desired degree of salinity by flooding the basins with Rio Grande water to which has been added the required amounts of sodium chloride and calcium chloride. A 50-50 mixture of the two salts is being used in the preliminary tests. This mixture should prevent the development of a seriously high percentage of sodium in the exchange complex of the soil.

Salt tolerance tests on the Cleopatra mandarin and sour orange stocks were initiated on November 11, 1947. Unbudded seedlings, and seedlings budded with Red Blush grapefruit [4/] are included in the tests. Also included is a series of Cleopatra mandarins budded with Valencia orange. In addition to a plot with Rio Grande water as a control, one plot is being treated with water containing 250 p. p. m. of salt and another with 5000 p. p. m. It is yet too soon after the start of these tests to expect results from the treatments.

Discussion

The main purpose of this report is to describe to the citrus growers of the Rio Grande Valley the approach to the rootstock problem in the investigations conducted jointly by the U. S. Department of Agriculture and the Texas Agricultural Experiment Station. The results presented for the rootstock nursery at Weslaco, Texas, should not be too broadly interpreted. The report is merely a factual one on what happened under those particular conditions. The rootstocks may possibly perform quite differently at Mission, Brownsville, or at numerous other locations. That is why the tests have been extended to include plantings at five other locations in the Valley. Differences in response of the rootstocks at the various locations are expected, as it is already well known that the Cleopatra mandarin, which is now under extensive commercial tests here in the Valley, shows chlorosis under some conditions and not others. There has also been a big variation in the reports on the growth responses of Cleopatra. Some nurserymen report that it performs as well as the sour orange stock while others report differently.

It will require a number of years of experimental effort to arrive at a point where rootstocks to replace sour orange can be recommended for the Rio Grande Valley. Rootstock investigations are necessarily long-term projects, sometimes requiring fifteen to twenty years for valid conclusions. The merit of a rootstock for grapefruit and orange depends to some degree on the behavior of the tree in the nursery but the final test must be based primarily on its behavior in the orchard. We need to know more about the effect of rootstock on the life of the tree, and on the yield, size, and quality of fruit produced. The salt tolerance of the various stocks and their susceptibility to cotton root rot, foot rot, and Rio Grande gummosis are factors that must also be considered. Likewise, the

[4/]Buds used for both the sour orange and Cleopatra mandarin stocks were taken from the same grapefruit tree.

possible effects of the scion variety on root growth and salt tolerance of the rootstock must not be overlooked.

Table 2. Citrus Rootstock Seedling Plantings in the Rio Grande Valley made on October 23, 1947.

Key to location of plantings:
R—Rio Farms, Inc., at Monte Alto
C—Ben Chambers, at Harlingen
B—San Roman Nursery, at Bayview
E—Engelman Products Co., at Elsa
G—Ray Goodwin, at Mission

No.	ROOTSTOCK Variety	Location of Planting
	Sour Oranges	
1	Texas sour orange	RCBE
2	Oklawaha sour	RCBEG
3	Algiers Seville	RB
4	Bergamia (Bergamot) orange)	RCBEG
5	Bigardier sour	RCBEG
6	Natsu Mikan No. C11184	RCBEG
7	Bittersweet	RBE
	Sweet Oranges	
8	Florida sweet seedling	CBEG
9	Parson Brown	RBEG
10	Pineapple	RCBEG
11	Homosassa	C
12	Joppa	B
13	Lamb Summer	R
14	Weldon	R
15	Malta Blood	R
	Grapefruit	
16	Duncan	RCBEG
17	Leonardy	RCBEG
18	Poorman	RB
19	Red Blush	RB
20	Royal	R
	Shaddocks 1/	
21	Thong Dee	RCBEG
22	Siamese	RCBEG
23	Nakorn	RBE
24	Kao Panne	E
25	Kao Kuan tia	RCE
26	Kao Phuang	BE
27	Winter Haven shaddock	R
28	Indio Pink shaddock	R
29	Citrus Grandis	R
	Lime, Lemon, Citron Group 2/	
30	Rough lemon	RCBEG
31	Ponderosa lemon	R
32	Sweet lemon	RCBEG
33	Kadu Mul pink lemon	RB
34	Meyer lemon	EG
35	Butnal sweet lemon	EG
36	Dahr Lun lemon	R
37	Palestine sweet lime	R
38	Mexican lime	R
39	Rangpur lime	RCBEG
40	Kusai lime	RG
41	Columbian sweet lime	BEG
42	Cuban (Cuban Shaddock)	RCBEG
43	Lakeland limequat	RBEG
44	Tavares limequat	RCBEG
45	Lemole	R
46	Lemonquat - W. H.	R
47	Citron, Indio No. 13	R
	Mandarin Group 3/	
48	Cleopatra	RCBEG
49	Sunki	RCG
50	Oneco tangerine	CE
51	Clementine tangerine	BE
52	Dancy tangerine	G
53	Willow-Leaf	RCG
54	Ponkan	RB
55	Peotinifera	G
56	Betangar mandarin	CE
57	Changsha mandarin	R
58	Tim Kat mandarin	RG
59	Noble's No. 10642	RCBEG
60	Sanguinea No. 25357	G
61	Mandarin No. 11412	RBE
62	Mandarin No. 117477	RB
63	Mandarin No. 10630	BE
64	Swatow No. 10031	CEG
65	Chu Koa mandarin	RCBEG
66	Phong Koa mandarin	R
67	Wilking	RG
68	Umatilla tangor	B
69	King	RBEG
70	Temple	RCBEG
71	Tangor No. 653	RCBEG
72	Kinnow	G
73	Kara	R
74	Satsumelo 10-0-3	RG
75	Mandelo	R
76	Alamoen	R
77	Seminole tangelo	RCBEG
78	Orlando tangelo	RCBEG
79	Sunshine tangelo	RCBEG
80	Minneola tangelo	RCBEG
81	Watt tangelo	RCBEG
82	Thornton tangelo	RCBEG
83	Sampson tangelo	RCBEG
84	Williams tangelo	RCBE
85	Yalaha tangelo	BEG
86	Pina tangelo	RCBEG
87	San Jacinto tangelo	R
88	Suwannee tangelo	BE
89	Webber tangelo	R
90	Seedy Marsh x Dancy	R
91	Satsuma x Imperial Gft.	R
92	Calashu	R
93	Kansu 4/	R
94	Kalpi 5/	RBG
95	Nippon kumquat 6/	BEG
96	Calamondin	RCBEG
	Trifoliate Group 7/	
97	Trifoliate (lge. flowers)	RBEG
98	Trifoliate (sml. flowers)	RBEG
99	Morton citrange	RCBEG
100	Sanders citrange	RCG
101	Troyer citrange	BEG
102	Savage citrange	G
103	Rusk citrange	R
104	Cunningham citrange	R
105	Citrange No. 15137	R
106	Rustic citrange	R
107	Citrangor No. 42681	BE
108	Citrangequat No. 48011	BEG
109	Glen citrangedin	E
110	Brownell Citradia	R
111	Citraldin No. 50130	R
112	Highgrove citremon	R
113	Sacaton citrumelo	G
114	Citrumelo No. 4481	RG
115	Citrumelo No. 4475	RCBEG
116	Citrumelo No. 4604	R
117	Citrumelo No. 4551	R
118	Citrumelo No. 4200	E
119	Citrumelo No. 4478	R
120	Citrumelo No. 1416	B
121	Citrumelo No. 4482	CE
	Miscellaneous	
122	Severinia buxifolia, narrow leaf	RCBEG
123	Severinia buxifolia, broad leaf	RBEG
124	Meiwa kumquat	R
125	Citrus southwickii	R
126	Ermocitrus glauca hybrid	G
127	Atalantia sp.	R

1/ Also known as pummelos

2/ This group is similar to the lime-lemon group of table 1, except that some of the varieties included are suspected of being natural hybrids with citron as well as with lime or lemon.

3/ This group includes mandarins, tangerines, tangors, tangelos, and several natural hybrids of which the mandarin is suspected of being one of the parents.

4/ Considered to be a hybrid of Citrus ichangensis with the sour mandarin (4), p. 427.

5/ Suspected of being a hybrid of **C. macroptera** with the common Philippine mandarin (4) p. 439.

6/ A controlled-cross hybrid of satsuma with the Meiwa kumquat.

7/ The trifoliate orange and controlled crosses between that and various citrus species.

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RESULTS OF A CITRUS DISEASE SURVEY

By

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During August of this year, a survey of the kind and amount of diseases in mature citrus trees in the Rio Farms groves was begun. The management of Rio Farms was interested in obtaining information as to the condition of its groves and, with the Extension Service, was interested in ascertaining the extent and importance of disease as a factor in the yield and longevity of citrus trees.

At the outset it was decided that the diseases of consequence were Scaly Bark (Psorosis) and Gummosis. These are two separate and distinct diseases and although they both may occur on the same tree at the same time, the continued presence of either results in a gradual loss of vitality manifest by smaller fruit, dead branches and decreasing commercial usefulness of the tree.

Scaly bark, or Psorosis, is a well known virus disease. Small or large patches of loosely attached bark may occur on the trunk, the branches, or on both. Apparently the virus is infectious only by propagation or rarely by natural root grafts in a growing orchard. Commercial usefulness of a citrus tree infected with scaly bark can be prolonged by scraping the infected area and painting with certain disinfectants. This must be done at the earlier stages, however, and never results in a cure. There is only one method of eradication and that is to be certain that the buds used to produce the trees come from trees that are not infected by this disease. This is a complicated problem because a tree may not develop outward signs of the disease until it is 10, 15, or even 20 years old. Too, it taxes a skilled technician to determine that an old tree does **not** have scaly bark. In California a certification and inspection program has been under way for a number of years and certified and registered virus-free trees are available.

The word "gummosis" is really a misnomer since there are many things that will cause a citrus tree to gum. Mechanical injury may cause gumming. The disease known as foot-rot, relatively common in California on sweet orange rootstock, is commonly called gummosis, and gumming has been known to accompany scaly bark. In this survey we have used the word "gummosis" to refer to the types of gumming described by Dr. G. H. Godfrey in Progress Report 841 of the Texas Agricultural Experiment Station. These three types are described as physiological gummosis, foamy gummosis, and internal wood rot gummosis. Dr. Godfrey states that the latter two are both infectious, internal wood rot gummosis being by far the most serious. The causative organism of these two, however, has not been isolated nor identified.

Treatment of the gummosis diseases described consists essentially in chiseling away the infected bark or wood, and treating the

area with a disinfectant. This is expensive, the tree may be so far gone that the labor and expense is not justified, and the re-occurrence of gumming on some trees has resulted in their being literally chiseled to death over a period of years.

Results of the Survey

The survey consisted of a tree to tree examination. Each tree was examined for outward symptoms of scaly bark and gummosis, and its position plotted in respect to other trees. Notes were taken on kind of disease present, extent of infection, and general health of the tree irrespective of disease. This was done in order that the trees could be checked each year as to their increasing or decreasing commercial usefulness. Thus far the survey has included several grapefruit groves (White Marsh variety) and one Valencia orange grove. Approximately 200 acres have been surveyed.

Tables No. 1 and 2 give some of the results of the survey in 5 citrus groves. All groves are of the same age, being approximately 15 to 17 years old.

TABLE I
EXTENT OF DISEASE IN 5 CITRUS GROVES

Grove	Variety	Total No. Trees	No. of Diseased Trees	% Diseased Trees
66- 2	White Marsh	1092	950	87%
52-12	White Marsh	517	107	21%
52- 5	White Marsh	517	125	24%
66- 7	White Marsh	1517	1183	79%
66- 5	Valencia	1419	79	6%

TABLE II
AMOUNT OF SCALY BARK AND GUMMOSIS IN 5 CITRUS GROVES

Grove	Total No. Trees	Trees with Scaly Bark No.	Trees with Scaly Bark Per Cent	Trees with Gummosis No.	Trees with Gummosis Per Cent
66- 2	1092	897	82%	686	63%
55-12	517	101	19%	18	3%
52- 5	517	121	23%	15	3%
66-7	1517	916	60%	930	61%
66-5	1419	79	6%	0	0%

Note: Many trees had symptoms of both Scaly Bark and Gummosis.

The seriousness of disease in these groves is quite apparent from the data in the tables, the percentage of diseased trees varying from 6% to 87%. Likewise it is evident that there are wide differences in the amount of scaly bark and of gummosis found in the different groves.

Scaly Bark (Psorosis)

The percentages of trees infected with scaly bark are 82% and 60% respectively for Groves 66-2 and 66-7. These two groves are on low-lying soils that are poorly drained. Groves 52-12 and 52-5 are on soils that are comparatively well drained and the scaly bark infection is 19% and 23% respectively. It is possible that these wide differences in the amounts of scaly bark are due to differences in the source of budwood. However, it is likewise possible that external lesions of scaly bark become evident at an earlier age on trees growing under the relatively poor growing conditions that you find on poorly drained soils, than on trees growing more vigorously on well drained soils. The sources of budwood are not known.

One additional observation should be mentioned here. It was quite apparent that scaly bark was much the deadlier disease. Some trees can apparently retain an outward healthy appearance when gumming heavily. In every case however where scaly bark was evident there was a marked decline in the health of the tree. This was true when outward symptoms of scaly bark were evident on only one scaffold limb. The infected limb invariably showed decline—"staghorn," yellowed leaves, even smaller fruit in some cases.

Gummosis

Wide differences in the amount of gummosis found in the various groves surveyed are also evident from Table II.

A. In Oranges.

No symptoms of gummosis were found in the Valencia orange grove (66-5). This is in agreement with other observations made to date in various orange groves in the Lower Rio Grande Valley. Although the evidence is by no means complete we have failed to find a single orange tree infected with any of the three types of gummosis described in the Texas Agricultural Experiment Station Progress Report No. 841. Foot rot (brown rot) gummosis does occur on oranges in the Valley but does not rank as a serious disease in this section.

B. In Grapefruit.

There is apparently a definite relationship between poor drainage and the amount of gummosis infection in the White Marsh groves of this survey. Groves 66-2 and 66-7 (poorly drained) show 61 to 63% of the trees infected with gummosis while Groves 52-5 and 52-12 (well drained) have only 3% of the trees infected. It should be remembered, however, that these observations were not made under controlled conditions. We do not know the factors responsible for this apparent relationship. If we did we would be several steps further along the way in solving the gummosis problem. Much research needs to be done before we can begin to understand the conditions under which gummosis develops in any citrus grove to a lesser or greater extent than in another.

We think that the answer to the citrus disease problem is two-fold. For the virus disease scaly bark we need a budwood inspection and certification program so that we can be sure that the trees we do set out will be free from this disease that definitely shortens the commercial usefulness of citrus trees. The only answer to the gummosis problem is more research, for as yet we do not know the actual causes nor the conditions under which this disease develops, let alone the cure.

CERTIFIED CITRUS NURSERY TREES AN URGENT NEED

By
J. ELIOT COIT

Last year Dr. Wallace of the Citrus Experiment Station at Riverside, California, gave an illustrated talk before this institute on "Psorosis Diseases of Citrus." It was published in the Proceedings. I would like to preface what I have to say with a quotation from Wallace.

"Psorosis" includes five distinct diseases caused by what we believe to be related strains or varieties of viruses. Psorosis A and B cause the bark condition commonly known as "scaly-bark." Orange, grapefruit and tangerine trees infected with these two psorosis varieties commonly develop the bark symptoms. There are no known insect vectors of the psorosis viruses and there is no definite evidence that insects are a factor in their spread. From the standpoint of the citrus grower this is an extremely fortunate circumstance. It is equally fortunate that the viruses of these diseases are not transmitted through seeds to any detectible extent. . . . Absolute control of psorosis lies in prevention. The absence of any significant amount of natural spread of the disease in the field makes prevention effective. Citrus trees are free of psorosis and remain so if psorosis-free bud-wood parent trees are used for the production of nursery trees.

Psorosis has caused and is causing great damage in California. It is increasing in importance here because so many orchards are only just now coming to the age when bark lesions appear.

How are you to go about getting psorosis-free nursery trees? The first thing to do it to develop a demand by education, publicity, and propaganda. The business of the nurseryman is to supply the demand, not to educate the public. When there is sufficient demand, nurserymen will grow the trees. Tax assessors, real estate salesmen, bankers who loan money, all must be made to realize that the value of the grove is greatly affected by the proportion of psorosis trees. Past yield records are of little significance with reference to a grove being rapidly depreciated by psorosis. No one is to blame for the condition the orchards are in today because at the time these trees were propagated, no one knew about the virus nature of psorosis or its transmission through infected buds. Ignorance will be no excuse tomorrow because today the method of prevention is known.

During the time you are whipping up a demand, some other things need to be done. Some public agency, the State Department of Agriculture, or the College of Agriculture should assist the growers by providing trained inspectors to pass judgment on and register individual mother trees free from virus disease which are accredited suitable for propagation. As Dr Wallace showed you by pictures last year, the recognition and positive identification of trees free from viruses requires considerable technical training, experience and skill. Inspections of candidate trees should be made periodically for at least a year, as it is a serious responsibility to say that a tree is free from psorosis viruses.

When the inspector is ready he receives applications from growers who have trees they believe to be healthy and who wish to propagate certified trees or sell bud-wood from registered trees to nurserymen. The grower pays an initial fee of from five to ten dollars per tree and one dollar a year for maintainance of registration. The size of these fees may vary depending on the number of candidate trees in any one orchard. Partial refunds may be allowed for any trees which are quickly found to be infected. When the inspector is satisfied that a tree is healthy, he attaches a metal tag bearing a number to the trunk, issues a registration certificate to the owner, and makes out a card showing the exact location by district, road, grove, row and tree number. This card is filed in his office and duplicates may be made and filed at other convenient public places. Anyone may consult this card index and make his choice of mother trees.

The owner of registered trees is now in position to advertise registered buds for sale—at say 10c each. Some owners in California allow partial refunds for buds which do not grow, after visiting the nursery and counting the failures. But with healthy buds and good root-stock there are seldom many failures. Good trees grown from registered buds are worth more money. The grower who buys such trees for his own use will be glad to pay the necessary premium. The subdivider whose purpose in planting trees is to make it easier to sell the land, may be tempted to buy cheaper trees,—or at least that is what they have been known to do in California.

When a nurseryman sells a lot of trees grown from registered buds he should, on request, give a certificate guaranteeing the exact source of the buds together with the registration numbers of each mother tree used. But such a certificate is worth as much and no more than the integrity of the nurseryman. If he personally cuts his buds and watches them being inserted he is a safer man to deal with than the nurseryman who sends a hired man to cut buds and does not stay in the field while they are being inserted. I once knew of a professional budder doing piece work who ran out of buds about three o'clock in the afternoon. Not wishing to lose the rest of the day, and the owner not being around, he walked over to an adjoining orchard and cut enough buds to finish out the day.

Another practical point about this business. The tree which is registered is an old heavily bearing tree. The fruiting twigs are all so small and angular that the buds are too small to handle conveniently, and they do not grow well. The professional budder who is accustomed to doing piece work will probably turn up his nose and refuse to use them. If he is to make good wages he wishes plump vegetative twigs from young trees. We have learned to anticipate this and, a year previous, give the mother tree vigorous thinning out and cutting back together with a little extra nitrate. By the time that buds are needed the tree will be covered with plump twigs in the vegetative rather than the fruiting phase, to which no budder would object.

In California psorosis free trees are registered by agents of the State Department of Agriculture who have been trained at the

Citrus Experiment Station. The service is on a partially self-sustaining basis. It has been in operation several years and we now have approximately 1200 citrus trees of all varieties registered and available to nurserymen and all who wish healthy buds. The owners of the trees decide for themselves what to charge for buds. There is free competition between such suppliers. An increasing number of our nurserymen who are in the business to stay, are using registered buds exclusively. I have bought many thousands of such trees for various clients of mine and have been highly pleased with the uniformity of these trees and their extra vigor of growth. In closing, I would like to quote again from Dr. Wallace:

"It is unnecessary to point out the disastrous potentialities of a disease such as psorosis if control measures are not put into effect. Failure to provide proper instruction of citrus nurserymen and propagators with regard to psorosis, and to inaugurate some system of aiding them in producing and distributing psorosis-free trees can, in time, result in serious financial losses to growers and to the citrus industry as a whole. This loss occurring gradually over a long period of time, although less alarming and less dramatic than that caused by certain other plant diseases, is none the less real."

SOIL SALINITY IN RELATION TO ROW CROP PRODUCTION

By

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In discussing "Some aspects of the salinity problem in irrigation agriculture" it was pointed out that salted soils constitute a hazard to successful agriculture for two primary reasons: (1) certain ions, notably sodium, affect the soil structure unfavorably, and (2) the presence of salt in the soil solution may have an adverse effect on the plant-soil-water relation owing to the reduction in available water or to the toxic effects of specific ions or salts.

In discussing the effect of soil-moisture relations on plants grown under saline conditions, two points deserve special emphasis. The first is the effect of salted soils on seed germination. If saline conditions exist, the first phase in the plant cycle, germination and seedling growth, is a critical one. Frequently the ability of a given variety to germinate and establish the seedling is the limiting factor in crop production. In field observations you have doubtless observed situations where there are sharply defined skips in rows or bare spots surrounded by plants that are growing normally. In many cases this condition is due to saline or alkali spots in which the seed has failed to germinate or at least to survive the seedling stage.

There are two ways in which salted soils may affect germination: (1) there may be enough soluble salt in the seed bed to build up the osmotic pressure of the soil solution to a point which will inhibit or prevent germination, and (2) certain constituent salts or ions may be toxic to the seed and seedling.

The entry of water into a seed is essential to germination. It takes place by imbibition and osmosis. If the osmotic pressure of the surrounding soil solution is high, entry of water will proceed very slowly, and if it is high enough, the water imbibed may not be sufficient to permit swelling, rupture of the seed coats and subsequent growth of the seedling.

With respect to the second point, experiments at the Salinity Laboratory and elsewhere have indicated that in addition to the effect of high osmotic pressure, certain salts or ions may be toxic to the young seedling. It has been shown that at equal osmotic pressures, germination was retarded more on NaCl substrates than on mannitol, which contains no toxic ions; that is, the Na and Cl ions were toxic.

Since the success or failure of a given crop may depend in large measure on the ability of the farmer to obtain satisfactory germination, it is important to determine the limits of salt tolerance of the various crops in the initial stages of germination and seedling growth.

A method has been developed by the Salinity Laboratory to determine the effect of salty soils on germination and seedling development. The general procedure follows: Soil samples, 2 kg. each, are weighed into jars. These are kept closed and in a constant temperature room (25° C.) until ready for use. The moisture content is determined for each sample and the amount of water required to bring each sample to 12 percent moisture is calculated. Sodium chloride is added to make the following percentages on dry soil basis: .05, 0.1, 0.2, and 0.3. Other amounts of salt can be added if desired.

The soil is then placed in a tin can large enough for mixing and water added gradually to bring moisture content to the required level. The samples are returned to jars and allowed to stand for at least 6 days at constant temperature to insure equilibrium of soil and water. At the end of this time, the actual moisture content is determined and 700 gm. of soil is placed in a large petri dish, tamped slightly and the seeds which are weighed previously are pressed lightly into the soil. An additional 700 gm. of the adjusted soil is then added. The covered petri dishes are placed in the constant temperature room for the remainder of the experiment. The electrical conductance is determined from an extract of a saturated sample of the soil used in each treatment, and from this the osmotic pressure of the soil solution of the adjusted soil is calculated.

This procedure works well. Germination can be studied under controlled conditions. The actual salt content and osmotic concentration of the soil solution can be determined. Furthermore, these conditions are relatively constant and do not fluctuate with time, location or weather as they would in the field. The criticism of using an artificial medium which has been made concerning studies using filter paper, etc., is not valid for this procedure. The type of results which can be obtained with castor beans, sugar beets and alfalfa is illustrated in the following tables.

a. **Germination of castor bean.** Two varieties of castor bean were used—Connor and Wieman. Twelve seeds were planted in each dish. There were five treatments: control, 0.05 percent, 0.1 percent, 0.2 percent and 0.3 percent NaCl on a dry weight basis. All soils were adjusted to 12 percent moisture. The data given in the next table represent the status of germination at the end of a two-week period.

Table 1.—Germination of two varieties of castor bean in salinized soil
Twelve seeds were placed in each culture

Variety	Added NaCl %	ECe * millimhos/cm.	O. P. soil soln. atmos.	Original dry wt. seeds gm.	No. seeds germ.	Final wt. of beans gm.	Water absorbed gm.	Soil moisture end exp. %
	0	1.1	1.3	4.88	12	29.25	24.37	8.1
	0.05	3.1	3.6	4.61	12	18.57	13.96	9.6
onnor	0.10	6.6	7.4	4.73	4	7.58	2.85	10.7
	0.20	11.1	12.8	4.87	0	6.56	1.69	11.0
	0.30	13.2	15.1	4.90	0	6.48	1.58	11.1
	0	1.0	1.2	6.06	12	35.50	29.44	7.3
	0.05	3.1	3.6	6.18	12	36.85	30.67	9.2
Wieman	0.10	6.4	7.5	5.90	3	10.04	4.14	10.9
	0.20	11.1	12.1	6.04	0	7.10	1.06	11.1
	0.30	14.0	17.7	6.20	0	7.26	1.06	11.0

* Conductivity of the saturation extract.

These data indicate that the castor bean is sensitive to salt in the early stages of its life cycle, as there is a marked reduction in germination in soils containing 0.10 percent salt on a dry weight basis. The effect of salt and the osmotic pressure of the soil solution on the amount of water absorbed is very striking and emphasizes the relation of osmotic pressure of the substrate to the ability of the seed and seedling to take in water.

b. **Germination of sugar beets.**

Table 2—Germination of sugar beets (U. S. 22) in salinized soil

Added NaCl %	Moisture %	ECe millimhos/cm.	O. P. soil solution atmos.	Germination 5 days %	7 days %	10 days %	15 days %
			May 27, 1947				
0	11.6	1.4	1.4	92	95	95	95
0.05	11.5	4.3	4.5	50	65	75	75
0.10	11.5	7.1	7.9	2	5	7	7
0.20	11.6	13.1	13.6	0	0	0	0
			July 9, 1947				
0	11.6	1.4	1.5	67	72	90	90
0.04	11.9	3.5	3.9	30	40	60	62
0.06	11.5	4.5	5.4	2	5	12	17
0.08	11.7	5.6	6.3	2	2	5	10
0.10	11.7	6.6	7.6	0	0	0	0
0.12	11.5	7.6	9.2	0	0	0	0

c. **Germination of alfalfa (Chilean variety).** Alfalfa seed was tested according to the germination procedure previously described. Twenty-five seeds were planted 3/4 inches deep in each dish. The results are shown in table 3.

Table 3—Germination of alfalfa (Chilean) in salinized soil

Added NaCl %	Moisture %	EC e millimhos/cm	O. P. soil solution atmos.	Germination 3 days %	5 days %	10 days %	17 days %
0	11.1	1.5	1.5	76	82	84	84
0.05	11.2	4.5	4.8	16	74	92	96
0.10	11.2	7.6	7.8	0	44	54	80
0.15	11.2	10.5	11.1	0	0	6	22
0.20	11.1	13.3	14.1	0	0	0	0

Germination of the alfalfa seed was retarded by increasing concentration of salt but there was no sharp reduction until the osmotic pressure of the soil solution exceeded 8 atmos. (0.1% added salt). These tests indicate that this variety of alfalfa has the ability to germinate under salinity conditions which will almost completely inhibit germination of the sugar beet seed tested.

These and other data obtained by germination tests indicate that in many cases the critical phase in the plant cycle is the germination of the seed and establishment of the seedling. If a saline condition exists, it is important to apply enough water to leach some of the salt out of the seed row or seed bed. This will reduce the osmotic pressure of the soil solution adjacent to the seed and permit the entry of water through the seed coats.

A number of methods have been used to meet this condition: (1) proper preparation of the seed bed by pre-leaching to reduce the salt in the surface few inches of soil, prior to seeding, (2) more frequent irrigation during the period of germination, (3) the use of supplementary furrows adjacent to the seed row for irrigation during germination. This practice has been successfully used with sugar beets in the Yakima Valley, Washington and in Colorado. A fourth method is to side-plant the crop below the crown of the row. As will be shown later, the upward movement of salt in the row due to capillary action may result in very high accumulations of salt in the upper few inches. If the crop is side-planted these high concentrations of salt will be avoided. This practice is sometimes followed with lettuce and melons in the Yuma and Imperial Valleys.

The second consideration is the effect of irrigation of row crops upon salt movement in a saline soil. It is known that salt distribution in a saline soil may be highly variable. For this reason, a portion of the root system of a plant may be in a soil zone which is relatively nonsaline, whereas another portion may extend into or be adjacent to highly saline soil. This condition arises since water can not move into and through the soil without carrying solutes with it. In consequence, zones of salt accumulation may occur in close proximity to leached areas, especially in furrow irrigation.

The Salinity Laboratory has carried on studies to create artificially such saline situations. By sampling the soil thoroughly over

the course of the growing season it is possible to ascertain the resultant status of salt distribution and the manner in which the variation in salinity affects both water removal by the plant and its growth performance.

Plots, 14' x 14', were laid off on the Laboratory grounds. The surface six inches were removed and run through a soil disintegrator. The sub-surface soil was then leveled, the surface soil returned, and its surface leveled. Each of two plots received 11 inches of the following three types of water: (1) Riverside tap water, (2) Riverside tap water plus 0.25 percent NaCl and 0.25 percent $CaCl_2$, and (3) Riverside tap water plus 0.5 percent NaCl and 0.5 percent $CaCl_2$. Thorough sampling of each plot showed the initial salt distribution to be relatively uniform in each plot to a depth of 3 feet. The salt content of the soil on a dry weight basis was approximately 0.1 percent in the plot receiving treatment (2), and about 0.2 percent in the plots receiving treatment (3).

Cotton seedlings selected for uniformity were transplanted to each plot in rows 42 inches apart with the plants 18 inches apart in the rows. Of each pair of plots at a given salt level, one was irrigated with 2 inches of water when the tensiometers in the root zone showed not over 500 cm. of tension, and the other received 4 inches of water when all tensiometers in the plot went off scale (800 cm. tension) but before the plants showed any evidence of wilting. For convenience, the plots which were irrigated frequently were designated as the "wet" plots, whereas those which were watered less frequently were called the "dry" plots.

Cotton seed failed to germinate in the plots containing 0.1 percent salt and yet excellent growth of the transplanted seedlings was obtained on the frequently irrigated plot containing 0.2 percent salt. Even in the absence of salt, the "dry" plants made significantly less growth than those on the "wet" plots, and this difference was even more marked on the salinized plots. It should be emphasized that the plants on the "wet" plot containing 0.2 percent salt made remarkably good growth, far better than past experience would indicate should be expected if the roots of these plants were growing in soil containing 0.2 percent salt uniformly distributed. Hence it was necessary to investigate thoroughly both the distribution of the salt under the plants and the loci of water removal with respect to this salt distribution.

Examination of the distribution of the salt in the wet plots to which 0.2 percent salt had been added showed at the conclusion of the study that there was a large pocket of soil underneath the furrows which was virtually nonsaline. This was to have been expected from the normal leaching effect of the irrigation water. On the other hand, the surface inch of soil along the ridges at the base of the plants was found to contain 5 to 6 percent salt. Thus, indiscriminate sampling of this plot might have indicated on the one hand that these plants were thriving in the presence of 5 percent salt, or on the other hand that they were growing in nonsaline soil. Analyses showed that there was a continual increase in salinity from underneath the furrow to underneath the row and up to the surface of the soil in the ridge. These observations emphasize the impossibility of ascertaining the true status of salinity under plants grown on ridges by merely taking one or two soil samples.

The pattern of moisture distribution under plants on the saline soil on which salt distribution was determined was also investigated. Water removal was found to be most extensive under the furrows, increasing the residual moisture with depth, and with displacement toward the soil beneath the plant row. Thus the pattern of residual moisture under the plants tends to coincide with the pattern of salt distribution. As would be expected, the plants were removing water from those portions of the soil mass penetrated by the root system where the osmotic pressure of the soil solution was lowest. Thus, even the plants on the plots to which 0.2 percent salt had been added were essentially reacting to a nonsaline substrate immediately following an irrigation. If the irrigations were frequent enough, moisture extraction from the nonsaline portions of the soil mass may have been adequate to meet the requirements of the plant without removal of water from portions of the soil mass where the osmotic pressure would have been appreciable. Obviously, if sufficient water is removed from such a soil mass varying in salt content, the tension of the soil moisture in the nonsaline zone may become sufficiently high so that water must be absorbed from zones having appreciable osmotic pressure. The intensity to which this situation develops during an irrigation cycle will be a major factor in determining growth response on saline soils subject to conditions such as those being studied. On the other hand, plants growing on a nonsaline plot removed moisture rather uniformly with some tendency for a higher degree of water removal under the rows than under the furrows.

At the conclusion of the experiment, typical vertical and horizontal root distributions were examined for the plants on the nonsaline soil. Roots were traced down to a depth of more than four feet, and were found to extend laterally over to and beyond adjoining rows and beyond adjoining plants in the same row. As far as could be ascertained, the soil was thoroughly permeated with roots down to a depth of over three feet. The typical vertical and horizontal root distributions found on the "wet" plots to which 0.2 percent salt had been added were quite different. No roots were found below a depth of 3 feet and distribution was rather sparse in the third foot. The roots extended laterally at right angles to the row for a distance of 3 feet or more, but it was quite striking that very few roots extended in a lateral direction along the row. A zone of soil along and beneath the ridges showed a high degree of salt accumulation, and it appears that these saline portions of the soil inhibited root penetration. The roots proliferated most abundantly in the zones lowest in salinity, and absorbed a major portion of their water from such zones.

This study has emphasized the need for detailed sampling and consideration of the moisture content of the soil in order to get a valid appraisal of the saline stress that the plant is actually integrating. It is possible to secure soil samples containing a high percentage of soluble salts under plants making good growth, but it is probable

that the salinity status of such samples would not be related to plant performance. On the other hand, it is possible to secure a soil sample which is nonsaline under plants actually suffering from salinity because of complete moisture depletion in the nonsaline pocket of soil which was sampled.

In general, these studies indicate that soil moisture stress is accentuated by salt and that under saline conditions more frequent applications of water will accelerate plant growth. The effect of salt concentration and soil moisture regime on growth is shown in table 4.

Table 4.—Effect of salt concentration and soil moisture regime on growth of Tall Fescue

Expressed as grams dry weight of tissue per culture

Added NaCl	Soil moisture regime 20 - 14 *	20 - 11	20 - 8	20 - 6	Average
%	gm.	gm.	gm.	gm.	gm.
No-salt	92.3	92.2	80.2	78.7	85.8
0.05	84.8	72.3	59.3	37.0	63.3
0.1	60.3	58.4	33.7	17.4	42.4
0.2	71.4	28.0	24.3	11.5	33.8
0.3	71.0	24.4	11.5	8.4	28.8
Average	76.0	52.1	42.0	30.6	——

* Figures represent maximum and minimum soil moisture percentages.

On the basis of dry weight yields, these data show the inhibiting effect of (1) decrease in available soil moisture, (2) increase in salt content of soil, and (3) the marked reduction in yield when high salt content and low soil moisture are combined.

A third consideration in row crop production is salt tolerance. If soils are slightly to moderately saline, it may be possible to put the land to economic use by selecting salt tolerant crops. Quantitive data are lacking on the salt tolerance of most crops, but some information is available. The following lists give classification of tree, field and truck crops on the basis of good, moderate, and poor salt tolerance. The lists are tentative, but they will serve as a general guide.

Fruit Crops

I Good Salt Tolerance	II Moderate Salt Tolerance	III Poor Salt Tolerance
Date Palm	Pomegranate	Grapefruit
	Fig	Pear
	Grape	Almond
	Olive	Apricot
		Peach
		Plum
		Apple
		Orange
		Lemon

Field and Truck Crops

I Good Salt Tolerance	II Moderate Salt Tolerance	III Poor Salt Tolerance
Sugar beet	Alfalfa	Vetch
Garden beet	Flax	Peas
Milo	Tomato	Celery
Rape	Asparagus	Cabbage
Kale	Foxtail millet	Artichoke
Cotton	Sorghum (grain)	Egg plant
	Barley (grain)	Sweet potato
	Rye (grain)	Potato
	Oats (grain)	Green beans
	Cantaloupe	
	Lettuce	
	Sunflower	
	Carrot	
	Spinach	
	Squash	
	Onion	
	Pepper	
	Wheat (grain)	

In the selection of salt tolerant crops, climate is an important factor. In general, a given species or variety of plant is most likely to succeed if it is grown under climatic conditions to which it is best adapted. Series of studies involving three types of climate (cool coastal, hot interior desert, and intermediate) were conducted by the Salinity Laboratory over a 3-year period. A number of crops—cotton, beans, onions, beets, etc. were tested at various levels of salinity. Beans were most salt-tolerant in the cool coastal climate, while cotton yielded better in the intermediate and hot interior climates than on the coast. Thus, the modifying effect of climate should be considered when crops are selected for salt tolerance.

CHEMICAL WEED CONTROL IN VEGETABLE CROP PRODUCTION

By

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The use of chemical weed killers (herbicides) as an aid in vegetable production has proved very profitable in many instances. New chemicals and new ways of using some old materials show great promise of further reducing 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 merely as suggestions for experiment station and farm trial. Because of differences in kinds of weeds, in climate, and soil conditions and in varieties and cultural practices the methods of using herbicides will necessarily vary from place to place. By keeping up with new developments in

vegetable growing areas one can often adapt new practices to his particular condition.

To simplify this discussion we will mention six important ways in which vegetable growers have found herbicides useful. Specific crops will be referred to under several of the six groupings.

1. Selective Spraying.

You will recall from our previous discussion on the Fundamentals of Chemical Weed Control that there are four recognized types of selective weed killers based on the way they act in the plant. We will refer to these types as we discuss the different crops.

Carrots

Many Valley growers have had experience with oil sprays for this crop. In the Northern and Eastern states the type of oil fraction known as Stoddard Solvent is being used because of its selectivity to its weed killing ability and because it evaporates quickly and is unlikely to leave an oily residue. California and to some extent in your section a less expensive fraction often called stove oil has been widely used. Because success of an oil depends on its composition which in turn varies with the source of petroleum, it is difficult to set down specifications for a good selective oil for carrots. Growers who have not found a reliable source should consult their agricultural specialists. If you have had difficulty from carrot injury or oily flavor I suggest you consult you local oil sources regarding a Stoddard Solvent type of material.

In the recently released circular bulletin 136 from the California Experiment Station, Dr. A. S. Crafts set 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° 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 preemergence 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.

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.

Just another note of caution: two rigs caught fire in Wisconsin last summer, one apparently from an exhaust spark from the tractor. Remember that atomized oil from spray nozzles is highly inflammable and take precaution accordingly. Selective oils have also been used successfully on parsley, parsnips and celery, particularly in the seed bed stage of the latter crop. Apparently parsley, which you are interested in here, is about as resistant as carrots. However, tests should be made with local sources of oil before going ahead with large scale plantings.

Onions

Sulphuric acid is being used with some success in the Northeast and in California the dinitro selective sprays, such as Sinox and Dow Selective Weed Killer, have been used successfully. The Iowa Experiment Station has recommended sodium pentachlorophenate as a selective for onions. All of these materials belong to the first group of selectives that we discussed yesterday. Because the resistance of the onion plant depends on leaf wax and that, in turn, varies with weather conditions results have not been consistently good. Injury has sometimes been excessive, particularly when spraying was done following moist cloudy weather. Some varieties are less resistant than others and unfortunately the ones you grow here are among the more susceptible. Selective spraying of onions doesn't look like a very good thing until we find a chemical that is more selective than those available at present. I think pre-emergence spraying of onions may have a place in your section and we will discuss that shortly.

Peas

Canning peas in the northern states are often sprayed with one of the dinitro selectives and this operation has proved very successful. A little leaf burn always 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.

Sweet Corn

Although a member of the grass family, which in general is considered resistant to 2,4-D, corn cannot be sprayed without certain reservations. Roots do not develop properly when treated at certain stages of development. A large number of experiments were conducted this year on the selective spraying of corn with 2,4-D. As this data has not all been compiled and analyzed, I am not prepared to make any recommendations. In fact, I feel that it should only be considered a subject for further experimentation possibly on a grower trial basis in 1948. Possibly the use of 2,4-D as a pre-emergence treatment on corn is a little further along, and we will talk about this in just a few minutes.

Beets

Solutions of common salt as a selective spray for beets look very 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 this 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 of this 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 the two leaf stage. Later the weeds are 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

This plant is a member of the beet family and some tests indicate that it has a certain amount of resistance to salt but it is not as tolerant as beets. There is no recommendation to make for spinach at the present time.

Potatoes

Although this crop has considerable resistence to 2,4-D, we are not sure how much it takes to begin to hurt the crop nor at what stage it is safest. It seems certain, however, that patches of perennials growing in potatoes can be spot treated without any great degree of damage to the crop. Tubers from sprayed plants have been found to store well and they sprout normally if they are grown for seed. Possibly, in emergencies, when excessive rain prevents early cultivation, a spray of about one-half pound of 2,4-D acid equivalent per acre would be worth trying. Not much is known as yet about possible differences in varieties and the way they respond. Certainly the use of 2,4-D as a selective spray on potatoes is still in the experimental stage.

To summarize, we might say that the dinitro sprays are definitely recommended for peas, selective oil sprays definitely recommended for carrots and parsley. The other materials discussed are still to be considered in the experimental stage, at least in your area. Although you are primarily vegetable growers, you may be interested to know that there are millions of acres of grain, rice, and sugar cane sprayed with 2,4-D. This has been very successful. The dinitro sprays have been very successfully used on a large scale on flax and also on new seedings of alfalfa and certain other legumes. Recently it has been found that flax is partially tolerant of 2,4-D and some experiments indicate it may be used sometimes to better advantage than the dinitro materials, but this is still in the experimental stage. The dinitros are still recommended for the flax crop.

2. Pre-emergence and Pre-planting Treatments with the Contact Type Herbicides

Some crops take a long time to come up and many weeds emerge first. Shallow pre-emergence tillage has often been practiced but of course it has its objections. Spraying with some of the oils or the dinitro phenolic contact sprays just before the crop emerges has proved very desirable in many instances. Corn, potatoes, onions and certain of the bulbous crops such as gladiolus and tulips have been handled this way very nicely. Certain warm weather crops like beans take a long time to emerge if the weather is cool, and the contact sprays have proved useful in such instances. I have seen this idea work out very well in tomato plant beds. In cool weather the weeds came up before the crop. It would be worth trying in both tomato and onion plant beds in South Texas and also on direct-seeded crops. One should use only small amounts of the spray, particularly for the small seeded crops. One gallon of Dow Contact Weed Killer in about 30 gallons of water per acre, has proved successful on onions. It is not likely to cause injury if properly timed. Often many weeds are killed that are just beginning to break the surface and one hardly realizes they are there.

In some instances it is possible to delay planting after fitting for several days so more weeds will be up before a pre-emergence treatment is made. Weed seeds ordinarily germinate only near the surface.

If the first flush of weed growth is killed with a contact spray before planting and then a crop seeded immediately without stirring the soil a surprisingly large reduction in weeding cost will often be realized. This type of treatment is often referred to as a pre-planting treatment with the contact weed killer. This scheme works best on the lighter soils that do not become too compact to permit planting if a rain occurs between fitting and seeding time. On heavier soils it may still be useful if gone over with a Meeker harrow before planting and shortly after spraying. This loosens the soil without actually stirring it and bringing new weed seeds to the surface.

3. Pre-emergence and Pre-planting Treatments with 2,4-D

This material looks promising for pre-emergence treatment on crops that have some resistance to it and which can be planted fairly deep so the roots will not come in contact with the material. The contact sprays merely kill weeds that are up and leave little residual effect if properly applied. 2,4-D does leave some residual effect and is not suggested except for crops which have been shown to have a certain amount of tolerance. Many good results have been obtained with this method on corn. It appears to be worth testing. 2 pounds per acre of 2,4-D equivalent applied as a spray a few days after planting but at least two or three days before first emergence is suggested. This can be applied in any convenient amount

of water depending, of course, on the kind of rig available. This treatment will not eliminate all weeds but will reduce the amount of cultivation required in many instances. The corn should not be planted especially shallow; put the seed down about as deep as you think it is safe under your soil condition.

Several experimenters have reported success with 2,4-D as a pre-planting spray applied two or three weeks before planting. This treatment kills many weeds in the process of germination but time should be allowed for it to decompose before the seeds of sensitive crops are placed in the ground. In Virginia they are experimenting with this method on spinach. The land is sprayed about three weeks before planting in the fall. Just before seeding it is loosened with a Meeker Harrow. We feel that pre-planting and pre-emergence treatments with 2,4-D are still in the experimental stage but they're certainly worth trying in your area.

4. Perennial Weed Control

There is no doubt that 2,4-D and probably certain other types of weed killers are very useful for the control of perennial weeds on vegetable land, particularly when they get started in patches. 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 if necessary in order to eradicate a new weed that he has not had before. 2,4-D is very useful on many species and I suggest that you follow the recommendations of your experiment station in the use of this material.

5. Vegetation Control on Drainage and Irrigation Ditches and Roadways.

The accumulation of organic debris in the bottom of ditches is certainly objectionable. It is also very desirable to eliminate noxious weeds from ditch banks because their seeds may be spread to productive farm land. The use of chemicals, particularly 2,4-D, has proved very desirable for the control of many weeds in such situations. There is little excuse now days for having a fouled up road side and fence row situation in the average farm. 2,4-D and possibly other newer weed killers may be used to good advantage in keeping vegetation in check in these areas. Of course, the nice thing about 2,4-D and its related weed killers is that they do not hurt grass which, after all, is essential for the prevention of excessive erosion. Of course, you would like to have something to kill Johnson grass, Bermuda grass and some of the others that are troublesome in this area. I think there will be some promising new things available for this purpose within a very short time.

6: Farm Sanitation with Respect to Insect and Disease Control

There are a number of insect pests and plant diseases that live from one growing season to the next on weed pests. In my section of the country we have been particularly troubled with the aster yellows virus which attacks carrots, lettuce and many other crops.

This virus over-winters on Canada thistle and a number of other weeds which are commonly found in ditches, along roadsides and in other untilled and ungrazed area. 2,4-D will kill many of these troublesome weeds, which are not only trouble in themselves but are also hosts for pests which cause considerable damage.

NUTRIENT REQUIREMENTS OF PLANTS AND SOME FERTILIZER PROBLEMS WITH ROW CROPS IN THE VALLEY

By

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The Lower Rio Grande Valley of Texas has been called the last great frontier of the west, and it is true that the soils of that area are relatively new in so far as the number of years under crop production is concerned. Valley farmers are more fortunate than those of many areas in that the inherent fertility of the soils has not been so completely depleted by long years of cropping. It should be pointed out, however, that Valley farmers, by virtue of the climate, are in a position to rapidly deplete soil fertility by continuous cropping throughout the year. The fact that both yields and quality of crops are declining on many fields that have been under cultivation for an appreciable number of years is ample evidence that the soils are far from being inexhaustibly fertile. The sharp, upward trend in the use of fertilizers in recent years reflects not only the upward trend in crop prices, but the fact that such fertilizers are required to maintain crop yields as well.

To find out how to best meet the needs of crops through soils as the medium of plant growth is the primary problem of soil management in any area. Soil management to provide for sustained maximum yields requires that attention be given all of the many soil conditions which affect plant growth. Fertilizers are of little value in soils that have been made unproductive by a rising water table or by the accumulations of excessive concentrations of salt, and many other examples could be cited as evidence that the effectiveness of fertilizers in maintaining or increasing crop yields can be limited by one or more adverse soil conditions other than actual nutrient deficiencies as such. It is also a well known fact that the various crops differ in their nutrient requirements, and the efficient use of fertilizers necessitates an understanding of how the various crops grow and how their requirements can best be met under any existing set of soil conditions.

Here in the Lower Rio Grande Valley where intensive irrigation agriculture is practiced, the many and varied conditions present a challenge which must be effectively met if crop yields are to be economically maintained. The use of commercial fertilizers to augment declining supplies of soil nutrients affords one avenue of approach to this problem.

In any discussion in regard to the use of fertilizers, a certain amount of basic knowledge of the elements which are essential for

the growth and development of plants is necessary. In order to establish this background, a brief reference to nutrient requirements of plants in general must be made. Once this understanding is established, general application can be made to local conditions.

The higher plants utilize in their growth and development a relatively small number of relatively simple, chemical compounds. It is from these compounds that plants synthesize the carbohydrates; fats, and proteins of which they are mainly composed. A large number of chemical elements have been found in plant tissue, but only a limited number have been shown to be indispensable. These elements are shown in Table I.

Table 1. Elements Essential for Plant Growth

Carbon	Nitrogen	Iron
Hydrogen	Phosphorus	Manganese
Oxygen	Potassium	Boron
	Calcium	Copper
	Magnesium	Zinc.
	Sulphur	

In listing the 14 essential elements, it should be pointed out that it must be demonstrated that the lack of an element results in injury, abnormal development, or death of plants before it can be considered indispensable. Complete proof of the essentiality of an element also requires demonstration that no other element of similar properties can be substituted for it. The definition of indispensability of an element does not exclude the possibility that other elements under certain conditions with certain plants may result in beneficial effects upon growth.

The 14 essential elements may be divided roughly into two classes based on the relative amounts used by plants. The elements, carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur are used in relatively large amounts, while the elements, iron, manganese, boron, copper, and zinc are collectively called the trace elements because they are absorbed by the plants in very small quantities. The essential elements may also be classified according to their source. Plants obtain carbon and oxygen from the air, and hydrogen is derived principally from the water of the soil. Despite the fact that 96.5 to 99.0 percent of green plant tissue is made up of these three elements, it is the other elements, which are derived from the soil that are usually limiting when nutrient deficiencies occur.

For the optimum growth of plants in the soil, the essential elements must be present not only in forms available to the plants, but the proportionate supply of these materials must be properly adjusted into what is called a physiological balance. Excesses of certain elements in the soil solution may be toxic and more detrimental than if these concentrations were below that required for maximum plant growth. A deficiency or an excess of certain elements frequently retards the availability or absorption of other elements. Under field conditions, soils that are in perfect physiological balance are seldom if ever to be found.

The six soil elements, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur receive major attention in the field of soil management and are commonly designated as the primary elements. Nitrogen, phosphorus, and potassium are the three elements most generally deficient or unavailable in soils, and are designated as the fertilizer elements. Calcium, magnesium, and sulfur may under certain conditions actually be deficient in the soil; however, these elements are used principally to adjust the reaction of the soil solution, or to otherwise increase the availability of other nutrients, and are generally designated as soil amendments. The trace elements are fundamentally just as important as the primary elements despite the fact that they are absorbed in very small quantities by plants. In recent years, more attention has been directed toward the role of trace elements in plant metabolism as improved techniques in microanalysis have enabled investigators to better isolate and determine these elements as they occur in both soil and plants.

Although our knowledge is far from complete, each essential element is known to play certain specific roles in plant metabolism. This material is quite voluminous, and, except where the functions of elements are closely interrelated, this discussion must be limited to the three fertilizer elements.

The influence of nitrogen on plant growth and development is perhaps more pronounced and more readily evident than that of any other element. It tends to promote vigorous vegetative growth and imparts to plants a deep green color. Plants receiving insufficient nitrogen are stunted in growth, and the leaves do not possess that dark, green color indicative of thrifty growth. The effect of an excess of nitrogen as well as that of a deficiency is often drastically evident in crop yields. Excessive supplies may result in excessive growth and lowered resistance to disease. The nitrogen requirements vary with different stages of growth of some crop plants, and time of fruiting and crop quality are often closely related to the supply of nitrogen at various times within the crop season. Excessive supplies of nitrogen during the early growing stages of tomatoes, for example, is known to produce excessive vegetative growth on which the setting of fruit may be materially delayed. With such leafy crops as cabbage, spinach, lettuce, on the other hand, large amounts of available nitrogen can be used to an advantage during earlier stages of growth. With root and tuber crops, excessive nitrogen may reduce yields by promoting excessive above ground growth.

Adequate supplies of available phosphorus tend to promote flowering, fruiting, and root formation in plants, and in this respect mav counteract somewhat the effects of excessive nitrogen. Fruiting and seed formation do not occur in its absence, and more than one-half of the phosphorus in mature plants is found in the fruits

and seeds. This element, therefore, hastens maturity and is sometimes used to a good advantage in areas where the growing season is short. The formation of fats and the transformation of starches to sugars in plants are processes which require available supplies of phosphorus. In general, the phosphorus requirements of annual plants are relatively heavy during early stages of growth and again near the end of the growth cycle. The maintenance of a balance between nitrogen and phosphorus in the soil is an art the successful use of which is often employed by growers in producing desired effects upon the growth and development of crops.

Potassium is apparently not an important chemical constituent of any plant organ; however, it is known to be necessary for the normal utilization of nitrogen and for the formation and translocation of manufactured foods within the plant. The process of cell division, so necessary in the growth of all plant structures, does not proceed in its absence. Adequate supplies of potash facilitate the utilization of other elements, and adequate supplies often tend to improve crop quality.

Since field crops vary widely in the product for which they are grown, something of the variation in their nutrient requirements is indicated by the differences in the general functions of the fertilizer elements in the nutrition of plants in general. Included in the factors contributing to the differences in the nutrient requirements of crops are: (1) differences in above ground growth, (2) differences in spread and character of root systems, and (3) differences in ability to thrive on lower concentrations of mineral elements. No attempt will be made here to classify crop plants on the basis of the characteristics of growth which contribute to these differences; however, the requirements of several representative crops as indicated by their nutrient content is shown in Table II.

Table 2. Nutrient Content of Crops

Crop	Yield	N lb.	P_2O_5 lb.	K_2O lb.
Tomatoes	10 tons (fruit)	60	20	80
Potatoes	300 bu. (tubers)	65	25	115
Cabbage	15 tons	100	25	100
Spinach	9 tons	90	30	45
Sweet Potatoes	300 bu. (roots)	45	15	75
Corn	60 bu. (grain)	57	23	15
Oats	50 bu. (grain)	35	15	10
Wheat	30 bu. (grain)	35	16	9
Cotton	1500 lbs. (seed cotton)	38	18	14
Alfalfa	3 tons	140	35	135
Cowpeas	2 tons (all)	125	25	90

In the variations noted in the nutrient content of crops, it is evident that the leafy crops such as cabbage and spinach have the highest nitrogen requirements; the significance of the extremely high nitrogen requirements of the legumes, alfalfa and cowpeas, is reduced somewhat by the fact that legumes as such are able to fix atmospheric nitrogen. On the basis of nitrogen requirement, the fruiting crops, root crops, and cereal crops may be ranked in that order following the leafy crops. The control of the nitrogen supply at critical periods in the growth cycle of the various crops is a problem the significance of which is not indicated by the total amount of the nutrient that is required.

The phosphorus requirement of crops, as indicated by their content of these nutrients in table 2, does not vary as widely as that of nitrogen. The fact that the phosphorus content of crops is generally lower than that of the other two elements may seem inconsistent with the general field practice of applying fertilizers in which phosphorus is the highest constituent; however, when the difficulty with which soils supply plants with this element is considered, the necessity for this field practice will be readily understood.

It is also to be noted that with the exception of the cereals, corn, oats, and wheat, the requirement for potassium is rather consistently high for all crops. Again, this fact seems to indicate an error in the general practice of applying fertilizers in the field; however, field practices are logical when the ability of the soil to supply this nutrient is considered.

The abilities of soils to supply nutrients required for optimum growth of plants vary greatly with soil characteristics and with past cropping history.

The available nitrogen content of all cultivated soils is constantly changing; the supply at any particular time is closely associated with the organic matter content and with the vegetation that is growing on the land. A vigorously vegetative crop will usually drain the supply of available nitrogen to low levels by the end of its growing season. Although decay of crop residues in the soil after harvest will restore some of the nitrogen taken up by the crop, that in the marketed portion is lost to the soil. Since there is no natural supply of soil nitrogen that can be made available through the weathering of soil minerals, that removed by cropping can only be replaced by growing legumes to fix additional supplies from the atmosphere or by adding the element in fertilizer compounds or in farm manures. Other danger points in the nitrogen economy of soils lies in the fact that nitrogen in mineral form may be lost from the soil by leaching and by escaping into the atmosphere in gaseous form. Nitrogen in the mineral form, which is most readily available to plants, is extremely soluble and is readily leached from the soil by percolating water. Where soils become poorly aerated from the ponding of water, appreciable amounts are lost to the atmosphere in gaseous form.

Control of the supply of soil nitrogen is more difficult on sandy soils than on those of heavier textures. Decomposition generally proceeds more rapidly on the lighter textured soils to release nitrogen in the mineral and highly soluble form; since water moves more readily through soils of lighter textures, leaching losses are greater.

Here in the Valley where extensive irrigation agriculture is practiced under conditions of a subtropical climate, the content of organic matter and nitrogen are difficult to control on all the cultivated soils. Current irrigation practices are not conducive to control of drainage losses, especially on the sandier soils, and the high demands occasioned by double cropping with non-leguminous crops are expensive to supply. The efficient use of nitrogenous fertilizers requires special attention to such factors as: soil characteristics and cropping history of the land, the crop to be grown, the nature and characteristics of the fertilizer material, and the time and method of application.

The phosphorus content is doubly critical in so far as the ability of the soil to supply available phosphorus is concerned; the amount of inherent phosphorus in soils is both low and slowly available to plants. The availability of phosphorus is related to the physical and chemical properties of soils. The tendency for the fixation of this element in an unavailable form is greater in the clays and heavier textured soils. In highly acid soils phosphorus unites with soluble iron and aluminum to become unavailable for absorption by plants; in soils that contain large amounts of calcium and other bases, phosphorus unites with calcium to become slowly available. The practice of applying much greater amounts than that actually required by the plants is an attempt to overcome the adverse soil conditions which tend to revert this nutrient to an unavailable form. It can be readily understood, then, that on Valley soils in which there are huge quantities of calcium, the higher rates of phosphorus as compared to the amounts of other elements are necessary. Since there are practically no losses of phosphorus through leaching, the optimum time of application would be at or before planting. Such time of application would insure placement of the material within the root zone of the crop. However, since phosphorus is strongly fixed when mixed with the soil, it appears that more attention might be given the placement of this material in relation to the seed or plants.

Soils, with the exception of those of extremely sandy texture, contain relatively large stores of potassium. A considerable proportion of this supply, however, is in a form which becomes somewhat gradually available to plants. Adequate absorption apparently requires a relatively high concentration of this element in the soil solution. Depletion of this element by extensive cropping may result in the inability of soils to supply the large quantities required by plants. Very sandy soils are inherently low in potassium and should show deficiencies at an earlier stage in their cropping histories than do soils of heavier textures. Potassium is fixed to some extent in the soil, and although this element, in most fertilizer compounds, is readily soluble, drainage losses are not generally thought to be serious. The application of potassium fertilizer or potash, as it is called in the fertilizer trade, should apparently be made at or before the time of planting. Because of its solubility such material should not be placed in direct contact with the seed or transplants.

Although the available experimental data tend to show that the use of potash fertilizers on some Valley soils do not result in profitable increases in crop yields, some growers are reporting beneficial results from the use of such materials. In view of the large amounts of this element that are absorbed from the soils by crops each year, deficiencies may develop as the soils are depleted by cropping.

Fertilizing a crop does not mean simply incorporating certain materials into the soil on which plants may feed. The addition of such materials to the soil may result in physical, chemical and biological actions and reactions. The nature and character of the fertilizer materials to be applied to the soil must receive careful consideration in order that these resulting actions and reactions will not be detrimental.

It is not possible to include herein all of the information that is available in regard to the character and the chemical composition of the many compounds in which the fertilizer elements are available. It is pertinent, however, that the general forms in which these elements are carried be briefly enumerated along with such statements as are necessary to establish something of the relative merits of the carriers most generally used in the Valley.

Some nitrogen fertilizer carriers and their comparative values as to various qualities are shown in table 3.

The principal nitrogen fertilizer materials used in the Valley at the present time are ammonium nitrate, and ammonium sulfate. Other materials, the use of which is somewhat limited, include sodium nitrate, calcium nitrate, and calcium cyanamid.

Ammonium nitrate is an excellent source of nitrogen for Valley soils in that both the ammoniacal and nitrate forms are present, and the residual effect in the soil is neutral to slightly acid. This material, however, is highly soluble and precautions should be exercised to prevent burning of the plants, and losses by leaching. The poor handling qualities of this material is the chief disadvantage associated with its use.

Ammonium sulfate flows rather freely through fertilizer distributors and has very good handling qualities. The acid residual effect resulting from its use is somewhat limited but beneficial. The nitrogen in this ammoniacal form is not as immediately available as that of the nitrate form, but under Valley conditions it is rapidly changed to nitrate forms by action of soil organisms. Although the ammoniacal nitrogen may be temporarily fixed by the soil, the rapidity with which it is changed to the nitrate form makes the nitrogen in this material highly susceptible to losses by leaching.

Calcium cyanamid is a fertilizer material which has excellent handling qualities in so far as its drillability is concerned. When this fertilizer is first applied to the soil, a plant toxin is formed by soil organisms acting upon it. Although this toxic compound persists only for a short period under average conditions, this fertilizer

should be applied sometime prior to the planting of the crop.

Sodium nitrate is used to a very limited extent in the Valley because of the adverse effects of the residual sodium that is left in the soil.

Calcium nitrate is used only in limited amounts in the Valley area. Under certain soil conditions, however, this material may have considerable merit. Calcium nitrate takes up water very readily and has very poor handling qualities.

Superphosphate is the principal source of phosphorus in fertilizers used in the Valley; however, a compound in which the phosporus is combined with ammoniacal nitrogen (16-20-0 and 11-48-0) is gaining in popularity. Superphosphate in which the phosphorus is combined with calcium, is available in grades which range from 20% to 47% available P_2O_5. The refined grades of superphosphate and the form which is combined with ammonium are generally more desirable because concentrations of calcium are lower or lacking in the compounds.

Muriate of potash (potassium chloride) is the principal source of potassium fertilizers. This material is available in both 50% and 60% grades (water soluble K_2O). In normal times, potash is available in the markets in the form of kainit (12-14%) sulfate of potash (50%), and nitrate of potash (44-46%). Neither experimental data nor local experience are available to indicate the relative merits of these materials under Valley soil conditions.

Table III—Nitrogen Fertilizers, Their Comparative Values As To Various Qualities

Material	Per Cent Nitrogen	Residual Effect with soil	Handling Quality
Ammonium Nitrate	30-35	acid	poor
Ammonium Sulphate	20-21	acid	good
Sodium Nitrate	16	alkaline	fair
Calcium Nitrate	15	alkaline	poor
Ammonia (Anhydrous)	82	acid	
Urea	46	acid	
Ammonium Chloride	26	acid	poor
Ammonium Phosphate	11-16	acid	good
Cottonseed Meal	6	acid	good

A PRACTICAL CONTROL FOR NEMATODES

By

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The common root-knot or root-gall nematode regularly causes losses to farm crops in the Lower Rio Grande Valley. No complete survey to determine the extent of such losses has ever been made. We have only scattered evidence from here and there, all over the Valley to indicate that the losses are tremendous. One year, a 10-acre field of beans reported as "in poor condition" by the grower was found to be so heavily infested by nematodes as to be practically a total loss. Fields of tomatoes and of peppers with reduced stand and reduced vigor of remaining plants have produced less than half the expected yield. Already this fall, tomato fields have been reported by the Extension Service as being infested with nematodes and non-productive. Only the farmer who has encountered such losses can fully realize their seriousness. These are just isolated examples of the direct loss to the current season's crop, ranging often from 25 to practically 100 percent. In addition to this is the fact of virtual ruination of fields for pay-crop vegetables caused by the building-up of tremendous numbers of nematodes in the roots and in the soil. Such fields are often abandoned by the tenant farmer in favor of new "clean" land.

I shall outline here a relatively simple, relatively inexpensive procedure that practically as well as theoretically will go a long way toward quick reduction of the nematodes to a point of practical control. First, however, I shall state a few facts about nematodes that will make for a better understanding of the method proposed.

At the end of the growing season, in a badly infested field, the still-living roots of the infested crop contain myriads of living nematodes as adult males, females, and partially developed immature forms, all of which will die as the roots die and decompose; as newly hatched larvae not yet having fed; and as eggs, mostly in gelatinous egg masses. A single egg mass may contain anywhere from 250 to 1000 eggs, mostly around 500. Only the eggs and the larvae will play a part in the infestation of subsequent plants.

As the roots decompose, the eggs and larvae are released into the soil. They are capable of remaining alive in the immediate vicinity of the point of their release for many months—a small proportion of them for well over a year in undisturbed soil by actual test, without any interim feeding.

Nematodes are extremely susceptible to injury and death by exposing them to certain unfavorable conditions in their environment. These are

High temperatures. Nematodes in the egg stage (most highly resistant stage) are killed in only a few hours at as low a temperature as 104°F. They are killed at 110° in an hour and 40 minutes. At 130° they are killed in less than 5 seconds.

Low humidity (drying). At 50 percent relative humidity, nematode larvae are killed in 4 minutes; eggs in egg masses in 2½ hours. At 70 percent relative humidity (frequently encountered as the daily average in the hot summer) the larvae are killed in 10 minutes; eggs in egg masses, in 4 hours. Nematodes protected within root galls were all killed in less than 3 days at 50 percent humidity, and in less than 5 days at 70 percent.

Sunlight (ultra violet). The sun's light alone, with effects of heating and of drying experimentally eliminated, was found to be capable of killing nematode eggs in a matter of 4 or 5 hours. (larvae, only 25 minutes).

All this detail, arrived at experimentally, may not seem to mean very much in itself. It does show, however, that any one of the three factors, high temperatures, drying, and sunlight, is capable of killing nematodes. All three acting together speed up the killing.

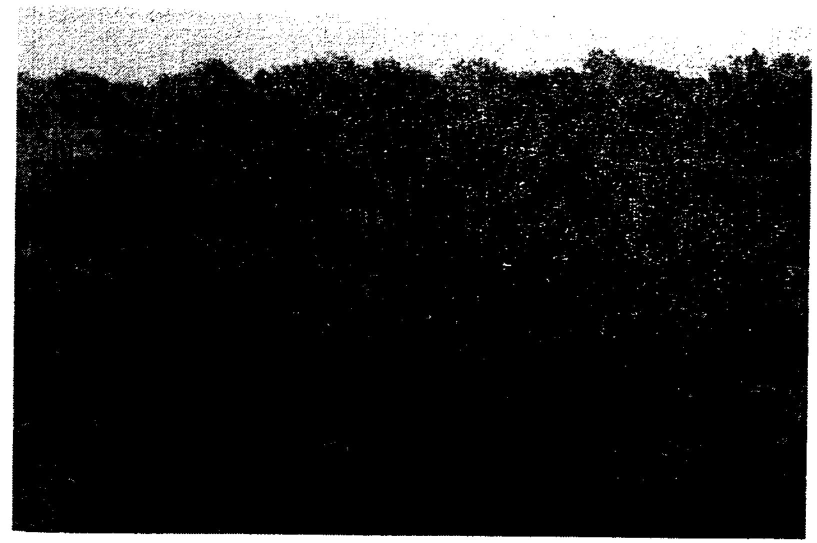

Fig. 1 The non-treated field of experiment 1. Note the undersized plants and the large areas of bare soil where plants are very small, or have failed completely.

Actual temperature readings were taken in the soil of a plowed field on a July day at the Experiment Station. The official air temperature at the time of the readings was 100°F. At 2 feet above the soil surface the reading was 107°; at 2 inches above the soil it was 109°. Soil temperatures, the averages of 2 separate readings, were as follows:

At 1 inch	130°
2 inches	120°
3 inches	109¾°
4 inches	103°
5 inches	97°
6 inches	96°

Bearing in mind that 104° will kill all nematodes, even in their most resistant condition, these figures show that there can be no survival, under the conditions, in the upper 3 inches of soil. On the basis of the figures previously mentioned, in any nematode-infested soil thrown up to the surface, the nematodes in all stages would be killed in the upper surface after only a few seconds exposure; in the second inch, after a period required for warming, only 5 minutes would be required to kill them; and in the third inch all would die after an hour and a half.

Theoretically, then, all that would be required to eradicate nematodes from the soil would be to throw up successive 3-inch layers of infested soil to the surface, and leave them exposed to the hot sun for a few hours. If a perfect job of this could be done, the results should be perfect. In practice, however, there is always a mixing of the soil layers, and the deeper layers are never brought completely to the surface.

A test was made in the same field as that upon which the temperature readings were made, to determine the effects of successive plowings on nematode infestation at different depths. The field was heavily infested at the outset, as shown by the second column of readings in the table. Here "0" represents no living nematodes; "1" means very slight, and so on up to "10", which means extremely heavy infestation. After 3 successive operations, which pulled up to the surface layers of soil at increasing depths, down to about 10 inches, another series of samples was taken, and nematode populations taken as before. A comparison of the two columns of figures is rather significant.

Depth, inches	No treatment	Plowed 3 times
1-2	0	0
2-4	2	0
4-6	6.5	0
6-8	7	tr.
8-10	10	3
10-12	8.5	5
12-14	7	4
14-16	7	1

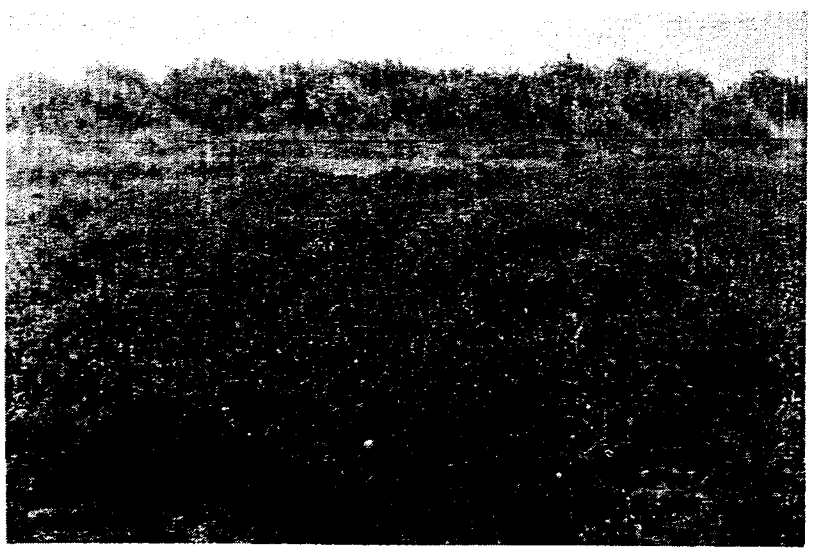

Fig. 2 A portion of the summer-plowed field of experiment 1. Note that the ground is completely covered by large, vigorous plants.

Down to depth of 6 inches there were no living nematodes, and even at 8 inches, only a trace (manifest by a tiny gall or two on a root system). The "quick drying" treatment was of distinct benefit in reducing the nematodes in the upper 8 inches of soil, at least, and apparently even deeper than that. There is very little movement of nematodes through the soil. Infestation of a root occurs when the root grows down to where the nematodes are. A planting of a crop like tomatoes in this particular soil should get off to a good start, as it would be able to make a strong root system early in its growth. Serious damage is done only when the first roots formed are immediately heavily infested.

Practical Applications

Tests were conducted to determine how this quick drying method would work out in actual field practice. A 40 acre field of Victoria sandy loam north of Weslaco in spring beans was heavily infested with nematodes. The owner wanted to plant fall tomatoes, but realized that, with so many nematodes in the soil, his chances for good success were rather slim. He followed the suggestions offered in detail, from exposure of the bean roots to the sun to kill the nematodes contained in them, to 3 successive plowings, each 2 or 2½ inches deeper than the one before. He used a disk plow, running the tractor fast in order to throw the soil up on top, rather than allowing it to fall back on edge. He was persuaded to leave a 5-acre corner of the field without the quick-drying treatment, using ordinary preparation-for-planting procedures just before planting time. Differences between the two portions of the field in plant growth were strikingly obvious. In the quick-dried portion, the plants were thicker-stemmed and larger throughout, and there was a much better stand of living plants. Sample plants removed from the soil showed a striking difference in the root systems. Those in the quick-dried portion showed long, clean, white roots, with a wide feeding range. Such infestation as was present was mostly on the terminals of deep roots, where the drying could not be effective. Those in the non-treated part of the field had all the main roots heavily galled, the roots were short, and the feeding range of the root system greatly reduced.

Most striking of all, in the effects of the treatments, were the figures on relative yields. Based on careful records, actual gross returns for tomatoes harvested were $120 more per acre on the "quick-drying" treated field than on the other. The cost of the extra plowing was only $9, leaving a profit for the operation of $111 per acre.

A similar experiment was conducted on heavy land about a mile south of the Experiment Station which had been in spring tomatoes that were extremely heavily infested with nematodes. The ground, which was at the time rather hard and dry, was plowed, leaving it rather lumpy. It was re-plowed twice, with an attempt to bring up the deeper moist soil each time. The results were much the same as before. Even on this heavy cloddy land the nematodes

Fig. 3 Representative tomato plants from experiment 1. **Left,** from summer plowed portion; many of the roots were actually 3 or 4 times as long as could be shown in the picture. **Right** from non-treated portion, the entire root system being shown in the picture. In addition to differences in the amount of root knot, note the difference in the size and abundance of top framework branches.

infestation was reduced to "0" down to 6 inches, and to "1" down to 8 inches. The succeeding crop was not followed through, but it was reported to me that it was successful; and furthermore, by following the same procedures since the test was made, the field has never again become as heavily infested as it was in the spring of 1943, when the test was made. Other farmers have reported that, whereas formerly losses from nematodes were occasionally extreme, since adopting this method nematodes are no longer a serious problem.

There is good reason to believe that any farmer who applies this relatively cheap method to his nematode-infested fields will benefit greatly in the way of increased yields in subsequent crops, over what would otherwise occur; in fact, the nematode problem would cease to exist as a serious factor in production. Of course, there may be complications such as prolonged cloudy weather during the period chosen for the treatment, in which case one would defer the treatment until conditions were more favorable. A heavy rain in an early stage of the treatment would necessitate starting over again when hot dry conditions prevailed. Usually, in the Lower Rio Grande Valley, there are plenty of favorable periods between May and August.

The complete schedule of operations to be applied during a hot, dry period, is as follows:

(1) Plow up the nematode-infested spring crop to expose the root systems.

(2) After a week plow or list to a depth of 6 inches to throw the bottom layer of soil to the top for drying.

(3) Repeat in from 3 to 7 days, depending upon drying conditions, but going 2½ inches deeper.

(4) Repeat, 2½ inches still deeper. If a middle buster is used it would be desirable to run it diagonally across the field at least once, to break up the undisturbed soil left between the middle-breaker points in ordinary operations.

(5) Still another plowing, at maximum depth, would further increase the effectiveness.

The total time required, under ideal conditions, would be only 16 days. The maximum over-all period would probably never exceed 4 weeks. Thereafter the usual procedures in preparation for planting could be followed according to the regular schedule.

IMPROVING VEGETABLE QUALITY BY DECREASING COST

By

F. S. JAMISON, *Horticulturist - Vegetables, University of Florida Agricultural Experiment Station, Gainesville*

My first trip to the Valley was made 20 years ago as a young instructor assisting Dr. Guy Adriance to conduct a class through the various points of horticultural interest. That was an experience that has not been forgotten. I could spend considerable time reminiscing over that and following trips. But one impression that I gained from those trips has remained unchanged. That impression was the vast potentialities of the area for growing vegetables. I know part of those potentialities now have been converted into carloads of vegetables. You can't live in Florida and not realize this fact, for the lower Rio Grande Valley of Texas is now Florida's most severe competitor in a number of winter and particularly early spring vegetables.

Competition is a challenge to a vigorous and healthy industry, just as it is to a healthy and vigorous individual. Growers in Florida intend not only to stay in the business of producing vegetables but they expect the industry to thrive and to continue to expand. Part of this confidence of our growers in the future is based on their respect for and belief in what can be accomplished by well planned and intelligent research. They have seen miracles result from research and believe that these can be made to happen again by intelligent research and application of the results to their every-day work. It has been my good fortune to work in a number of states, but nowhere have I seen growers so keenly aware of the advantages to be realized from a strong research program nor have I seen research more actively and aggressively supported by growers than in Florida.

The Hope-Flannagan or RMA Act, as you choose to call it, has stimulated thinking in regard to the marketing of vegetables. The cry will probably be for improved quality at lower cost. Improved quality to many growers and shippers means more grading belts, more culls to dispose of, additional cost for fancy waxes, wrappers and packages. In fact, when improving market quality is mentioned to most people, it simply means additional marketing cost.

While packages and wrappers may be necessary for transporting and marketing the crop, the fact remains that people don't eat wrappers or packages. They eat vegetables, and that is where quality improvement must be made if Florida vegetables are to be sold to good advantage in competition with vegetables from other areas. Florida has done a great deal to improve the quality of its vegetables during the past 15 years and much of this improvement in quality has resulted in relatively lower rather than higher unit cost.

Potatoes have been produced in the Hastings area of North Florida for many years, the variety Spaulding Rose No. 4 being produced on almost the entire acreage; or, rather, it was until the spring of 1935. That year several growers were persuaded to try several acres of a new variety called Katahdin. This variety had yielded exceedingly well on experimental plots and those who ate it believed it possessed superior quality as compared with the Spaulding. Growers objected to it because of its white skin, claiming that the markets would never accept a white-skinned early potato. The market not only accepted it but actually paid a premium for it. That was the beginning. A higher yielding variety than Katahdin has replaced Katahdin and it is possible that Sebago may be replaced by Sequoia or Pontiac. These new varieties all have some resistance to one or more of the diseases which played havoc with the Spaulding Rose. The average yield in the Hastings area has been increased, estimates ranging from 30 to 50 bushels an acre. Here, then, is one place where higher quality was secured without additional cost. This one instance of where a superior variety has resulted not only in higher yield but higher quality can be multiplied many times. One more example may be sufficient. Green beans are an important crop in Florida. Approximately 100,000 acres are planted each year. Previous to 1939 Bountiful occupied the major part of the acreage. Bountiful is a splendid variety of bean; it produces a high yield of good beans but, if left on the vines a day too long, it becomes tough, woody, and fibrous. The variety was also particularly susceptible to rust that was appearing with increasing severity along the lower East Coast. Black Valentine, Plentiful and Florida Belle, all relatively new varieties, have, to a large extent, replaced Bountiful. They yield equally well or even better; some are more resistant to disease, and all have superior quality to Bountiful.

We believe these varieties will be extinct within the next 5 to 7 years. Higher yielding strains of superior quality, resistant to specific diseases and equally good for fresh, frozen or canning beans are now in experimental plots. As rapidly as possible seed of the better ones will be multiplied and released to growers.

The development of new varieties may result in other savings. Lake County, in Central Florida, is one of the earliest melon shipping areas of the United States. Shipping usually begins in May and continues into the latter part of June. Fusarium wilt is an extremely serious disease in the area. Since the disease will live for years in the soil, the only method of avoiding it is to plant on land that previously has not been used for melon production. This means clearing new land each year. In 1930 a breeding program was initiated to find a melon resistant to this disease. The variety Leesburg was introduced as a result of this breeding program. This melon, resistant to wilt, had superior quality, was oblong in shape, white-seeded and averaged approximately 5 pounds smaller than the variety being grown. Growers complained of its size and the white seed. In Blacklee, a subsequent introduction, black seed were included and the melon was comparable in size and shape to the one they were then growing, which was Tom Watson. Florida growers will concede that there is no finer variety than the Blacklee, but the melon is 10 days later than the Cannon Ball, the commercial variety now being grown. Thus research workers are now trying to put earliness, black seeds and Fusarium resistance in another variety, a round one this time. While Florida growers have failed to accept Leesburg and Blacklee, they are being grown in areas where earliness is not as important a factor. You here in Texas grow many of the Blacklee, while Leesburg is grown the whole length of the Mississippi Valley in ever-increasing volume. And it is not beyond the realm of possibility that, when production costs become increasingly important, these varieties may be grown again in the area for which they were originally developed.

The development and introduction of superior varieties is permitting Florida growers to produce new crops. Imperial 44, 847 and Great Lakes lettuce perform sufficiently satisfactorily to enable a number of growers to grow this crop profitably. Excel and Texas Early Grano onions are being tried by growers with a great deal of enthusiasm, while the introduction of superior hybrid varieties of sweet corn has added another important crop. Probably 8,000 acres of Golden Cross Bantam and Ioana were grown last season and experimental results indicate that such varieties as Golden Security, Erie, Tri-State and others may perform even better than Golden Cross Bantam or Ioana.

But the introduction and development of varieties is only one method used by Florida growers in producing higher quality at lower cost. Improved cultural practices is another method. Florida soils vary widely in the degree of soil acidity. The marl soils of the lower East Coast have a pH of 8.0 or even higher, while some of the mucks or peats underlaid with sand may have an acidity value as low as pH 3.8. Other soils used for vegetable production in the state may vary between these extremes. When we wish to grow vegetables on either very acid soils or very alkaline ones, we know certain corrective steps must be taken. Only during the past season was this fact re-emphasized.

The acreage planted to tomatoes in the vicinity of Ft. Pierce on the East Coast has expanded rapidly during the past several years, newly cleared land being planted each year. This practice required not only clearing the land, but diking and ditching, an expensive procedure. The reason for using new land was that yields and quality dropped severely when a second crop of tomatoes was grown. A survey of the area revealed that, during the first year tomatoes were produced, the pH was approximately 5.2, but, by the second year, the pH had dropped to 4.8 or even lower. The organic matter present in these soils averaged 1%. This explained in part the rapid drop in pH. Experimental plots were established on which the pH was raised by the use of basic slag, hydrated lime or dolomite, respectively. The use of these materials resulted in approximately doubling the yield over the check areas. Not only was the yield increased, but the quality of the fruits was decidedly improved. Many of the fruits produced on the acid soil had corky spots appearing through the flesh of the fruit. This condition was entirely corrected when lime was used. The apparent solution of this seemingly simple problem will eliminate the need for clearing, diking and ditching new land each season. The quality of the crop is improved, and certainly the cost of production is reduced.

The amount and kind of fertilizer to use is an ever-present question. In Florida at the present time we believe that it can best be answered by fertilizer trials on the specific soil type in question or on quite similar soils. It is readily recognized that soil testing, once evaluated for particular soils, may be of value in determining certain deficiencies but methods are as yet unavailable for Florida which will permit a soil analyst to determine the fertilizer need in advance of planting for a specific crop on a given soil. In the marl glades of Dade County the important crops have been potatoes and tomatoes. For years the standard fertilizer used on potatoes has contained 4 percent nitrogen. Experimental evidence is rapidly accumulating that indicates that the nitrogen can be decidedly reduced or even eliminated without any effect on crop yield or quality.

Before the war Florida growers believed they could not produce crops unless 25 to 40 percent of the nitrogen in the fertilizer was derived from cottonseed meal, castor pomace, tankage or some other organic material. They have been doing fairly well without it. Experimental work has for some time indicated that they could do so providing the fertilizer was properly applied.

The method and time of applying fertilizer has received considerable attention during the past several years. The customary or time-honored way of applying fertilizer in Florida is to spread it down the plant or seed row, wait 10 days or 2 weeks, and then plant the crop. There was a definite reason for this practice, especially on sandy soils. Young plants or seedlings would be severely injured if planted immediately following the application of 1200 to 2000 lbs. an acre of fertilizer. Placing the fertilizer in definite bands 2½ inches to the side of the seed or plants allows for the application

of fertilizer and planting to proceed simultaneously. This method of applying fertilizers has initiated additional changes in fertilizer practices. Top or side dressing with soluble nitrogenous materials has been a standard practice. On certain soil types if the fertilizer is properly banded all the nitrogen to supply the crop need may be applied at planting time and side or top dressing eliminated.

Another way of applying fertilizer that is used by growers in the Everglades area may be of interest. Here 10 pounds of nitrate of soda is added to each 100 gallons of spray material and sprayed on the crop when either insecticides or fungicides are applied. No experimental test is available on the efficacy of this method of applying fertilizer but it probably is an effective way, particularly during cool weather.

The story of the use of the so-called minor elements such as manganese, zinc, boron, and copper on citrus in Florida is widely known. What they have accomplished through the use of the material is truly remarkable. But they have been equally successful in producing vegetables. When discussing soil acidity it was mentioned that, on alkaline soils, corrective measures usually must be taken to insure satisfactory crop production. The marl soil of Dade County, relatively high in nitrogen and organic matter, was relatively unproductive before it was found that a small application of manganese sulphate—75 to 150 lbs. an acre—stimulated crop growth and increased crop quality.

The peat soils of the Everglades were unproductive until it was found that copper sulphate, applied at the rate of 50 pounds an acre, made the soil productive. Furthermore it usually was necessary to add the material only once or, at best not more than once every four or five years. We now know that, in addition to copper, it is necessary on most of the peat soils to add manganese and, in isolated instances, crops are benefitted by the use of zinc and boron.

A few years ago crack-stem of celery was a serious trouble in all the important celery producing areas. The trouble did not reoccur each season but, when it did occur, there was little the farmer could do about it. It did not affect yield. The petiole simply developed hair-like cracks which rapidly became brown; in less severely infected fields heavy stripping of the outside leaves allowed part of the crop to be salvaged. Working at Sanford, an Experiment Station worker found that 10 pounds of borax an acre prevented this trouble. The application of boron as borax is now a standard practice with celery growers. Quite often it is added to the spray and applied along with a fungicidal spray.

The remarkable response of crops to minor elements where they are deficient has resulted in the wide use of these materials. It should be noted that most of the areas where results have been secured by the use of the materials, the soils were alkaline or were approaching this condition, the exception being boron. The application of these materials to acid soils is not recommended until definite deficiencies have been determined. To do otherwise is a waste of money and may result in crop injury.

Widespread use is made of copper in watermelon fertilizer but as yet there is only negative evidence in regard to its use.

Proper irrigation and drainage practices result not only in increased yields but also improvement in crop quality. It is generally known that Florida has drainage canals but what is not generally realized is that most vegetables in Florida usually are irrigated. Our pumps are 2-way. During the past several years growers have paid increasing attention to irrigation. The use of overhead irrigation by means of portable slip-joint pipe has allowed for earlier planting of crops in the fall and provides a means of keeping the surface soil moist without saturating the entire soil mass. In areas where irrigation is not used experiments have shown that crop yields may be increased manyfold by its use.

Florida has just as many diseases and pests as any state and new methods are being sought to combat them. These methods include resistant varieties, soil fumigation and the use of the newer organic fungicides and insecticides. Some of these are remarkably effective. Dithane was so effective in controlling potato late blight that now it is necessary in certain seasons to apply defoliants (a polite name for certain weed killers) to get the potatoes ready for shipment.

These improvements in production methods have improved, as a rule, crop quality, and decreased the unit cost of production. We have been discussing crop quality and, while most think of crop quality in terms of appearance and edibility, there are an increasing number of folks who are thinking of crop quality in terms of nutritional quality.

Is the product filled with those minerals and vitamins that people have been informed they will get if they eat vegetables? In Florida a rather comprehensive study has been made to determine whether or not our vegetables are good. Specific crops and varieties of crops were grown at known fertilizer levels in all important production areas. Some interesting facts have been revealed by these studies. Vitamin C content is relatively unaffected by variety, fertilizer level or soil type; it is definitely influenced by certain other environmental factors. In general, vegetables produced in Florida are equal in vitamin and mineral content with those produced in other states. Frankly, however, it is difficult to make accurate comparisons because other states have at best a rather incomplete picture as to the composition of the vegetables they grow. Improvements in production methods may result in higher crop quality at lower unit cost of production. But in Florida it is realized that packing house operations are important, not only in determining unit cost but also as they influence crop quality.

Time and motion studies applied to celery harvesting and packaging operations showed that many of the operations were

not only inefficient but were wasteful and injurious to the crop. These studies were of such nature that they not only showed inefficiency but showed specifically where this inefficiency occurred, so that corrective steps could be taken to correct it. For instance, the number of packages turned out by one packing house was increased approximately 30 percent with but very little increase in labor simply by applying some of the information gained in this study. It probably would be propaganda to say that this study has *revolutionized packing house procedure but, certainly, the results* of this work are carefully considered whenever a new celery packing house is built.

No discussion of packing houses would be complete without mentioning the disposal of waste material that, in Florida, at least, is an ever-present problem. The waste occurring in celery fields and packing houses has been dehydrated on an experimental basis and used as a substitute for alfalfa leaf meal in poultry feed. This feed produced as good results as that containing alfalfa leaf meal when fed to experimental lots of chicks. Additional studies are necessary to determine the economy of the operation before it can be recommended as a sound commercial operation. While this small beginning does not solve the problem of packing house waste, it furnishes sufficient evidence that, by searching, an effective use may be found for much of this material that is now only a costly nuisance.

One other item that probably should be mentioned is the packaging of vegetables. There is no longer any doubt that many vegetables will appear in retail stores in unit packages just as crackers, sugar and coffee do. The question is where will this packaging into consumer-sized units be done? Will it be done at the point of origin or the terminal market? Certainly it should be done where it will afford the best protection to the product and where it can be done most economically. If it can be done at the shipping point there will be effected a saving by the elimination of much waste material that is now being shipped. If it is to be done at the terminal market, the type of package we are now using may need considerable overhauling. Certain Florida growers are even now shipping produce to prepackaging houses located near terminal markets. They have shipped tomatoes in field boxes, corn with the husk removed and cauliflower stripped of all its leaves. Before prepackaging becomes widely used, there are many technical problems that must be solved. Should these problems be solved, prepackaging will influence not only the type of package but production methods as well.

Tomatoes at present are probably more widely sold in consumer packages than any other vegetable. They are virtually all prepackaged at the terminal markets. It would be nice to believe that growers could pick tomatoes showing color and place them in a small package that would deliver ripe tomatoes to the housewife. There are a number of difficult problems that must be solved before this can become an actuality. Conditions may be different in

Texas but, if tomatoes are picked turning-to-pink in Florida, growers can expect to harvest fewer marketable fruits. In a comparison of the total and marketable yield of 21 tomato varieties, picked as green-mature and turning-to-pink, while total yield was not seriously affected by time of picking, the yield of marketable fruit was definitely reduced where they were harvested when the fruit showed color. The marketable tomatoes were ripened in a ripening room and the number of tomatoes that failed to ripen in 15 days at 75°F. are shown. In our tests any tomatoes that failed to ripen in 15 days at this temperature are of exceedingly low quality. They probably are sold at a low price by the prepacker. We are hoping to find some means of sorting out these tomatoes at the packing house.

Tomatoes are mentioned, for there is probably no crop that warrants more attention. The quality of the tomatoes reaching the consumer is poor. I do not except tomatoes shipped from Texas. There is no vegetable in more demand; the potential capacity of the markets is tremendous, providing we can get something there besides the sickly yellow, wrinkled, watery fruits that they are now receiving.

An effort has been made to present a few of the problems that the Florida grower has encountered and what has been done about them. It should be realized that the list of problems is incomplete and many of the solutions inadequate, and to others there is at present no solution. If hard work and intelligent planning can produce the answers, then Florida growers will find the answers to their present and future problems.

ONION BREEDING WORK IN TEXAS

By

BRUCE A. PERRY, *Plant Breeder, Substation No. 19, Winter Haven, Texas*

Breeding work on onions in Texas has as its objectives varietal improvement and disease and insect resistance. The breeding program was considerably expanded in 1940 through a cooperative agreement between the U. S. Department of Agriculture and the Texas Agricultural Experiment Station.

Varieties

Two outstanding varieties of onions have been released through the Texas Station and cooperating stations, (1) Texas Early Grano in cooperation with the California Station and (2) Excel (Yellow Bermuda 986) in cooperation with California and the U. S. Department of Agriculture. An early selection of Texas Early Grano, carried as "502" has more upright foliage, deeper bulbs, and has shown definite superiority in tests with commercial strains.

Excel has been outstanding in extensive commercial tests in the Winter Garden - Laredo district for early maturity and for high percentage of marketable bulbs. Tests conducted in 1945 and 1946 indicate that Excel is 10 days earlier than commercial strains of

Yellow Bermuda and that it will outyield commercial strains by 20 to 25 percent—two factors which are given prime consideration in the adoption of any selection for the Winter Garden - Laredo onion producing area.

Resistance to Disease

Work is in progress on the development of pink root (*Phoma terrestris*) resistant types of the commercial varieties. This work is being done in cooperation with the Wisconsin Station and the U. S. Department of Agriculture. Seedlings are tested for pink root resistance under controlled conditions in the greenhouse by Dr. R. H. Larsen, University of Wisconsin. Onion bulbs surviving the tests in Wisconsin are planted in pink root infested soil at Winter Haven. In the 1946-1947 planting 39 lots were tested, from which 12 lots were selected showing only slight to moderate injury from the pink root disease. In previous plantings Excel has been remarkably tolerant to pink root, and will produce a fair return in conditions where strains of Grano would be a failure.

Resistance to Insects

The breeding work on the resistance of onion to thrips (*Thrips tabaci*) was begun in the fall of 1940. The lines that have been used in this study were supplied by Dr. H. A. Jones, U. S. Department of Agriculture. In 1940-41, 76 different lots of thrips-resisting onions were studied; in 1941-42, 166 lots; in 1942-43, 291 lots; in 1944-45, 36 lots; in 1945-46, 613 lots; in 1946-47, 1586 lots; and this year about 1800 lots are included in our trials. In each of these years seed were sown in September, and plants were selected in November which exhibited characters known to be associated with thrips-resistance, such as glossy foliage and rounded leaves. Bulb selections were then made in April and sent either to Beltsville, Md., for further crossing, or to California for seed production, or to Greeley, Colorado, for vegetative increase and then to California for seed production. Of the earlier selfed-back crosses, TR 31 (1943) looks very promising as a commercial possibility for thrips-resistant Bermuda onion. It is believed that this selection has been developed to the extent that it can be released for commercial planting as soon as seeds can be made available.

Hybrids

The production of hybrid onion lines has shown great promise to growers as a means of obtaining greater yields. Seed of 17 hybrid lots was supplied by the U. S. Department of Agriculture for testing in Texas in 1946-47. These lines were put out in a replicated planting on two different soil types along with the pollen parent, Texas Early Grano, TR 31, and also with Excel. Two or three of these hybrid lines looked very promising this spring at harvest time. However, most of the lines contain the reddish pigment from the original male-sterile line. It will be necessary to do additional inbreeding in order to eliminate this pigment from our male-sterile lines. Also, additional inbreeding will be necessary with the commercial material in order to establish pure lines for the hybrid work. These difficulties should be fairly easy to overcome and it will then be a matter of "trial and error" to establish the best combinations to produce commercial hybrids for the Winter Garden area.

Seed Production

A very satisfactory arrangement has been worked out with the El Paso Valley Station (Substation No. 17, Ysleta, Texas) for onion seed production. Bulb selections are made at Winter Haven in the spring from some of the breeding lines and from Texas Early Grano and Excel. These selections are then put out in September at the Ysleta Station for a seed crop. We have found this a most satisfactory arrangement for maintaining an abundant supply of foundation seed of our newer onion varieties. It is believed that this program will help greatly in maintaining the yield, quality and uniformity of the onion crop.

TOMATO BREEDING IN THE TEXAS WINTER GARDEN

By

BRUCE A. PERRY, *Plant Breeder, Substation No.* 19
Winter Haven, Texas

The tomato is primarily a late fall crop in the Winter Garden district, although there is some early spring production. Our breeding work at Winter Haven has been devoted chiefly to adaptability, including the extension of the fruiting season, and improving the quality and increasing the production. The chief difficulty in growing fall tomatoes in the Winter Garden is the comparatively short season. Under this condition the early maturing varieties have shown up best, but many of these varieties have not been acceptable for shipping as green-wraps.

Since 1931, dozens of strains of varieties have been tested at the Station. A few of the earlier maturing varieties have proved of real value commercially. The late varieties, such as Stone, Greater Baltimore, Globe, Marglobe and U. S. 24, are useless. Last fall (1946) several plantings were made in this area of Improved Pearson strains but these were of such poor quality that several of the local packers refused to buy them. In Station trials Rutgers has yielded better than Marglobe and many farmers grow this variety, but it has never yielded as well as Stokesdale, nor has it excelled it in shape and size of fruits. Yield data are presented in Table 2.

The recent spring variety trials at the Station indicate that Bounty and Red Cloud are well adapted to growing conditions here. These two varieties are very early and have outyielded all other varieties in the past two spring plantings. Yields of spring trials are presented in Tables 1 and 3.

The breeding work with summer fruiting lines since the release of the Summerset variety has been chiefly with crosses of this variety to such larger fruiting varieties as Victor, Bison and Stokesdale. By continuous crossing and backcrossing to these varieties it

is believed possible to greatly increase the size of the fruit of a strain that will set fruit in the summer. Several of our latest selections involving crosses of | (Bison x Summerset) x Stokesdale | x Victor, Stokesdale x (Bison x Summerset), and (Bison x Summerset) x Stokesdale, have produced fruits in August averaging more than three ounces. Individual plant selections are made in July or August on the basis of productivity, size and quality of the fruits.

A similar program is under way to produce more desirable varieties for the fall green-wrap market. Crosses are being made between such varieties as Stokesdale, Red Cloud, Rutgers, Bounty, Victor, Pearson, and some others. Selections are then made from the F_2 and backcross generations. No crosses have been made using Marglobe-like varieties because of the poor yields of these strains in this area. Our future program of tomato breeding will include work toward establishing disease resistance in the more productive varieties for this area. At present our worst tomato disease is believed to be Southern Blight, and so far prospects of developing strains resistant to this disease have not been very encouraging. Other diseases which must be considered in this program are Western Yellow Blight (Curly Top), Tip Blight (Spotted Wilt), and various leaf diseases. Fortunately, we have not been troubled with the common wilt disease in our tomato plantings.

Table 1 Tomato Yield Record, Spring 1946

Variety	Source of Seed	Days to Ripe	Marketable Yield in Pounds Replication 1	2	3	4	Average Plat	Acre
Stokesdale	Stokes	69	59.8	69.6	35.2	68.8	58.35	13238
Louisiana Dixie	Reuter	75	12.1	19.1	17.8	11.0	15.00	3403
Valiant	Stokes	65	41.4	36.0	58.0	40.4	43.95	9970
Wasatch Beauty	Gill Bros.	67	39.5	58.0	40.2	43.9	45.40	10300
Sel. 24-1	Substation 19	69	69.8	73.0	66.8	72.6	70.55	16006
Bounty	Burpee	58	97.5	95.2	115.1	87.0	98.70	22392
Red Cloud	Nebraska Sta.	62	100.8	102.9	129.9	79.3	103.22	23418
Sioux	Nebraska Sta.	67	75.1	105.5	75.1	54.9	77.65	17616
U. S. 24	Veg. Breed. Lab.	77	10.3	9.3	4.5	4.1	7.05	1599

Variety difference of 24.5 pounds per plat significant at 1% level.

Table 2 Tomato Yield Record, Fall 1946

Variety	Source of Seed	Percent Marketable	Marketable Yield Plat	Pounds per Acre	Rank
Garden State	Porter	79	34.7	9447	14
Hybrid 178	Porter	67	23.3	6343	21
Grothen's Globe	Burpee	68	25.9	7051	19
Firesteel	Vaughan	66	35.0	9529	12
Stokes 24-1 Sel.	Substa. 19	59	14.8	4029	28
Early Canner	Landreth	63	17.3	4710	23
19m - 1 Sel.	Substat. 19	74	56.2	15300	4
19m - 3 Sel.	Substat. 19	69	28.1	7650	17
19m - 6 Sel.	Substat. 19	53	46.5	12660	6
Fordhook Hybrid	Burpee	62	36.8	10019	10

Table 2 (Continued) Tomato Yield Record, Fall 1946

Variety	Source of Seed	Percent Marketable	Marketable Yield Plat	Marketable Yield Pounds per Acre	Rank
Burpee Hybrid	Burpee	76	37.4	10182	8
Early Giant	Gurney	70	16.5	4492	26
Earliest of All	Salzer	49	35.4	9638	11
New Mildglobe	Hastings	57	8.2	2232	31
Orange King	Will	28	15.4	4193	27
Red River	Will	50	37.3	10155	9
Pearsons Improved	Lagomarsino	46	10.5	2859	30
Pearl Harbor	Hawaii AES	35	42.9	11680	7
Red Cloud	Nebr. AES	53	53.2	14484	5
Sioux	Nebr. AES	61	32.9	8957	16
Supreme Marglobe	Ferry-Morse	78	11.9	3240	29
Rutgers' Certified	Ferry-Morse	63	33.9	9229	15
Improved Pearson	Ferry-Morse	56	27.9	7596	18
Stokesdale, Certified	Ferry-Morse	81	67.4	18350	1
Master Marglobe	Stokes	74	17.0	4628	24
M - 12	Stokes	82	65.3	17778	2
M - 15	Stokes	70	7.1	1933	32
Stemless Penn-orange	Pa. AES	44	17.0	4628	24
Bounty	Burpee	41	58.7	15981	3
STEP 30 Sel	VBL	51	22.7	6180	22
STEP 32 Sel	VBL	51	24.4	6643	20
Stokesdale	Stokes	67	34.8	9474	13

Table 3 Tomato Yield Record, Spring 1947

Variety	Source of Seed	Days to Ripe	Replication 1	Replication 2	Replication 3	Replication 4	Average Plat	Average Acre
Rutgers	Veg. Breed. Lab.	87	5.7	3.8	3.5	2.4	3.95	1434
Grothens Globe	Veg. Breed. Lab	84	3.2	11.6	6.9	3.3	6.25	2269
U. S. No. 24	Veg. Breed. Lab.	85	4.3	5.7	2.7	5.1	4.45	1615
Pearson	Veg. Breed. Lab.	82	38.3	30.5	32.4	30.0	32.80	11906
*STEP 10	Veg. Breed. Lab.	87	5.9	1.0	1.2	1.1	2.30	835
14	Veg. Breed. Lab	74	33.0	31.4	21.4	10.9	24.18	8777
18	Veg. Breed. Lab.	82	17.2	22.9	14.8	5.8	15.18	5510
22	Veg. Breed. Lab.	82	5.6	2.5	9.6	2.1	4.95	1797
24	Veg. Breed. Lab.	82	5.8	19.5	7.3	4.3	9.23	3350
37	Veg. Breed. Lab.	87	1.1	5.0	3.5	1.4	2.75	998
38	Veg. Breed. Lab.	89	2.7	4.8	4.2	2.8	3.63	1318
Stokesdale, Certif.	Ferry-Morse	72	32.3	19.2	19.0	29.0	24.88	9031
Red Cloud	Nebraska Sta.	70	54.5	46.3	35.2	28.6	41.15	14937
Sel. 24-1	Substa. 19	72	33.7	23.1	28.6	32.6	29.50	10709
Bounty	Burpee	66	62.6	52.2	55.7	26.3	49.20	17860
M - 12	Stokes	68	45.9	50.7	22.6	23.5	35.68	12952
Stokesdale	Stokes	72	37.1	44.7	22.5	30.9	33.80	12269

Variety difference of 12.76 pounds per plat significant at 1% level.

* Lines received from The U. S. Vegetable Breeding Laboratory, Charleston, S. C., as part of the Southern Tomato Exchange Program .

SPINACH AND CANTALOUPE BREEDING IN THE WINTER GARDEN AREA

By
E. MORTENSEN

Cantaloupes have been grown in the Texas Winter Garden area for several years, but there are many hazards in growing most commercial varieties. Mildews, both downy and powdery, and melon aphis are ever-present threats to the cantaloupe crop. Hence, the commercial acreage has been on a comparatively small scale.

The qualities necessary for commercial acceptance in a cantaloupe variety are given by Whitaker and Davis (1946) as follows: round to slightly oval, well netted, free of deep sutures or ribs; size, 45 to a standard crate; flesh firm, well colored, non fibrous, slightly aromatic, high sugar; a strong healthy vine. This is a big order, when the plant breeder has to use parent material that is far from this ideal.

Control of mildew with chemicals has never been very satisfactory. Breeding resistant varieties has offered the best possibilities of control. No resistant material was known to us 15 years ago but the Georgia variety had been found resistant to sulfur burn, and sulfur was considered to be a good control for mildew. The Georgia is a variety of poor quality horticulturally and completely unsuited for shipping.

Cantaloupe breeding began in 1933 at Winter Haven, when L. R. Hawthorn crossed the Georgia variety with Hale's Best, Honey Rock, Burrell's Gem and Superfecto. The first generation of these crosses were dusted with sulfur in the fall and only the cross with Hale's Best was found to be resistant to sulfur injury.

Selections were made in 1934 with controlled pollination from Hale's Best x Georgia. These were found to be still resistant to sulfur burn in the fall. Tests in 1935 showed one selection to have no sulfur damage, but the third generation selections, as well as the original Georgia parent, burned when dusted with sulfur on May 26, 1936. Selfing with cages was done in 1937 and further dustings with sulfur showed that burning was not consistent.

A variety named Rocky Dew was obtained from a Florida seed house in 1936. It was found to be resistant to downy mildew but susceptible to powdery mildew. A test with the newly released Powdery Mildew Resistant No. 45 (Jagger and Scott, 1937) at the same time showed it to be susceptible to downy mildew but resistant to powdery mildew. This finding indicated possibilities of getting direct resistance to both diseases, and the sulfur-resistant feature became less interesting and was discontinued by Mr. Hawthorn after the 1937 season.

In 1939, Dr. S. S. Ivanoff, plant pathologist at the Winter Haven substation, took over the cantaloupe breeding program. A collection of inbreds from the U. S. D. A. and the Florida Experiment Station were used in crossing with No. 45 and Seed Breeders. In the fall, aphis resistance was found in the variety Cuban Castillian and in some of the Florida inbreds of Rocky Dew. Smiths Perfect was found to be resistant to both aphis and downy mildew. Selection from a cross of Rocky Dew with Seed Breeders resulted in a variety of the Hale's Best type being released in 1945 (Ivanoff, 1945). This variety shows strong resistance to downy mildew and aphis but susceptibility to powdery mildew. This is now in commercial production under the name of Texas Resistant No. 1.

Further crosses involving Texas Resistant No. 1 were made in 1945 by Ivanoff, and again in 1946 by T. J. Nugent using Powdery Mildew Resistant No. 5 and Smith's Perfect. This was done to try to get resistance to both mildews and still retain aphis resistance.

Further objectives are to get better carrying qualities into Texas Resistant No. 1. At the present time, the Texas Resistant No. 1 fills the so-called ideal requirements with the exception of firmness of flesh and carrying quality.

One selection from crosses of Smith's Perfect, Powdery Mildew Resistant No. 5 and Texas Resistant No. 1 now has fruits with excellent keeping quality, firm flesh, small cavity, good netting, but is oblate in shape. Further tests will be necessary to determine market acceptence and resistence to diseases and aphis on various soil types.

Spinach Breeding

Spinach is one of the leading winter crops in South Texas. The necessity for a spinach breeding program became evident in the Winter Garden area in the 1935-36 season when we suffered a severe outbreak of curly top, a virus disease transmitted by leaf hoppers (Jones, 1936). At the following session of the State Legislature an appropriation was obtained for a plant pathologist with the main purpose of trying to breed a disease-resistant spinach variety.

This project was begun by L. R. Hawthorn and S. E. Jones in the winter of 1935-36, and was taken over by S. S. Ivanoff in the 1937-38 season. T. J. Nugent conducted these investigations in 1946.

This project has run into a number of difficulties and progress has been very slow. In the first place, curly top has been rare since the season of 1935-36. The appearance of white rust in severe form in 1938-39 caused a change of objective (Ivanoff, 1939). The white rust disease, caused by *Albugo occidentalis*, is relatively new and no control measures have been developed.

Another obstacle is the short spring season for seed production. The length of day is not favorable for flowering until April and in most years hot weather sets in very soon afterwards.

The spinach plant is difficult to work with. It normally produces male and female flowers on separate plants (Rosa, 1925),

and very few perfect (monoecious) flowering plants are found. Hence, it is difficult to maintain resistance in selections after they are made since selfing of the plants is not possible except with rare monoecious plants.

Two approaches have been made to this problem. At first, selections were made in commercial fields. Plants were dug with a ball of earth and moved to a central point for seed production. This was not successful because too short a time was available before hot weather set in after the shock of transplanting had been overcome.

The Spinach Growers Association in 1945 financed a special plot on the Ritchie farm near Crystal City where the selections could remain in place and have a better chance of producing seed. Two crops have been grown under this arrangement.

An extremely heavy infestation of white rust occurred in the 1945-46 season, and selections were mostly in the Viroflay variety which has shown more resistance to white rust than the Savoy types. In the spring, after selections had been isolated by cutting out all undesired plants, the beet leafhoppers appeared and infected the selections with curly top which eliminated most of them before viable seed could be obtained.

Unusually cool weather, which is favorable to spinach seed production, prevailed in the 1946-47 season. White rust was not so severe, and a good opportunity was afforded for selecting monoecious plants. A total of 44 monoecious selections were made in the Old Dominion and Bloomsdale types. In addition, dioecious seed was saved from the stronger, healthy plants. This seed had good viability.

Increasing the seed of the selections presents additional difficulties. Seed production in the United States is mostly restricted to extreme Northwestern Washington. It is hoped that some suitable area in the Rocky Mountains may be found where seed could be increased in the summer, thus doubling our efficiency. So far, we do not have definite information on this.

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CANTALOUPE BREEDING FOR DOWNY MILDEW RESISTANCE IN LOWER RIO GRANDE VALLEY

By

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You have all heard the saying about a sudden outbreak of plant disease that "it is caused by the weather." Well, the common cantaloupe leaf-blighting disease, correctly called "downy mildew," is one to which that saying might have been applied; for it is one that occurs at its worst in a wet growing season. Of course, it is not really caused by, but only favored by, the wet season. The true cause is the fungus which grows as a parasitic mildew on the leaves, causes dying in spots then killing of the entire leaf; and eventually, in severe cases, the entire plant is killed during the growing season. In the past, this disease has been the chief limiting factor in cantaloupe production in the Lower Rio Grande Valley.

There are, then, these two conditions that must be present for the disease to occur: (1) the causal organism, and (2) an environment favorable to the disease. There is also a third—the susceptible host plant. If we could control any one of these three conditions favorably, the disease could be eliminated. We shall have to pass up the first two as being virtually unattainable. The causal fungus appears to be with us every year. We cannot control the weather, at least not favorably. That leaves us with the factor of the susceptibility of cantaloupe varieties as a basis upon which to work in looking toward practical control; and it is this phase of the problem with which this paper deals.

Some years ago my attention was called to the fact that a little wild melon, called locally "smell melon," found growing in various out-of-the-way places in the Valley, had been found to be green and alive around the edges of cantaloupe fields that were pretty well shot with disease. Possibly this would prove to be the source of mildew resistance to breed into the cultivated cantaloupe. Investigation showed that, botanically speaking, the wild melon was indeed of the same species as the cultivated varieties. It looked a far cry from the cantaloupe, however, as the fruits were very small (rarely more than 2 inches in diameter); were smooth skinned, had solid flesh like a cucumber, and certainly did not have any of the taste or smell characteristics of a cantaloupe. The character of disease resistance appeared to be the only feature of it that we would want.

Just as a venture, the cross was attempted by using pollen from Hales Best cantaloupe on a female flower of the wild melon. It was an exciting and gratifying moment when it was discovered that the cross was successful, and a young fruit was developing. While the fruit looked precisely like all the others on the vine, it was known that the seed in them contained half cantaloupe heritage. Those tiny seed, less than ¼ the size of those of the cantaloupe, when planted the next season, produced vigorous vines that were

almost entirely free from mildew when commercial varieties planted alongside were badly diseased. But the fruits that developed were a wonder to see! Intermediate in size, it looked precisely like a miniature watermelon, smooth skinned, and green striped. It turned orange color when ripe. Knowing that, in the language of genetics, resistance was more or less dominant, and that nettedness was recessive and could be expected to appear in the next generation, was more or less a guide to subsequent procedures.

The F_1 generation was back-crossed to cantaloupe in order to hasten the acquisition of cantaloupe characters, even though it was known that this would retard getting pure resistance. The next generation, then, would be ¾ cantaloupe and ¼ smell melon. That next generation was truly exciting. There was, as expected, a segregation into all types and combinations between smell melon and cantaloupe. In so far as possible in the limited time available, every plant had to have one or more flowers self pollinated in order to initiate pure lines and this had to be done, of course, before there was any indication of fruit type. When fruits matured, 90 percent or more of them had to be eliminated and discarded, as being completely off-type. Fruits and seeds were saved only from plants that showed good resistance to mildew, and when the fruits themselves were of good horticultural type, at least approaching that of a good commercial melon.

To make a long story short, this procedure of elimination and selection was continued through several years, two generations a year, spring and fall crops. Always, in order to be fairly certain that the selections for resistance were fairly reliable, Hales Best was planted. In several seasons Hales would pass out completely from mildew, without maturing a fruit, when selected strains of the cross were thriving. So I knew I was on the right track. I shall never forget how painful it was at times to make discards. One season, two sister strains were growing side by side, B-16 and B-17. B-16 had a beautiful form and net—almost the ideal. But for some reason, probably related to the fact that its parent, while showing resistance, was still hybrid for that character, this particular strain showed susceptibility to a marked degree, and had to be discarded. B-17, on the other hand, seemed to be the one in four that inherited pure resistance. It was saved, and its offspring through several generations has continued to be resistant. It showed poorer net than the other, and a tendency to be flat rather than slightly elongate; but it was wonderfully sweet and flavorful. Most of the objectionable features have been eliminated by careful selection through several generations.

We now have this selection in apparently pure form, as the last planting showed very high uniformity. It was one of the best, this critical fall season, for resistance to both mildew and aphids, was uniformly good in size and form, well netted, shallowly ribbed, with deep flesh and relatively small seed cavity, with a pretty, bright orange flesh with a contrasting narrow green border, and consistently good sweetness and flavor.

Before it is released for commercial planting, the seed, of course, must be increased. Even before that, however, it must be put out for field trial in various melon sections of this and other states. If it proves, under field conditions, to be as good as it appears to be in the small plot tests, the seed will be increased as quickly as possible for commercial plantings.

This would appear to be a good place to stop were it not for the fact that the job is not yet over. There is always room for improvement in developing a new variety of any crop. In the case of the Valley-bred cantaloupe it would be a serious error not to continue. I have other relatively pure lines with high disease resistance and certain other characters that are simply too good to drop. One, for example, with the desired net, form, and size, has extra deep flesh, bright orange flesh color to the very rind, and a very small stem scar. This last feature reduces the chances for stem-end decay, which is a hazard in shipping. Its chief drawback is that it ripens to the full-slip stage while still green on the vine, which makes for difficulty in harvesting at just the right stage. It colors well in a few days after picking. A cross between this and the one previously described, if followed by careful selection, might very well result in one combining the best characters of both.

Still another line will be preserved, with entirely different ancestry. The source of mildew resistance in this case was a melon from India, a large smooth skinned, deep fleshed, tasteless fruit. Out of this cross has come a beautiful heavily netted, ribless fruit with good flesh characters. It has shown only slight variation in the last two generations. If the planting next spring of "selfs" from the fall crop show up well, I suspect that you will hear more about this strain in the future.

None of these new strains, or I might call them varieties, has yet been named. All of them are still designated by number. But every one of them can be traced back, generation by generation, to the original crosses, as described.

FIELD DAY EXHIBITS

The third and last day of the Citrus and Vegetable Institute was devoted to a field day in which 310 visitors were divided into five groups with from one to three guides to the group. Exhibits were shown at Panchita Ranch, Rio Farms, Engelman Products Company, Experiment Station and Hoblitzelle Ranch. At noon a barbecue dinner was served at Rio Farms headquarters building.

Exhibit No. 1 Drainage, vegetable varieties and new machines. Panehita Ranch. D. J. McAlexander, Agronomist and Farm Manager for F. H. Vahlsing, Inc., and E. B. Dubuisson, Port Fertilizer Company, Elsa, showed (1) shallow drainage and tile laying equipment; (2) vegetable varieties; (3) insect and disease control methods; (4) land plane for leveling surface for irrigation; (5) Seaman Roto-

Tiller, a machine used to pulverize the soil to a depth determined by the setting of the machine.

Exhibit No. 2. Citrus Gummosis and Scaly Bark. Rio Farms.

Plant Pathologist of the Valley Experiment Station, Dr. G. H. Godfrey, with the assistance of county agents Charles F. Beasley, Frank C. Brunnemann and J. A. Oswalt, showed early, intermediate, and late stages of these serious diseases. The distinguishing features of the two in the very early stages, particularly, were pointed out. Prepared cavities in the wood beneath the bark symptoms were shown to indicate characteristic differences in internal wood symptoms. The extent of these diseases were shown in 16 year old grapefruit orchards.

Exhibit No. 3. Soil and Soil Water Problems in Citrus Orchards. Engelman Products Company, Elsa.

W. H. Hughes and Robert T. Corns showed (1) dead tree caused by high water, sloughing of root system, extent of dead roots, comparison of healthy trees with those affected by high water table; (2) high pressure sprinkler irrigation system; (3) relift drainage pump; (4) airplane dusting of citrus orchards; (5) root distribution of healthy trees.

Exhibit No. 4. Experiment Station.

Dr. W. C. Cooper, U.S.D.A., and W. H. Friend, Superintendent, Experiment Station, exhibited and explained (1) citrus varieties; (2) root stock experiments; (3) citrus breeding work and (4) citrus fertilizer experiments.

Exhibit No. 5. Sub-Tropical Fruits. Hoblitzelle Ranch.

Dr. R. F. Cintron, horticulturist, and Morris Allen exhibited papaya seed bed, nursery, field plantings and methods of winter protection. Visitors were shown avocado nursery, methods of grafting, field plantings, winter protection and varieties. Also a citrus orchard planted on contour was shown.

ACKNOWLEDGEMENT

The officers of the Rio Grande Horticultural Club gratefully acknowledge the contributions of the following organizations and individuals toward the success of the Rio Grande Valley Citrus and Vegetable Institute of 1947:

To staff members of A. and M. College of Texas, who took a major part in participating in all phases of the Institute.

To Rio Farms, F. H. Vahlsing, Inc., Hoblitzelle Ranch, and Engelman Products Company whose personnel and facilities made "Field Day" a valuable part of the Institute.

To the city of Weslaco and its School System for making available rooms for the meetings.

Particularly to the Citrus Advisory Council, Rio Farms, and Mr. Carl Hoblitzelle (recently elected to Honorary Membership in the Rio Grande Horticultural Club), for underwriting the expense of out-of-state guest speakers.

To the Committee chairmen and committee members of the Rio Grande Horticultural Club (listed below) who gave liberally of their time and effort.

Rio Grande Horticultural Club
William H. Hughes, Elsa, President
E. W. Linnard, McAllen, Vice President
J. B. Corns, Weslaco, Secretary-Treasurer

Committees for Rio Grands Horticultural Institute
November 18-20, 1947

PROGRAM

J. B. Corns, Chairman, Weslaco	Ray Goodwin
Morris Allen	Paul Heller
W. C. Cooper	D. J. McAlexander
Stanley Crockett	George P. Wene

PROCEEDINGS

G. H. Godfrey, Chairman, Weslaco	R. F. Lindsey
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Ben Chambers, Chairman, Harlingen	J. S. Sanders
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SESSION CHAIRMEN

General sessions, first day, Nov. 18.

Morning session. W. H. Hughes, president Rio Grande Horticultural Club, Elsa, Texas.

Afternoon session. Dr. J. B. Corns, Weslaco, Texas.

Evening session. Carl Hoblitzelle, Hoblitzelle Ranch, Mercedes, Texas.

Citrus sessions, second day, Nov. 19.

Morning session. A. L. Ryall, U. S. D. A., Harlingen, Texas.

Afternoon session. Alden M. Drury, Manager Rio Grande Valley Citrus Exchange, Weslaco, Texas.

Evening session. Ray Goodwin, E. M. Goodwin, Inc., Mission, Texas.

Vegetable sessions, second day, Nov. 19.

Morning session. D. J. McAlexander, F. H. Vahlsing, Inc., Elsa, Texas.

Afternoon session. C. A. Ripley, Grower and Shipper, Mercedes, Texas.

Field day, third day, Nov. 20.

J. A. Oswalt, County Agricultural Agent, Edinburg, Texas.