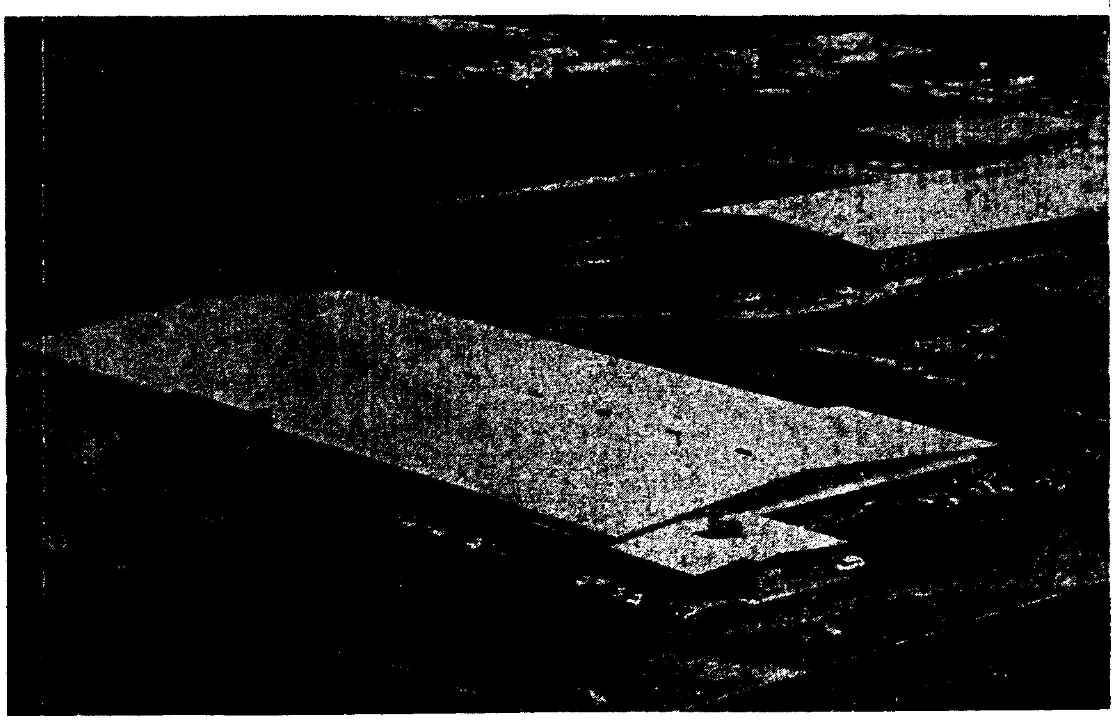
JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 23, 1969



COVER: New fresh citrus growers cooperative marketing facility constructed by Edinburg Citrus Association in 1968-69 to accommodate a portion of Texas' increasing production in the Rio Grande Valley.

JOURNAL
OF THE
RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 23, 1969

Published by
RIO GRANDE VALLEY HORTICULTURAL SOCIETY
P. O. Box 107, Weslaco, Texas

DEDICATED TO:

Edward O. Olson for his dedication to Horticulture in the Rio Grande Valley from 1951-65 and whose insistance on perfection made this Journal well known and highly respected in the Horticultural world. Accuracy and perfection described him best, and Ed Olson left these indelible impressions in his wake.

EDWARD OLSON MEMORIAL ISSUE

Edward Olson 1919-1969

Edward Orlando Olson was born on February 17, 1919, in Brookings, South Dakota. Ed was a typical Dakota Norwegian: lean, sparse, tow-haired, long-striding. In order to make sure that the family Norwegian heritage was not overlooked, Ed used to like to rattle off a little Norwegian verse to liven up most any situation.

His mother and brother, Gordon, outlived him and were present at his funeral at Indio, California. Ed was graduated from Brookings High School in 1936. He attended the South Dakota State College and received his B.S. degree in Horticulture in 1940. During his college years at South Dakota State, he worked several summers on fruit breeding projects to combine cold hardiness with improved fruit quality in many different fruits for the Dakotas.

In 1941, Ed worked a while for a seed company in Cleveland, Ohio and then traveled west to Washington State College, Pullman, Washington. He left in December 1941, after an attack of rheumatic fever which weakened his heart. On recovery, he took graduate work in Horticulture and Botany at Colorado State College. He received his M.S. degree in 1944, and got a job as Assistant Horticulturist and Assistant County Agent in the Black Hills of South Dakota. Later, he worked for Jos. E. Seagram and Sons, Inc., Louisville, Kentucky, between December 1945 and 1949. During this period he also attended LSU at Baton Rouge, Louisiana, but drew wages from Seagram's. In 1946, he married Effie Peck from Cleveland, Ohio. At Seagram's he went through a training program that involved shift work on fermenters, stills, and control laboratory. After receiving his Ph.D. in Plant Pathology at LSU in 1948, he returned to Louisville and spent almost a year in their fermentation research laboratory.

On November 1, 1949, Olson joined the USDA Citrus Investigations Unit in the Rio Grande Valley at what was then known as Substation No. 15 of the Texas Agricultural Experiment Station. Ed worked as plant pathologist on a citrus rootstock project with me for 10 years. His other associates during this period included Bert Gorton and Ascension Peynado. This small group of four scientists worked as a team on diseases, salt tolerance, and cold hardiness of citrus roostocks. I had very close contact with Ed and found him to be a warm, steady, reliable friend, whose scientific advice was invaluable to me and for whose opinions in all fields of human interest I greatly respected. Ed developed many close friends in the Texas citrus industry during this period: among these are Norman Maxwell, Dr. Bailey Sleeth, Dr. R. H. Cintron, Art Shull, and Everett Ballard. In 1959, Ed was assigned duties as head of the USDA Citrus Investigations at Weslaco, Texas, and he served in that capacity until 1966. While at Weslaco, Olson's accomplishments include:

1. Studies that showed Rio Grande Gummosis disease could be duplicated by fungus invasion.
2. Demonstration that many selections of local Texas citrus varieties and out-of-state introductions carried latent viruses. This in turn led to a greater research emphasis on virus-free materials and extensive studies on tristeza, psorosis, exocortis, and xyloporosis. Nineteen selections were released in cooperation with the Texas Agricultural Experiment Station.
3. Cooperation with others to establish new rootstock trials to attain the original objectives of determining which rootstocks were adaptable to local soils, climate, and other hazards.
4. Introduction of seed of many citrus species, varieties, and hybrids. He introduced budwood of more than 300 nucellars and hybrids from Florida and California, and tested them for viruses.

Dr. Olson was appointed a member of the graduate faculty of the A&M College of Texas in 1959, and served in that capacity for seven years. He was a member of an ad hoc committee on citrus nomenclature, American Society for Horticultural Science from 1962 to 1967. He served as Associate Editor, Phytopathology from 1955 to 1958; was a member of Sigma Xi honorary scholastic fraternity. He attended the 1st International Organization of Citrus Virologists (IOCV) meeting at Riverside, California in 1957, the 2nd IOCV meeting at Orlando, Florida in 1960, the 3rd IOCV meeting at Sao Paulo, Brazil in 1963, the 4th IOCV meeting at Rome, Italy in 1966, and was preparing to attend the 5th meeting in Japan at the time of his death. He served as Secretary-Treasurer of the organization from 1957 until his death, and was Chairman of the Committee on Indexing Procedures in 1960.

Ed's hobbies in Weslaco were sailing, scouting, camping, and reading. He was Mate of Ship 54 of the Sea Scouts, Weslaco; and was a bosom pal of Dr. Bill Kitchell, veteran sailboat enthusiast at Weslaco. Olson actively participated in civic affairs; served as President of Weslaco Lion's Club 1955; President of Weslaco United Fund 1963; Head of Heart Fund Drive for Weslaco in 1964; and served on the executive board of the Rio Grande Valley Council of Boy Scouts for several years. Ed taught Lutheran Sunday School; sponsored youth programs in the

Church, and served as president for three years. Dr. Olson had three children: Orrin, Kristen, and Lore. Orrin served two years in the U.S. Marines in Vietnam.

In 1966, Dr. Olson was approached by Dr. L. C. Cochran, Chief of the Fruit and Nut Crops Research Branch, at Beltsville, Maryland, with a proposal that he join an expanded citrus virus disease research unit at the U. S. Date and Citrus Station, Indio, California. Ed moved to Indio in June 1966, and immediately plunged into a whole new career of research on the citrus virus disease called "Stubborn." In collaboration with Dr. John Carpenter, USDA, Indio, and Dr. Clair Calavan, University of California at Riverside, he carried out experiments that verified experimentally the leaf and fruit symptoms associated with Stubborn. In the midst of these experiments on Stubborn disease, Ed Olson suffered a heart failure. He died on June 18, 1969.

Ed Olson sought perfection in his work, be it experimentation on citrus virus diseases, editing the Journal of the Rio Grande Valley Horticultural Society, sailing a boat, superintending the Lutheran Church, or attending an IOCV meeting. To me, the loss of Ed Olson means the loss of a friend. The feelings of his numerous friends, especially in the Rio Grande Valley, are well expressed in a letter from his Texas friend, Dr. R. H. Cintron, who wrote: "Ed is not a man whom you can ever forget." Everyone who has come in contact with Ed Olson's Journal of the Rio Grande Valley Horticultural Society must have been inspired by him to some degree. It is a kind of immortality in the memories of those of us who read and think highly of this Journal.

— William C. Cooper

Aims and Objectives of the Society

The purpose of the Rio Grande Valley Horticultural Society is the advancement and development of horticulture in the Lower Rio Grande Valley. It is the aim of the Society to stimulate interest in research and its practical application to Valley problems with fruit, vegetables and ornamentals.

At monthly meetings subjects of interest are presented by specialists in their fields. These presentations are followed by open forums. The Newsletter announces and discusses the monthly programs and brings other news of interest to Society members.

The Society has sponsored 22 annual Institutes, where outstanding speakers from all parts of the country present new developments in the field of horticulture. Panel discussions, social get-togethers and a barbeque round up the all-day program.

Talks given at the Institute and reports of Valley research are published in the Journal of the Society, which provides a continuing record of horticultural progress in the Valley.

Anyone interested in horticulture can become a member of the Society. The annual fee is $4.00, which includes the Journal. Applications for membership, and annual dues should be sent to the Secretary-Treasurer, Rio Grande Valley Horticultural Society, Box 107, Weslaco, Texas.

Officers of the Rio Grande Valley Horticultural Society 1969

TOM LONGBRAKE
President

PRESIDENT:
Tom Longbrake

VICE PRESIDENTS:

Citrus	Dr. Calvin Lyons
Vegetables	Connor Davis
Ornamentals	Milton Cash
Special Fruits	Dr. José Amador

SECRETARY:
Norman Maxwell

TREASURER:
Dr. John Fucik

NEWSLETTER EDITOR:
Bailey Sleeth

DIRECTORS

Citrus	Howard Kappler
Vegetables	Dwayne Bair
Ornamentals	Mrs. Glenn White
Special Fruits	A. H. "Dutch" Karcher
At Large	Jim Kimbrel
At Large	Douglas Earley

INSTITUTE PROGRAM COMMITTEE

Dr. Bailey Sleeth, Chairman
Mr. Bruce Lime Mr. Norman Flitters Mr. Glenn White

Editor: Tom Longbrake
Ass't Editors: Heinz Wutscher, Rex Reinking, Harold Brown

ARTHUR V. SHULL
Recipient of the Arthur T. Potts Award 1969

The Arthur T. Potts award is presented to one person each year by the Rio Grande Valley Horticultural Society in recognition for outstanding work in horticulture. The award was named for its first recipient, Arthur T. Potts. Past recipients of this award are Dr. Wilson Pompenoe, E. M. Goodwin, Dr. J. B. Webb, Dr. G. H. Godfrey, Dr. W. C. Cooper, Lon C. Hill, W. H. "Bill" Friend, Paul W. Leeper, Stanley B. Crockett, Harry Foehner, Sam D. Tayloe, O. F. Marrs and Dr. P. W. Rohrbaugh.

This year's recipient is Mr. Arthur V. Shull.

Mr. Shull has achieved the respect of the horticultural industry in the Valley. His cooperation with others in research and his own work in developing new ideas and sharing his results and information with others has benefitted all Valley fruit growers.

Among Mr. Shull's accomplishments has been the gathering of information on the costs of citrus production. His findings on citrus production costs in this area are based on records he has kept at Rio Farms for a period of many years.

One of his tasks has been to coordinate the cooperative research between state and federal agencies and Rio Farms. In this connection he has shared in research on rootstocks, breeding work and other problems. The rootstock studies involved cold hardiness, salt tolerance, variety testing, and work with nucellar citrus.

Mr. Shull demonstrated the economic desirability of closer tree spacings in citrus orchards. He contributed to the present trend of planting 100 or more trees per acre. He also pioneered work in cultural practices. He has done research with irrigation and other cultural practices for citrus including chemical weed control. Through the years he has helped in developing new oilseed crops and special fruits.

Mr. Shull has always worked toward a practical application of research information. He has been a behind-the-scene helper to many citrus researchers. While this help has been invaluable, it has not always been recognized.

Art Shull was born in Neosho, Missouri June 5, 1910, and attended the Donna schools for one year after his parents moved to the Valley. He returned to Missouri to graduate with friends and former classmates. He rejoined his parents, Mr. and Mrs. J. E. Shull, who are still living at Progreso where his mother was postmistress for a number of years. Upon his return he went to work for the Progreso Development Company at Progreso and later was transferred to an associated company, Progreso Haciendas. He left his position as manager of this company to join the staff at Rio Farms in May, 1943, becoming citrus manager there.

He was a member of the Beta (Texas) Chapter of the Society of Sub-tropical Horticulturists, director of the Texas Avocado Society, member of the California Avocado Society, charter and continuing member of the Lower Rio Grande Valley Horticultural society which he served as director and vice president for citrus on several occasions.

He was a member of the planning committee which organized Texas Citrus Mutual and is a continuing member of the board of directors, currently serving as vice president representing Hidalgo County. He also is a member of Mutual's executive committee.

He also has been a member of the Hidalgo County Program Building Committee and currently is a member of the citrus subcommittee of the Agricultural Advisory Committee of the Lower Rio Grande Valley Research and Extension Center. He represents Rio Farms in the Texas Citrus Nurserymen's Association.

Mr. Shull also has been active in civic as well as industry circles. He was president of the school board at Monte Alto and was a member of the Lions Club for years.

He is married to the former Roberta Marrs. The Shulls have a family of seven children.

Table of Contents

Table of Contents

Program of the Twenty-third Annual Institute of the Society

January 21, 1969

MORNING PROGRAM

Dr. George R. Schulz, Chairman

Address of Welcome .... Dr. R. A. Hensz, President
Rio Grande Valley Horticultural Society

Cultural Revolution in
the Citrus Orchard .... Dr. R. F. Leyden, Soil Scientist
exas A&I U. Citrus Center, Weslaco

Investigation of Acute Pesticide Poisoning –
Rio Grande Valley, 1968 .... Mr. R. J. Steeno
Environmental Health Specialist
Texas Dept. of Health Community
Pesticide Study Lab., San Benito

New Food from Old Sources .... Dr. E. E. Burns, Assoc. Professor
Texas A&M, Food Technology

Increasing Farm Income
through Marketing .... Dr. Chan Connolly, Assoc. Professor
Texas A&M U., Res. and Exten. Center, Weslaco

Agricultural Research .... Dr. T. W. Edminister
Deputy Administrator
Office of Administrator, USDA, ARS, Washington, D.C.

Presentation
of the Arthur T. Potts Award .... Dr. R. A. Hensz, President
Rio Grande Valley Hortciultural Society

AFTERNOON PROGRAM

Dr. R. H. Cintron, Chairman

Sweet Sorghum: A Promising New Crop in
South Texas – Yield Potentials and
Cultural Practices .... Mr. W. R. Cowley
Superintendent of Research
Texas A&M U. Res. and Exten. Center, Weslaco

Sweet Sorghum: Sugar Processing .... Mr. B. A. Smith
Research Chemist
USDA, CRS, Fruit & Veg. Proc. Lab., Weslaco

Control of Coloring and Abscission in
Citrus by Speeding up the Natural
Production of Ethylene .... Dr. W. C. Cooper, Leader
USDA, CRS, CRD Citrus Research Investigations
Orlando, Florida

Breeding and Selecting Better Vegetable
Varieties for the Valley .... Mr. Paul Leeper
Horticulturist
Texas A&M U. Res. and Exten. Center, Weslaco

Some Direct and Indirect Effects
of Pesticide Resistance .... Mr. William G. Hart,
Entomologist
USDA, ARS Entomology Res. Div., Weslaco

EVENING PROGRAM

Mr. Glenn White, Chairman

The City's Parks and
Beautification .... Mr. Cecil E. Massey
City Manager, City of Weslaco

How to Use Ornamentals to
Make the Home Attractive .... Mr. Morris Clint, Jr.
Nurseryman – Brownsville

ADDRESS OF WELCOME

23rd Annual Horticultural Society Institute

DR. RICHARD A. HENSZ
President
Rio Grande Valley Horticultural Society

It gives me great pleasure to open this 23rd annual Rio Grande Valley Horticultural Society Institute and to welcome each of you to this full day of Horticulture. Whether your interests are in fruits, vegetables, or ornamentals you will hear much of interest as our speakers share their knowledge and experience with you today.

This Horticultural Society has been active throughout the past year. As most of you know monthly meetings have presented us with opportunities to hear fine speakers discuss many timely horticultural subjects. I want to again thank those speakers, and the officers and directors who arranged the programs, for making all of our evening meetings so successful this year.

However, it is this annual Institute that is the highlight of the year for the Society. Each speaker on today's program is an expert in his field. They have spent much time preparing their presentations and I know what they have to say will be well worth the time you have taken to be here. Take this opportunity to visit with them during the refreshment breaks. Let me remind you that our evening program will be of particular interest to the ladies, so, if you have not brought your wife with you this morning remember you will not want her to miss this evening's program.

The ornamental nurserymen have an excellent exhibit of plants across the street in the dining hall. During the coffee break you will want to inspect the displays and perhaps get some ideas for landscaping your own yard or business. We appreciate these special efforts by our nurserymen.

Let me remind you too that it is very easy to become a member of the Society. Membership dues are $4.00 annually. This also entitles you to receive a copy of the journal of the Society which is a compilation of recent horticultural research pertinant to the Lower Rio Grande Valley. During the day the girls at the registration desk will be glad to take your membership dues.

Our special thanks goes to the men on the Institute Program Committee who planned, arranged, and worked so hard in preparation for this meeting today. Also our appreciation goes to the many others who have contributed in many ways to make this 23rd Annual Institute a success.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY MEMBERSHIP, 1969

SPECIAL PATRONS

Rio Grande Valley Gas Co. — Dennison's — Walter Baxter Seed Co.

ANNUAL PATRONS

Bentsen Development Co.
La Casita Farms, Inc.
Griffin & Brand of McAllen, Inc.
Hoblitzelle's Ranch-O-Hills
Olin Mathieson Chem. Corp.
Rio Farms, Inc.

ANNUAL SUSTAINING

The Ansul Company
Asgrow Seed Company
Central Power & Light Company
First National Bank, Mission
First National Bank, Weslaco
FMC Corp. (Niagara Chem. Div.)
FMC Corporation
Gulf Distributing Company, Inc.
Jimmy Hill (Ford), Inc.
Knapp-Sherrill Canning Co.
Magic-Valley Electric Co-Op.
McAllen State Bank
Mission-Harlingen Canning Co.
Mobil Oil Corporation
Stauffer Chemical Co.
Taormina Company
Tex-Ag Chemicals, Inc.
Texsun Corporation
Tide Products, Inc.
Vahlsing, Inc.
Valley Production Credit Assn.
Valley Transit Company, Inc.

MEMBERSHIP LIST

S. T. Aderhold
Rt. 1, Box 363, Edinburg 78539
Roger Albach
Box 188, Weslaco 78596
George Alcorn
Box 23, Orange Springs, Fla. 32682
Gerald H. Allen
Rt. 1, Box 36, Los Fresnos 78566
Jose Amador
Drawer 1104, Weslaco 78596
Bruce Anderson
600 SW Tower, Houston 77002
W. W. Anderson
Box 24, Weslaco 78596
Stanley Andrews
Rt. 1, Box 52AA, Alamo 78516
E. B. Ault
Rt. 2, Box 32, Weslaco 78596
W. V. Ausmus
608 Esperanza, McAllen 78501
Walter J. Bach
Box 194, Weslaco 78596
Jack C. Bailey
113 Plantation Dr., Leland, Miss.
Leo L. Bailey
431 W. King, Kingsville
Earl Baney
Box 22, Linn
Bill Bates
420 Ebony Lane, Edinburg
C. R. Breckenridge
Rt. 1, Box 305, Donna 78537

Ellis G. Bovik
Box 598, Weslaco 78596
Carl Boyd
Box 842, Elsa 78543
Harold E. Brown
715 S. Ohio, Weslaco 78596
Ralph T. Brown
Rt. 1, Box 437,
Port Sulphur, La. 70083
Roy G. Bru
1216 Kerria, McAllen 78501
L. O. Buchanan
½ Mi. S. Palm Drive, Harlingen
Glen A. Boulton
Rt. 2, Box 33A, Mission 78572
H. C. Card
Rt. 2, Box 250, Weslaco 78596
Milton Cash
318 N. Closner, Edinburg 78539
J. B. Chambers, Jr.
Box 1733, Harlingen 78550
Wm. B. Chapman
2303 Woodwind Way
League City, Texas 77573
R. H. Cintron
Mercedes, 78570
S. H. Collier
942 Kansas, Mercedes 78570
Dr. Chan Conolly
2208 Highland St., McAllen 78501
Dr. W. C. Cooper
Citrus Research Center, USDA
Orlando, Fla.
Dr. J. B. Corns
809 Indiana, Weslaco 78596
R. T. Correa
Box 537, Weslaco 78596
C. Craft
Box 700, Pomona, Calif. 91769
Brad Crockett
Box 389, Harlingen 78550
R. K. Crawford
Box 937, McAllen 78501
Stanley B. Crocket
Box 389, Harlingen 78550
Robert R. Cruse
1106 W. 3rd St., Weslaco 78596

Don R. Curl
Weslaco 78596
Lev F. Curl
Apartado Postal 815
Monterrey, Nuevo Leon, Mexico
Conner Davis
709 S. Louisiana, Weslaco 78596
R. C. Davis
Box 624, Donna 78537
C. E. Davidson
Rt. 1, Box 357, Mission 78572
Herbert A. Dean
Box 942, Weslaco 78596
C. E. Donaldson, III, Capt. USN
U. S. Navy SHIPLO, Europe
APO New York 09285
E. B. Dubuisson
Box 844, Elsa 78543
D. C. Earley
Box 337, Los Fresnos 78566
Clifford C. Eckert
15160 Old River Road
Guerneville, Cal. 95446
Gilbert W. Ellis
Rt. 1, Box 300, Mission 78572
Werner F. Ehrhardt
Box 2612, Harlingen 78550
Bobby Etchison
Box 929, Mission 78572
Clay Everhard II
413 Westway, McAllen 78501
Glenn H. Fankhauser
Box 965, Mission 78572
David B. Fitz
1700 Quamasia, McAllen 78501
Ing. Agr. Federico Garza Flores
Fac. Agronomia, U.N.L.
Monterrey, Nuevo Leon, Mexico
Harry Foehner
Box 831, Harlingen 78550
Henry M. Friedl
Box 372, Alamo 78516
L. L. Frerking
Rt. 1, Box 442, Weslaco 78596
M. F. Frost
Box 100, McAllen 78501

Joe R. Furr
44-455 Clinton St.,
Indio, Calif. 92201
John E. Fucik
Texas A&I Citrus Center
Weslaco 78596
E. E. Gardiner
Rt. 1, Box 495, McAllen 78501
H. L. Germen
Rt. 2, Box 72, Mercedes 78570
W. T. Gibbs
1323 Oblate, Mission 78572
Fred A. Gibson
1411 Walnut Ave., McAllen 78501
Dr. George Godfrey
318 S. 12th St., Edinburg 78539
Seymour Goldweber
Box 156, Perrine, Fla. 33157
E. M. Goodwin
Box 829, Mission 78572
Eugene M. Goodwin II
Box 829, Mission 78572
Larry Goule
5510 Gleason Drive, San Antonio
F. P. Griffiths
Box 388, Weslaco 78596
J. F. Gross
Box 585, Pharr 78577
R. H. Guinn
Rt. 1, Box 30, Edcouch 78538
Woodruff Halsey
Box 927 Howard AFB, Canal Zone
APO New York 09832
Richard C. Halter
2107 New Mexico St.
Baytown 77520
Joseph Hamilton
USAID/Ibadan, Dept. of State
Washington, D. C. 20521
Glenn Harding
Box 366, Raymondville 78580
James A. Hardin
Box 537, Weslaco 78596
Joe L. Harris
223 Bougainvillea, Mission 78572
W. Edward Hart
Box 691, McAllen 78501

W. P. Hauser
706 W. Kelly, Pharr 78577
C. M. Heald
Rt. 2, Box 48, Weslaco 78596
J. L. Hempel
Rt. 1, Box 249, McAllen 78501
S. W. Henderson, Jr.
Rt. 1, Box 403, Edinburg 78539
Richard A. Hensz
Texas A&I Citrus Center, Weslaco
Col. Robert L. Hensz
15 Pinecrest Terrace
Pease AFB, New Hampshire 03801
Arthur E. Hentz
Rt. 3, Harlingen 78550
J. W. Hicks
Box 75, Weslaco 78596
Lon C. Hill
Corpus Christi 78400
Len Hobson
Hobson's Choice
Letaba, South Africa
W. S. Hoock
611 Palmer Road, Yonkers, N. Y.
Robert M. Huston
622 Berkeley Ave.
Menlo Park, Cal. 94025
Harold S. Johnson
Rt. 1, Box 225, Mission 78572
Dr. Kenneth F. Jones
3547 Woodvalley Dr.
Houston 77025
A. H. Karcher, Jr.
Box 600, Edinburg 78539
Cornelius Kazen
Rt. 2, Wauchula, Fla. 33873
Harold E. Kendall
Box 458, Goulds, Fla. 33170
Harold L. Kent
Rt. 2, Box 70, Lutz, Fla. 33549
Milton L. Kersten
Rt. 1, Box 247, Donna 78537
Jim Kimbriel
2226 E. Austin, Harlingen 78550
E. W. Kinsey
Rt. 3, Box 317, Mission 78572

B. W. Kirsch
Box 1118, Raymondville 78580
Arlen D. Klosterbaer
Box 65, Weslaco 78596
Robert J. Knight, Jr.
13601 Old Cutler Rd.
Miami, Fla. 33158
Herman F. Krause
Rt. 1, Box 237, Pharr 78577
Dr. A. H. Krezdorn
Fruit Crops Chairman
University of Florida
Gainsville, Florida 32601
H. F. Krusemark
2516 Expressway, McAllen 78501
Howard M. Kutzenburger
Harlingen 78550
Cecil L. Lanier
Box 578, McAllen 78501
Edgar Lee
1001 Central Blvd.
Brownsville 78520
Paul Leeper
1007 S. Texas, Weslaco 78596
Leverett R. Leonard
Box 429, McAllen 78501
Henry Link
1800 E. State Highway
Weslaco 78596
Elmer Linnard
2¼ Mi. N. 10th, McAllen 78501
David Long
Box 26, Altus, Ark. 72821
Thomas D. Longbrake
Drawer 1104, Weslaco 78596
Eldin Longwell
Box 208, Hargill
Mrs. Beth Lova
Rt. 2, Box 304, Weslaco 78596
Calvin G. Lyons
Box 1104, Weslaco 78596
Hoke McKim
Rt. 1, Box 316, Edcouch 78538
Ruth I. McNally
Rt. 1, Box 71, Donna 78537
O. F. Marrs
Monte Alto

Norman Maxwell
Box 62, Weslaco 78596
Carlos C. Mendiola
Sierra Leona #245
Mexico, D. F., Mexico
R. M. Menges
803 S. Iowa, Weslaco 78596
Filmore Meredith
1103 W. 5th, Weslaco 78596
Emil H. Meyerhoff
Rt. 1, Box 147, McAllen 78501
Marvin P. Miller
21160 Lawless Rd. (Suite 202)
Riverside, Calif. 92507
Mrs. Perry Moffitt
Rt. 1, Box 930, McAllen 78501
Kateri R. Morony
Box 898, Alamo 78516
David D. Naher
Box 2205, Kingsville 78363
Col. Henry Neilson
Box 1347, McAllen 78501
Masao Nichiura
Hort. Research Station
Okitsu Branch, Shimiza City
Shizuoka, Japan
Robert Lee Nolan
633 Hoffman
Corpus Christi 78574
John Norton
9573 Oliver No.
Minneapolis, Minn.
J. D. Odoms
701 Laurel, McAllen 78501
C. C. Oglevee
305 Oklahoma, Weslaco 78596
Ellis B. Orr
Box 697, La Feria 78559
Dr. Donald R. Peterson
Dept. of Soil & Crop Sciences
Texas A&M University
College Station 77840
Frank Penn
115 N. Loth, Edinburg 78539
Ascension Peynado
Box 267, Weslaco 78596

Robert G. Platt
Department of Horticulture
University of California
Riverside, Calif. 92502
George Pletcher
Box 70, Harlingen 78550
Charlie Rankin
1515 Kerria, McAllen 78501
Warren E. Reid
Rt. 1, Box 140, Alamo 78516
Rex B. Reinking
Texas A&I Citrus Center, Weslaco
Charles A. Rogers
Box 1088, Donna 78537
Noel Ryall
Rt. 3, Los Fresnos 78566
Guadalupe Saldana
Box 388, Weslaco 78596
Herman A. Schmidt, Jr.
113 Holly Lane
Boanton Twp., N. J. 07005
Walter A. Schulze
Box 817, Alamo 78516
Jack J. Sharkey
107 N. Ripley Street #304
Alexandria, Virginia 22304
Floyd O. Sharp
Box 88, Tacna, Ariz. 85352
Ivan Shiller
Rt. 2, Box 382, Brownsville 78520
C. W. Showers
RFD, Box 103, Mission 78572
A. V. Shull
Rt. 1, Edcouch 78538
Ross B. Smiley
Box 951, Mission 78572
J. D. Smith
Rt. 1, Box 264, Harlingen 78550
Robert Carl Smith
Box 694, Donna 78537
Lt. Col. Oscar F. Smith
Box 114 Air South
F.P.O. 09521, New York
Thomas S. Stephens
Box 388, Weslaco 78596

B. C. Stephenson
Box 455, Harlingen 78550
Orval Stites
Box 182, Donna 78537
Benton Storey
Horticulture Department
Texas A&M University
College Station 77840
A. R. Swanson
Rt. 1, Box 26, Alamo 78516
Sam D. Tayloe
Rt. 1, Rio Farms, Inc.
Edcouch 78538
Elmslie T. Thomas
Box 204, Alamo 78516
Dewey Thomas
Rt. 1, Edcouch 78538
Dr. Claude E. Thomas
Box 267, Weslaco 78596
Maxwell Till
901E "Greenacres"
Adelaide, South Australia
Franklin M. Turrall
3574 Bandina Avenue
Riverside, Calif. 92506
Harold Vance
1119 Bank Southwest Building
Houston 77002
George W. Vest
1301 S. Texas, Weslaco 78596
Ed Wallace
803 S. 77 Sunshine Strip
Harlingen 78550
George P. Wene
Department of Entomology
University of Arizona
Tucson, Arizona 85721
Glenn G. White
Box 505, Donna 78537
Frederick Whittle
Weslaco 78596
N. R. Willis
Box 2278, Brownsville 78520
Josiah Work
Box 258, Harlingen 78550

MEMBERSHIP LIST (Continued)

John L. Wright
Rt. 3, Box 52, Los Fresnos 78566
Howard Wright
Box 447, Weslaco 78596
Heinz K. Wutscher
Box 267, Weslaco 78596
Otha A. Wyrick
822 E. Taylor, Harlingen 78550

CITRUS

Preliminary Studies on Redblush Grapefruit Growth[1]

By Roger Young and Art Shull[2]

Abstract: Redblush grapefruit enlargement was measured during the 1967-68 and 1968-69 growing seasons. Fruit growth rate was rapid from April to October and then declined in the late fall and winter. Soil moisture availability affected fruit growth, particularly during the hottest part of the growing season. Low soil moisture reduced fruit growth, and irrigation or rain stimulated growth. Slow fruit growth in the late fall and winter was related to lower temperatures. Although a few fruit reached legal harvest sizes in September, most fruit reached acceptable sizes late in the fall and winter. Fruit set in mid-March in 1967 grew larger than those set in early April in 1968.

INTRODUCTION

The development of full citrus fruit size and maturity occurs over a 7 to 12 month period in the Rio Grande Valley. Besides the large differences in the time required for maturation of various varieties, wide fluctuations in climatic conditions occur during growth and maturation which may ultimately influence fruit size and quality. Therefore, it is important to understand the process of fruit growth and to be aware of various influencing factors.

The purpose of this report is to describe seasonal growth changes in Redblush grapefruit under Valley conditions, and to relate these changes to variations in temperature and moisture conditions.

MATERIALS AND METHODS

Measurements were made on fruit on 15-year-old 'Redblush' grapefruit (*C. paradisi* Macf.) trees on sour orange (*C. aurantium* Linn.) rootstock in 1967 and 1968. Ten randomly selected outside fruits on each of four trees were tagged in April, and circumferences were measured every 10 to 20 days. Fruit volumes were calculated from the tables and formulas published by Turrell (11). The grove was located at Rio Farms, Monte Alto, Texas.

Air temperatures in the grove were recorded with a thermograph, and irrigation and rainfall records were kept by Rio Farms.

---

1 The work is part of a cooperative project of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, the Texas Agriculture Experiment Station, Weslaco, Texas, and Rio Farms, Inc., Monte Alto, Texas.

2 Plant Physiologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Weslaco, Texas, and Manager, Citrus Dept., Rio Farms, Inc., Monte Alto, Texas.

RESULTS

In the 1967 season, fruit set in the test grove was in mid-March and the volume thereafter increased rapidly until June 20, followed by approximately 5 weeks of no growth (Fig. 1). During this 5-week period, moisture available to the trees was low and some leaf-wilting developed. This water stress was reflected in the lack of fruit growth and slight shrinkage. Temperature maximums were in the mid 90's and minimums in the low 70's, which resulted in a period of high water consumption by the trees. A 1-inch rain in July and a 6-inch irrigation July 30 supplied adequate moisture to cause fruit growth to resume and wilting to disappear. From July 30 to January 20, water availability was not an apparent factor, since a 6-inch irrigation was applied September 1; and 12 inches of rain occurred September 20. The soil remained wet between September 20 and January 20 after several light rains.

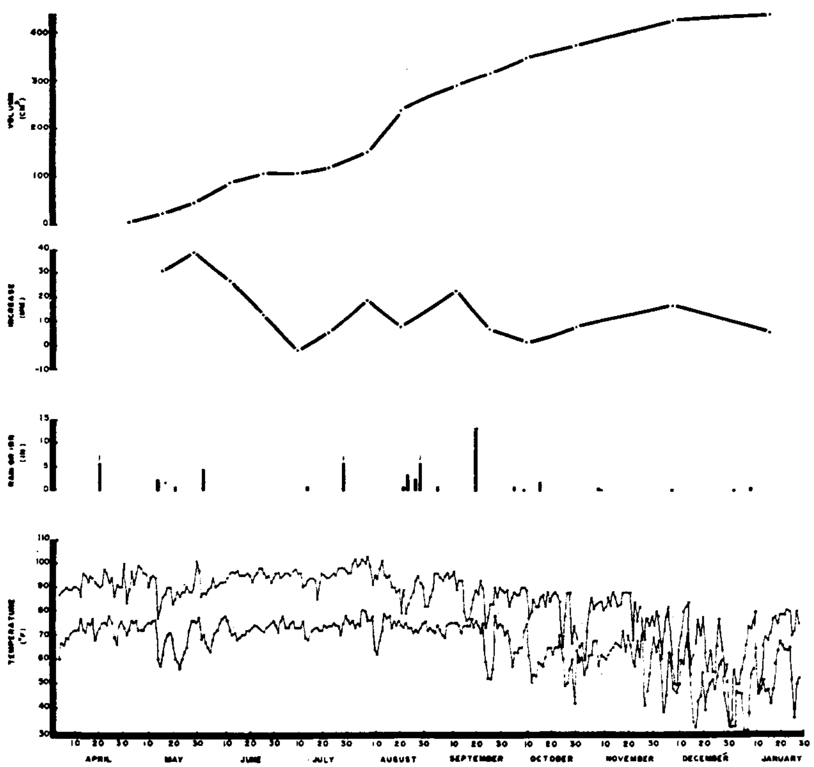


Figure 1. Seasonal changes in the growth of Redblush grapefruit in 1967-68 as related to temperature and water application.

Although about half of the fruit were blown off the trees by Hurricane 'Beulah' September 19, the rate of growth of fruit remaining on the trees did not increase. Actually, the rate of fruit growth declined after October 1 corresponding to the gradual decrease in temperatures. The smallest increase in fruit size occurred in December and January when many nights of 50°F or lower occurred. Seventeen per cent of the tagged fruit reached ring size 96 November 1 and 42% reached ring size 96 December 5.

In 1968, fruit set was in early April and fruit volume increased at a nearly constant rate through October (Fig. 2). A 4-inch rain in early May and a 6-inch irrigation in mid-August, with intermittent 1-and 2-inch rains, supplied adequate moisture during the hottest part of the season, to allow steady fruit growth. Two 6-inch irrigations, on September 30 and January 5, supplied the needed moisture for the fall and winter months. Fruit growth rate between October 1 and January 15 gradually declined, and this again paralleled the progressively cooler temperatures. After January 15, temperatures warmed considerably and fruit growth

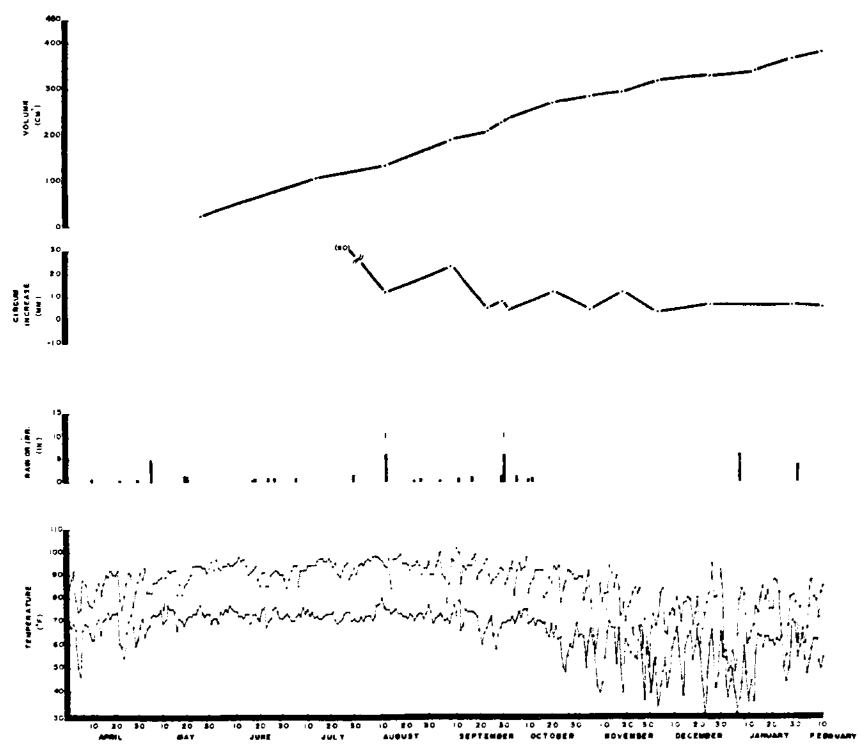


Figure 2. Seasonal changes in the growth of Redblush grapefruit in 1968-69 as related to temperature and water application.

resumed at a rate comparable to that during midsummer. Fruit in 1968 were smaller than in 1967.

Individual fruit grew at different rates (Fig. 3). Several selected large fruit, 1968, were barely 126 ring size by October 1 but continued growth through the fall and winter and attained 80 ring size in January. Several small fruit, although they continued growth, did not attain ring size 126 by January. Other fruit on the test trees ranged in size between the extremes shown in Figure 3.

In all the studies, biweekly changes in fruit circumferences were largest in the younger fruit.

DISCUSSION

The rate of Redblush grapefruit volume increase was greatest between April and October and gradually decreased thereafter through January. Increment increase in fruit circumference were greatest in the young fruit. Since circumference changes in older and larger fruit were small, this method of fruit growth measurement was not adequate to reflect the significant volume changes in the fall. Fruit volume through the season reflected a more accurate fruit growth pattern and would be more useful to the grower in monitoring the seasonal development of his fruit. The factor most limiting to fruit growth in the spring and summer months in these studies appeared to be moisture. Previous studies with Valencia orange (6), Redblush grapefruit (5, 7), Eureka lemons and Navel oranges (1) have indicated that moisture application, either by irrigation or rainfall, stimulated fruit growth, and low moisture availability caused a decrease in fruit growth and sometimes shrinkage. Our findings are similar.

Temperatures during the spring and summer months did not appear to be a limiting factor for fruit growth. No prolonged periods occurred when air temperatures were above 100°F; and generally, the maximum temperatures ranged in the mid 90's during the hottest part of the growing season. In 1968, when moisture was adequate in the summer, fruit growth rates were rather constant throughout the summer and fall, even though temperatures varied. Temperatures in excess of 100°F for Valencia oranges (6) and 97° for Eureka lemons and Navel oranges (1) have been reported to decrease the rate of fruit growth. This study indicated that Redblush grapefruit growth decreased in the late fall and winter when the day and night temperatures were cooler. Similar results have been reported by Fucik (4).

The time of fruit set was a factor in the size the fruit attained by the end of the season. In 1967, fruit set was in mid-March and the average fruit volume December 30 was 425 cc. In 1968, fruit set was in early April and average fruit volume attained December 30 was 325 cc. This difference in fruit volume was also apparent in mid-September. Since temperatures in the summer were similar for both years, and moisture was not limiting in 1968, it would appear that the smaller fruit in 1968 were probably due to the late bloom and fruit set.

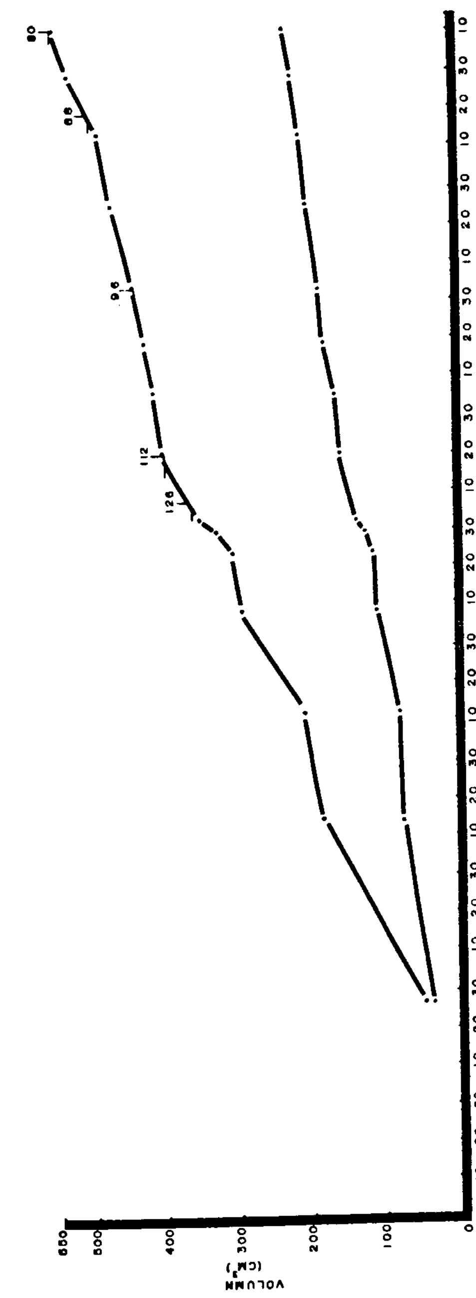


Figure 3. Seasonal volume changes, with indicated ring sizes 126 and larger, in large and small Redblush grapefruit during 1968-69 growing year.

Seasonal growth of Redblush grapefruit in the Rio Grande Valley occurs between March and January. Minimum state maturity standards require a 7.2 Brix to acid ratio, a 9-degree Brix and 96-ring-size fruit having at least 150 cc juice. Previous studies have indicated that although some fruit are legally mature in September (3, 8, 9, 10), the consumer acceptability is not good until late October (3). Consumer panel tests of Red grapefruit juice have indicated that both bitterness and tartness are undesireable characteristics (2), and both these factors contribute to the poor consumer acceptability of fruit harvested in the early fall. In addition, our studies and those of Fucik (4) indicated that only a small percentage of the fruit in September had attained legal size. Therefore, it would appear that delaying harvesting Redblush grapefruit to the late fall and winter would benefit the grower, not only by having better fruit which is more acceptable to the consumer, but by having larger fruit which increases the yield per acre. It was observed that, in many cases, fruit growth was sufficient after September to result in increases in as many as four grade sizes between September and January.

LITERATURE CITED

1. Beutel, J. A. 1964. Soil moisture, weather and fruit growth. *Calif. Citrograph* 49(10): 372.

2. Branson, K. E., Carter Price, and H. V. Courtenay. 1961. Consumer panel test of Texas fortified Red grapefruit juice. Texas Agricultural Experiment Station MP 481.

3. Cooper, W. C., and Bruce J. Lime. 1960. Quality of Red grapefruit on old-line grapefruit varieties on xyloporosis- and exacortis-tolerant rootstocks. *Jour. Rio Grande Valley Hort. Soc.* 14: 66-76.

4. Fucik, John E. 1967. Some aspects of growth and sizing of Redblush grapefruit. *Jour. Rio Grande Valley Hort. Soc.* 21: 58-67.

5. Gerard, C. J., A. V. Shull, B. Sleeth, and S. D. Tayloe. 1968. Preliminary evaluation of a semi-permanent irrigation system for citrus. *Jour. Rio Grande Valley Hort. Soc.* 22: 3-9.

6. Hilgeman, Robert H., Henry Tucker, and Thomas A. Hales. 1959. The effect of temperature, precipitation, blossom date and yield upon the enlargement of Valencia oranges. *Proc. Amer. Soc. Hort. Sci.* 74: 266-279.

7. ————. 1966. Effect of climate of Florida and Arizona on grapefruit enlargement and quality; apparent transpiration and internal water stress. *Proc. Fla. State Hort. Soc.* 79: 99-106.

8. Krezdorn, A. H., and R. F. Cain. 1952. Internal quality of Texas grapefruit. *Jour. Rio Grande Valley Hort. Soc.* 6: 48-52.

9. Lime, Bruce J., Thomas S. Stephens, and Francis P. Griffiths. 1954. Processing characteristics of colored Texas grapefruit. I. Color and maturity studies of Ruby Red grapefruit. *Food Technology* VII (12): 566-569.

10. Lime, Bruce J., Thomas S. Stephens, and Francis P. Griffiths. 1956. Processing characteristics of colored Texas grapefruit. II. Correlation color measurements and pigment analysis of Ruby Red grapefruit. *Jour. Rio Grande Valley Hort. Soc.* 10: 53-63.

11. Turrell, Franklin Marion. 1946. Tables of surfaces and volumes of spheres and of prolate and oblate spheroids, and spheroidal coefficients. University of California Press.

Rooting of Unbudded and Budded Citrus Cuttings[1]

John E. Fucik and Richard A. Hensz[2]

Abstract: An experiment was undertaken to study the rooting of budded cuttings of sour orange, *Citrus aurantium*, as a means of propagating citrus trees for commercial plantings. Shoots selected for rooting under mist propagation were divided into three groups. The first was cut and placed unbudded in the propagation beds, the second was cut, budded to either Marrs orange or Redblush grapefruit and then placed in propagation beds, the third was budded on the tree, and later cut and rooted. Other variables included different indolebutyric acid (IBA), rooting medium, and nutrient treatments. At the end of the 10 week rooting period, the amount of rooting, percent bud take, and the number of live cuttings was determined. The cuttings which have been budded on the tree were significantly superior by all three performance criteria. The IBA treatments showed a reverse effect on rooting and cutting survival between the first and second groups, but had no effect on the third group. Several advantages of producing nursery trees by rooting budded cuttings over the common budded seedling system are cited.

INTRODUCTION

Rooted citrus cuttings are widely used to produce ornamental potted plants. Though many reports indicate rooted trees out-produce budded seedlings, trees for commercial orchards are not generally propagated from rooted cuttings (1). Halma (7) has shown no difference of practical significance existed between rooted and budded Valencia and Navel orange trees. He also found the initial growth of rooted Eureka lemons in California was superior to budded trees although a similar test with Valencia oranges gave inconsistent results (6). Uniformity of initial size of the rooted cuttings or budded trees did not decrease variability in subsequent growth within these two groups of trees (4, 5). Halma and Eggers (8) grafted lemon twigs onto sour and sweet orange cuttings and obtained 80% rooting of the cuttings. Since few commercial citrus varieties were grown on their own roots and propagating cuttings from rootstock varieties was difficult compared to raising seedlings, these findings had little practical impact.

The discovery of the rooting hormone, indolebutyric acid (IBA) and the development of mist propagating techniques have increased the ease of rooting cuttings of many woody plant species including citrus. Under mist, a high light intensity, and a well-drained rooting medium kept at a temperature of 75°F, lemon cuttings will root in 4-6 weeks, oranges in 6-8 weeks and mandarins in about 4 months (10). In many plant species the presence and condition of buds has been shown to

[1] Cooperative citrus research of Texas A&I University Citrus Center, Weslaco, and Texas Agricultural Experiment Station of Texas A&M University, Weslaco.

[2] Associate Professor of Agriculture and Director, Texas A&I University, Weslaco.

markedly influence rooting (15, 16, 17). The effect of buds and budding on the rooting of citrus cuttings has not been extensively investigated. Because available evidence indicates propagation by budding citrus cuttings would not only be successful but result in considerable savings in time and labor, an experiment was undertaken to study the rooting of budded sour orange cuttings.

MATERIALS AND METHODS

In early March, shoots of ¼ - ⅜ inch (0.6-1 cm.) diameter were selected from the previous year's growth of mature sour orange trees, *Citrus aurantium*. Two-thirds of the shoots were removed from the trees and cut into 12-14 inch (30-34 cm.) lengths. All the leaves were trimmed off except three or four on the distal end. A half of these cuttings were treated with indolebutyric acid (IBA) and immediately placed in the rooting medium. The remaining cuttings were budded with either Marrs orange or Redblush grapefruit, treated with IBA, and placed in the propagating medium. The buds were inserted about 8-10 inches (21-26 cm.) from the base of the cutting and were wrapped with polyethylene budding strips. The cuttings were placed about 4 inches (10 cm.) deep in the rooting medium. Cutting, trimming, treating with IBA, and budding 128 cuttings required approximately 6 man-hours.

The following day the selected shoots remaining on the sour orange trees were budded in place to Marrs orange or Redblush grapefruit. In three weeks, when the buds had taken, these shoots were also cut, treated with IBA, and placed in the mist beds. They differed from the first two groups in getting only two nutrient applications and being subjected to the second but not the first mist schedule described below.

The IBA solution was prepared by dissolving 500 mg. of 3-indolebutyric acid in 25 ml. of ethyl alcohol and diluting to 50 ml. with distilled water to give 10,000 ppm IBA. For one treatment the base of the cutting was dipped in the IBA solution for 5 seconds. For the other treatment, the base plus 4 inches (10 cm.) of the cutting was dipped in the IBA solution for 5 seconds.

Two rooting mediums were used. One was a mixture of half perlite and half sand. The other was half peat moss and half sand. All the propagating beds were heated with lead heating coils laid in the bottom of the bed. These kept the medium at 85-90°F throughout the experiment (3, 13, 14).

Half the cuttings received a nutrient spray on the second, third, and fourth week after beginning the experiment. The nutrient solution was a Shive's No. 1 formula modified by having all major elements at one-half strength, and copper, zinc and manganese at .5 ppm and iron at 1 ppm.

The first three weeks the mist system was set on a 5 seconds on — 5 minutes off cycle from 6 AM to 6 PM. Since this resulted in an overly wet medium, the cycle was changed to provide three sprays, 4 seconds long and 6 minutes apart every hour. In addition, the tip-half of the leaf blades were cut-off to allow for better air circulation and water run-off from the leaf surfaces. Rain water was used for the mist sprays.

In mid-May, 10 weeks after beginning the experiment, the first group of cuttings was removed. Rooting was evaluated using a classification system ranging from 1, for no rooting to 5, for the greatest root development. Such an index has been shown to be statistically valid for determining rooting responses (12). Figure 1 shows examples of all but the no rooting class. In addition to the amount of rooting, the number of buds and cuttings surviving were recorded.

The experiment was arranged in a split plot design with rooting

Figure 1: Range in amount of rooting of sour orange cuttings. Rooting was rated from 2 on the left to 5 on the right. Cuttings with no roots were given a rating of one.

mediums being the main plots. Half of each plot was given the nutrient additions. Within the half plots the rest of the treatments were randomly arranged and replicated 16 times (11).

RESULTS

Of the factors studied in this experiment only the IBA and budding treatments showed significant effects on the amount of rooting. Table 1 gives the means of the rooting index ratings and the percent of cuttings which rooted for the IBA and budding treatments. In both the amount and number of cuttings which rooted the shoots budded on the tree exceeded those budded after removal from the tree. The unbudded cuttings were not significantly different from the other budding treatments. In the first two treatments dipping the basal 4 inches of the cutting into the IBA solution increased the amount of rooting and the percent of cuttings which rooted.

In Table 2 the percent of buds still living at the end of the experiment are shown. The major factor influencing bud survival was the method of budding. The 63% difference in survival between buds placed on cut shoots and buds placed on shoots while still attached to the trees was highly significant. The reversal of the effect of the IBA between the two budding treatments indicated a significant interaction of these two variables at the 5% level.

At the end of the experiment the percent of cuttings still alive was determined. This included those cuttings with active cambium and

Table 1. The effect of indolebutyric acid (IBA) and budding treatments on the rooting of sour orange cuttings.

	BUDDING TREATMENTS			
IBA TREATMENT	*Unbudded*	*Cutting Budded*	*Shoot Budded on Tree*	*MEANS OF IBA TREATMENT*
Base of cutting dipped	1.97 41%	1.78 31%	3.50 78%	2.42 50%
Base + 4 inches of cutting dipped	3.03 66%	2.03 41%	3.56 78%	2.88 * 61%
Means of budding treatments	2.50 ab 53%	1.91 a 36%	3.53 bc 78%	

The decimal value is an index rating of the amount of roots from 1 (none) to 5 (high). The number of cuttings which rooted is given in percent.
Means having a subscript in common are not statistically different at the 1% level of significance.
* The means of the IBA treatments are significantly different at the 5% level.

green leaves but which showed little or no evidence of root formation. The factors which showed significant effects on the percent of surviving cuttings are given in Table 3. The difference in survival between the cuttings in peat moss + sand and those in perlite + sand is significant at the 5% level. Among budding treatments, the budded-on-the-tree cuttings differed from the budded cuttings but neither differed from the unbudded cuttings at the 1% level of significance. At the 5% level however, all budding treatments differed significantly from each other. The 4 inch IBA dip was associated with a decrease in cutting

Table 2. The effect of indolebutyric acid (IBA) and budding treatment on the percent of buds surviving on rooted sour orange cuttings.

	BUDDING TREATMENTS		
IBA TREATMENTS	*Cutting Budded*	*Shoot Budded on Tree*	*MEANS OF IBA TREATMENTS*
Base of cutting dipped	47%	88%	67%
Base + 4 inches of cutting dipped	34%*	100%*	67%
Means of budding Treatments	41%	94%**	

* The interaction of IBA on budding treatment is significant at the 5% level.
** The difference between budding treatment means is significant at the 1% level.

Table 3. The effects of indolebutyric acid (IBA), rooting medium and budding treatments on the survival of sour orange cuttings.

	BUDDING TREATMENTS			
IBA TREATMENTS	*Unbudded*	*Cutting Budded*	*Shoot Budded on Tree*	*MEANS OF IBA TREATMENTS*
Only base dipped	94%	59%	100%	84%
Base + 4 inches dipped	88%*	78%*	97%*	88%
	BUDDING TREATMENTS			
ROOTING MEDIUM	*Unbudded*	*Cutting Budded*	*Shoot Budded on Tree*	*MEANS OF MEDIUMS*
Perlite + sand	88%	59%	97%	81%
Peat moss + sand	94%	78%	100%	91%*
Means of budding treatments	91% ab	68% a	98% bc**	

* The differences between mediums and the interaction of IBA on the budding treatments are significant at the 5% level.
** Means having a subscript in common are *not* statistically different at the 1% level of significance.

survival in unbudded cuttings, an increase in survival in the budded cuttings, and had no effect in the budded-on-the-tree cuttings. This interaction effect was significant at the 5% level.

DISCUSSION

By the criteria of this experiment, the shoots which were budded on the trees and then rooted had the best overall performance of the three systems tested. During the first three weeks in the mist bed excessive moisture may have hindered callous formation and bud take. Many buds rotted under the polyethylene bands. This condition may have weakened the budded cuttings and accounted for their low survival rate compared to the unbudded cuttings which received similar treatment. On the other hand, altering the mist schedule, natural changes in the sour orange trees, or the effects of budding may all have contributed to the superior rooting of the budded-on-the-tree cuttings. Their better root systems in turn may have contributed to their greater survival. The unbudded cuttings though had 25% lower rooting but only 7% less cutting survival. This suggests either rooting and survival are unrelated in the unbudded cuttings or budding on the tree may have a salutory effect on root formation.

The rooting response to IBA is not consistent with the experiences of other writers (1, 3, 10). Since the increase in rooting to the 4 inch IBA dip was limited to the first two groups of cuttings, the response may be related to the more intensive mist cycle. The high moisture conditions which resulted may have sufficiently leached or diluted the small quantity of IBA retained by the basal-dipped cuttings to render it ineffective. What other factors may have caused this interaction between IBA and budding treatments must be determined by further investigation.

These results indicated the scion or bud variety does not influence rooting, bud take, or cutting survival under this system of propagation. Reports of other workers support this conclusion (1, 2, 10).

For this short 10-week rooting period the lack of response to the nutrient applications might be expected. Successful rooting of cuttings appears to be related to maintaining a high carbohydrate supply in the cuttings through the creation of optimum conditions for photosynthesis (9, 10, 13, 14). Nutrient additions might be beneficial in the latter half of the rooting period or coincident with transplanting from the propagating beds.

With skilled labor becoming both scarce and costly, the production of citrus nursery stock from rooted cuttings deserves consideration. The budding of seedling trees involves the cost of seed collection or purchase, seedbed preparation, and the cultivation, selection, and transplanting of seedlings. Comparing these costs to those for producing trees from budded cuttings should give a 25-40% savings especially in labor requirements. The reduction in land and equipment needs would probably compensate for the added costs of mist propagation facilities.

Transplanting the rooted cuttings directly to individual containers would eliminate the costs of digging and balling. Also the ease of budding and cutting shoots would certainly be preferred to the squatting and stooping associated with budding seedlings in the nursery. A final important feature is that a budded, rooted cutting could be ready for transplanting to the field in 10 to 12 months compared to 18 to 24 months for a budded seedling.

If the cuttings and buds were carefully selected from vigorous, disease free trees, no evidence has been found to indicate the resultant trees would be inferior to budded seedlings in yield and fruit quality.

CONCLUSION

Under favorable mist propagation conditions, up to 78% rooting can be expected with sour orange cuttings. Of the two systems of budding cuttings, shoots which were budded on the tree then removed and rooted had a higher bud take, better rooting, and greater survival than shoots which were cut, trimmed, budded, and immediately placed in the propagating beds. The use of budded cuttings would appear to have considerable advantage over the budded seedlings in savings of labor, space, and time.

LITERATURE CITED

1. Batchelor, L. and H. Webber. 1948. The Citrus Industry, v. II, Production of the Crop. Univ. of Calif. Press, Berkeley and Los Angeles, Calif. 398 pp.
2. Gardner, F. E. and G. E. Horanic. 1959. Relation of citrus nursery tree size from ½ to ⅞ inches to ultimate size and production. Proc. Fla. State Hort. Soc. 72:102-105.
3. Ford, Harry W. 1957. A method of propagating citrus rootstock clones by leafbud cuttings. Proc. Amer. Soc. Hort. Sci. 69:204-207.
4. Halma, F. F. 1932. Variability in citrus propagated by cuttings and by budding. Proc. Amer. Soc. Hort. Sci. 29:365-366.
5. ———————. 1941. Comparative study of initial and subsequent size of citrus cuttings and buddings. Proc. Amer. Soc. Hort. Sci. 38:336-338.
6. ———————. 1939. Growth of own-rooted and budded citrus trees. Proc. Amer. Soc. Hort. Sci. 37:279-282.
7. ———————. 1944. Quality of fruit from own-rooted and budded orange trees. Proc. Amer. Soc. Hort. Sci. 44:223-226.
8. ——————— and E. R. Eggers. 1936. Propagating citrus by twig grafting. Proc. Amer. Soc. Hort. Sci. 34:289-290.

9. Hartmann, H. T. and C. J. Hansen. 1955. Rooting of soft-wood cuttings of several fruit species under mist. Proc. Amer. Soc. Hort. Sci. 66:157-167.
10. Johnston, J. C., K. Opitz, and E. Frolich. 1959. Citrus Propagation. Calif. Agric. Exp. Sta. Cir. 475. 23 p.
11. Leclerg, E., W. Leonard, and A. G. Clark. 1962. Field Plot Techniques. Burgess Pub. Co., Minneapolis, Minn.
12. Mahlstede, J. P. and E. P. Lana. 1958. Evaluation of the rooting response of cuttings by the method of ranks. Proc. Amer. Soc. Hort. Sci. 71:585-590.
13. Marstron, M. E. 1966. The importance of bottom heat in mist propagation (Abstr.) Proc. XVII International Hort. Congress I:365.
14. Sykes, J. T. and B. H. Howard. 1966. The effect of temperature, light intensity and carbohydrate content on the rooting of cuttings under mist. Proc. XVII International Hort. Congress III:433-441.
15. Tureckaja, R. H. 1960. The role of leaves and buds in the formation of roots on stem cuttings. (In Russian, with English summary.) Fiziol. Rast., 7:531-6 [in Hort. Abstr. 31:3635.]
16. van der Lek, H. A. A. 1925? Over de wortelvorming van houtige stekken. (Root development in woody cuttings.) [With English summary.] Meded. LandbHoogesch. Wageningen. 28(1):1-230.
17. ———————. 1934. Over den invloed der knoppen op de wortelvorming der stekken. (The influence of the buds on root development in cuttings. [With English summary.] Meded. LandbHoogesch. Wageningen. 38(2):1-95. (in Hort. Abstr. 5:11).

Projected Citrus Supply for Rio Grande Valley, Texas 7 Year Period 1968-69 to 1974-75

CHAN CONNOLLY[1]

Abstract: The Texas citrus industry is now in a state of recovery from the 1962 freeze. The projected aggregate citrus supply for the Rio Grande Valley, Texas is estimated to increase from 480,710 to 1,018,530 tons during the 7 year period 1968-69 to 1974-75.

Point estimates indicate that the early orange supply will increase from 135,-210 to 318,941 tons resulting in a 136 percent increase; grapefruit from 260,000 to 506,859 tons reflecting a 96 per cent increase; and late oranges from 85,500 to 192,730 tons indicating a 125 percent increase.

The basic assumption used in making the projections was that no major freeze damage would occur during the planning horizon.

INTRODUCTION

The first commercial carlot shipments of citrus fruit from Texas started after World War I and reached a peak of 1,224,000 tons during the 1945-46 season. The 1951 and 1962 freezes drastically reduced the tonnage to a low of about 10,625 tons during the 1962-63 season. The industry is now in the process of recovering from the 1962 freeze.

The purpose of this study is to project citrus production for the 7 year period 1968-69 to 1974-75. This will provide knowledge for decision making in respect to the future marketing task. Rapidly increasing citrus supplies will cause environmental changes which need be examined carefully by the industry in order to meet the challenges and opportunities which they create. The implications of rapidly increasing supplies necessitate future structural changes in the marketing institutions at the production level.

METHODOLOGY

Assumptions: The basic assumption in making these forecasts was that no major freeze damage would occur between the present period and 1975, and new plantings will continue at the 1967 rate.

Citrus tree census as of October 1, 1967, was used as a basis for estimating the acreage now planted (Table 4). Texas citrus tree plantings in the Rio Grande Valley were used to estimate the current rate of plantings (Table 5). The 1968-69 U. S. Department of Agriculture production estimates were used to determine present production level (3).

[1] Associate Professor, Texas Agricultural Market Research and Development Center, Department of Agricultural Economics and Sociology, Texas A&M University Agricultural Research and Extension Center at Weslaco.

The 1974-75 yield levels were estimated by Horticulturists from Texas A&M and Texas A&I Universities[2].

Grapefruit:

35,241 = acres now planted

9.5 = yield in tons per acre for bearing acreage for the 1968-69 season

3,430 = acres to be planted during the 1969-71 period

12.5-15.0 = 1975 expected average yield in tons per acre for acreage now planted

6.5 = 1975 expected average yield in tons per acre for acreage to be planted during the 1969-71 period.

35,241 × 12.5 = 440,513 Tons

35,241 × 15.0 = 528,615 Tons

3,430 × 6.5 = 22,295 Tons

Range of forecast in tons: 462,808 to 550,910

Average: 506,859 Tons

Early Oranges:

24,440 = total acres now planted

10.0 = average yield in tons per acre for the 1968-69 season

814 = estimated acreage to be planted during the 1969-71 period that will be bearing in 1975

12.0-14.0 = 1975 average expected yield per acre for acreage now planted

3.0 = 1975 average expected yield per acre for acreage to be planted during the 1969-71 period.

24,440 × 12.0 = 293,280 Tons

24,440 × 14.0 = 342,160 Tons

814 × 3.0 = 2,442 Tons

Range of forecasts in tons: 295,722 to 344,602

Average = 318,941

[2] Forecasts were developed with the assistance of Dr. Richard Hensz, Director of Texas A&I Citrus Center, Dr. Calvin Lyons, Texas A&M Extension Horticulturist and Mr. Norman Maxwell. Texas A&M Research Horticulturist at Weslaco.

Late Oranges:

16,386 = acres now planted

5.2 = Average expected yield in tons per acre for the 1968-69 crop

150 = expected acreage to be planted during the 1969-71 period

11.5-12.0 = average expected yield in 1975 for acreage now planted

1.3 = average expected yield in 1975 for acreage to be planted during the 1969-71 period

16,386 × 11.5 = 188,439 Tons

16,386 × 12.0 = 196,632 Tons

150 × 1.3 = 195 Tons

Range of forecasts in tons: 188,634 to 196,827

Average = 192,730

RESULTS

The range and mid point estimates for total citrus production in the Rio Grande Valley are tabulated in Table 1.

Using the 1968-69 production estimates reported by the U. S. Department of Agriculture and the mid point estimates, citrus supply levels were extrapolated for the intermediate years (Table 2).

Projected aggregate citrus supply in tons by season for the Rio Grande Valley, Texas for the 7 year period 1968-69 to 1974-75 is tabulated in Table 3.

Table 1. Forecasted citrus production – Rio Grande Valley, Texas, 1974-75 crop year.

Commodity	*Range*	*Mid Point Estimate*
	Tons	*Tons*
Grapefruit	462,808 to 550,913	506,859
Early Oranges	295,722 to 344,602	318,941
Late Oranges	188,634 to 196,827	192,730

Table 2. Projected aggregate grapefruit, early orange, and late orange supply in tons, boxes, and cartons Rio Grande Valley, Texas. 7 Year period 1968-69 to 1974-75.

	GRAPEFRUIT		
Season	*Tons*	*Boxes–80 lbs.*	*Cartons–40 lbs.*
1968-69	260,000	6,500,000	13,000,000
1969-70	301,145	7,528,625	15,057,250
1970-71	342,290	8,557,250	17,114,500
1971-72	383,435	9,585,875	19,171,750
1972-73	424,580	10,614,500	21,229,000
1973-74	465,725	11,643,125	23,286,250
1974-75	506,859	12,671,475	25,342,950
	EARLY ORANGES		
Season	*Tons*	*Boxes–90 lbs.*	*Cartons–45 lbs.*
1968-69	135,210	3,004,636	6,009,273
1969-70	165,832	3,685,152	7,370,304
1970-71	196,454	4,365,640	8,731,280
1971-72	227,076	5,046,128	10,092,256
1972-73	257,698	5,726,616	11,453,232
1973-74	288,320	6,407,105	12,814,210
1974-75	318,941	7,087,507	14,175,014
	LATE ORANGES (VALENCIA)		
Season	*Tons*	*Boxes–90 lbs.*	*Cartons–45 lbs.*
1968-69	85,500	1,900,000	3,800,000
1969-70	103,372	2,297,156	4,594,311
1970-71	121,244	2,694,311	5,388,622
1971-72	139,116	3,091,467	6,182,933
1972-73	156,988	3,488,622	6,977,244
1973-74	174,860	3,885,778	7,771,556
1974-75	192,730	4,282,885	8,565,770

Source: Table 1.

Table 3. Projected aggregate citrus supply in tons, Rio Grande Valley, Texas. 7 Year period 1968-69 to 1974-75.

Season	*Tons*
1968-69	480,710
1969-70	570,349
1970-71	659,988
1971-72	749,627
1972-73	839,266
1973-74	919,905
1974-75	1,018,530

Source: Table 1.

Table 4. Citrus tree census October 1, 1967.

Variety	Non-Bearing Acres	Non-Bearing Trees	Bearing Acres	Bearing Trees	Total Acres	Total Trees
Hidalgo County						
Early Oranges	9,308	916,012	11,732	962,179	21,040	1,878,191
Valencias	3,080	330,824	11,585	877,196	14,665	1,208,020
Total Oranges	12,388	1,246,836	23,317	1,839,375	35,705	3,086,211
Mandarine	225	22,695	220	20,539	445	43,234
Grapefruit	6,045	702,401	22,088	1,706,853	28,133	2,409,254
All Citrus	18,658	1,971,932	45,625	3,566,767	64,283	5,538,699
Cameron County						
Early Oranges	513	58,576	1,200	110,947	1,713	169,523
Valencias	290	32,565	645	59,483	935	92,048
Total Oranges	803	91,141	1,845	170,430	2,648	261,571
Mandarins	40	5,122	40	3,662	80	8,784
Grapefruit	1,438	166,613	4,880	442,621	6,318	609,234
All Citrus	2,281	262,876	6,765	616,713	9,046	879,589
Willacy County						
Early Oranges	378	36,768	589	42,627	967	79,395
Valencias	218	22,313	568	40,428	786	62,741
Total Oranges	596	59,081	1,157	83,055	1,753	142,136
Mandarins	31	4,036	60	4,036	91	8,072
Grapefruit	240	20,256	550	41,691	790	61,947
All Citrus	867	83,373	1,767	128,782	2,634	212,155
Total Valley						
Early Oranges	10,199	952,780	13,521	1,115,753	23,720	2,127,109
Valencias	3,588	385,702	12,798	977,107	16,386	1,362,809
Total Oranges	13,787	1,397,058	26,319	2,092,860	40,106	3,489,918
Mandarins	296	31,853	320	28,237	616	60,090
Grapefruit	7,723	889,270	27,518	2,191,165	35,241	3,080,435
Total Citrus	21,806	2,318,181	54,157	4,312,262	75,963	6,630,443

Source: Texas Citrus Mutual (TCM), Edinburg, Texas.

Table 5. Texas citrus tree planting in the Lower Rio Grande Valley 1952-68.

Year beginning July 1	GRAPEFRUIT White flesh	GRAPEFRUIT Pink and red flesh	GRAPEFRUIT Total	ORANGES Early and mid-season	ORANGES Val-encia	ORANGES Total	Other citrus	All citrus
1952	2	298	300	40	52	92	23	415
1953	8	509	517	74	88	162	10	689
1954	3	239	242	63	38	101	11	354
1955	5	237	242	53	42	95	17	354
1956	26	185	211	72	46	118	24	353
1957	28	209	237	92	83	175	11	423
1958	8	160	168	87	59	146	18	332
1959	16	191	207	112	79	191	5	403
1960	34	150	184	182	83	265	17	466
1961	16	58	74	118	49	167	5	246
Before freeze Jan. 9-12, '62								
After freeze Jan. 9-12, '62	1	2	3	5	4	9	....	12
1962	12	86	98	224	119	343	8	449
1963	14	192	206	268	98	366	26	598
1964	13	254	267	318	87	405	38	710
1965	10	350	360	301	98	391	35	786
1966	8	287	295	96	33	129	11	435
1967	2	158	160	38	7	45	5	210

Source: U. S. Department of Agriculture and Texas Department of Agriculture, Texas Citrus Tree Plantings in the Lower Rio Grande Valley 1952-68, Release September 20, 1968.

LITERATURE CITED

1. Texas Citrus Mutual, Edinburg, Texas. Texas Tree Census, October 1, 1967.
2. U. S. Department of Agriculture and Texas Department of Agriculture. Texas Citrus Tree Planting in the Lower Rio Grande Valley 1952-68, Release September 20, 1968.
3. U. S. Department of Agriculture and Texas Department of Agriculture. Texas Citrus May 1, 1969, release May 12, 1969.

Recent Changes in Characteristics of Orange Consumption

JOHN P. NICHOLS and THOMAS L. SPORLEDER[1]

Abstract: Changing patterns of product consumption have relevance for an industry's marketing problems, programs, and policies. The objective of this article is to briefly examine per capita orange consumption for selected products from 1951 to 1967. Analysis of recent orange consumption patterns reveal that fresh consumption has been slightly declining while processed orange product consumption is generally increasing. This trend is likely to continue and thus has implications for existing and future orange processing capacity in the Rio Grande Valley of Texas.

INTRODUCTION

Consumption patterns are of major importance to producing and marketing firms in all industries. Requirements for information to aid future planning necessitates recognition of the changing needs and desires of consumers. Consumption patterns provide information and guidelines for making decisions concerning new product concepts, production expansion and development.

The orange industry in Texas is currently undergoing a period of rapid expansion of production capacity (1). Such an expansion has stimulated examination of marketing problems of significance to the Texas orange industry. The need for new processing facilities, the need for finding new products and markets and the need for increased cognizance of consumer desires are examples of marketing problems of recent concern to the industry.

All of these concerns are stimulated by expected rapid expansion in production. Decisions on these matters must be made with respect to available information including trends and patterns in consumption. The purpose of this article is to briefly examine these patterns for several orange products and discuss their significant implications to the Texas orange industry. Per capita consumption patterns for grapefruit are not discussed in this article since these patterns have been examined elsewhere (2).

METHODOLOGY

While orange production is regional, consumption is national in scope. Therefore marketing problems must be considered on a broader national scale. Planning decisions, when production is expanding rapidly, must be made in relation to changing characteristics of the markets

[1] Assistant Professors, Department of Agricultural Economics and Sociology, Texas A&M University.

in which it will operate. The basic data selected for use in the analysis is the United States average per capita consumption series published by the United States Department of Agriculture (3). A seventeen year period from 1951 through 1967 was used for all orange products except chilled orange juice (Table 1). Per capita consumption data for this product were not reported prior to 1955. Thus the estimates reported in Table 2 for this product are based on a series from 1955 through 1967.

A linear regression time trend model was used in the analysis of the data. It should be recognized that this analysis reveals the average direction and magnitude of change in per capita consumption over time but does not, in itself, indicate the factors causing these changes. Casual factors may be suggested by examining the revealed patterns in conjunction with other information concerning each product.

PER CAPITA CONSUMPTION ANALYSIS

Fresh Oranges. The mean average annual per capita consumption

Table 1. Per capita consumption of fresh oranges and selected processed orange products; United States, 1951 through 1967, product weight basis.

	Product Form			
Year	*Fresh oranges*	*Frozen conc. orange juice (single-strength equiv.)*	*Canned orange juice*	*Chilled orange juice*[1]
		– – – *Pounds* – – –		
1951	28.8	6.64	3.81	....
1952	27.9	10.76	3.58	....
1953	27.6	11.82	3.13	....
1954	24.5	12.65	3.08	....
1955	24.8	14.33	2.95	0.94
1956	22.6	13.96	2.42	1.05
1957	21.6	15.23	2.45	1.72
1958	17.6	11.67	2.66	1.60
1959	19.8	14.49	1.91	1.87
1960	19.3	15.62	2.12	2.10
1961	16.1	15.30	1.70	1.65
1962	15.6	17.98	1.92	2.19
1963	11.9	11.84	1.69	1.14
1964	14.3	10.58	1.17	1.29
1965	16.4	14.10	1.24	1.90
1966	16.4	13.47	1.53	3.04
1967	18.1	19.49	1.57	4.15

[1] Data not available prior to 1955 because the product was not commercially sold in this manner before then.

Source: U.S.D.A. Fruit Situation. Economic Research Service, August, 1968.

of fresh oranges for the period from 1951 to 1967 was 20.2 pounds (Table 2). During this same period consumption per capita has declined at an average annual rate of 0.9 pounds. However, this overall average decline disguises several important considerations that would temper its interpretation.

For the purpose of closer analysis, the 1951 to 1967 period can be arbitrarily broken into two segments, 1951 to 1958 and 1959 to 1967. During the 1951 to 1958 period, per capita consumption of fresh oranges declined steadily. During the latter period, 1959 to 1967, per capita consumption was relatively constant compared with the earlier period. In fact, since 1963, per capita fresh orange consumption has increased. The 1963 per capita consumption was the lowest of any year during the 1951 to 1967 period. Full appreciation of this data requires understanding of the association of consumption with other factors. Some variation in per capita consumption can be due to variations in supply availability. This is particularly true in citrus since the supply available may vary substantially from one year to the next because of freezes (as was the case from 1962 to 1963).

It is apparent, then, that computed average annual rates of change in per capita consumption must be interpreted with caution. First, and most obvious, long run averages do not necessarily reveal next year's market performance. In addition, variation in fresh orange per capita

Table 2. Computed values for linear regression time trends, United States per capita orange consumption for selected products, 1951-67.

Product	*M*[1]	*a*	*b*	$\sigma y{\cdot}x$[2]	*V*[3]
		– – – *Pounds*	*per Capita* – – –		
Fresh Oranges (fresh weight basis)	20.2	28.3	−0.90	2.44	.12
Canned orange juice (single-strength basis)	2.3	3.7	−0.15	0.26	.11
FCOJ (single-strength basis)	13.5	10.6	0.32	2.57	.19
Chilled orange juice[4] (single-strength basis)	1.9	0.8	0.15	0.68	.36

Note: Model $Y = a + bX + u$
where: Y = Per capita consumption in pounds
a = Level of trend line
b = Slope of trend line
x = Time in years
u = Statistical error term

[1] M = Computed mean per capita consumption for the trend period.
[2] $\sigma y{\cdot}x$ = Estimated standard error of estimate.
[3] V = Coefficient of variation = $(\sigma y{\cdot}x) \div (M)$
[4] For the period 1955 to 1967 (see text).
Source: Computed from U.S.D.A. per capita consumption data (Table 1).

consumption from year to year may not be explained solely by a change in effective demand at the consumer level but may be due to variations in supply availability in terms of quantity, quality, season and production area. However, none of these considerations necessarily negate the usefulness of computed coefficients representing long term changes in patterns of consumption. The annual average decline of 0.9 pounds noted earlier for per capita consumption of fresh oranges does give a valid indication of the long-run change in consumption of fresh oranges which has occurred, whatever the cause.

To fully understand orange consumption characteristics it is important to examine the market for processed orange products. The decline in fresh orange per capita consumption discussed above, when considered in relation to increasing total orange production, implies that processed product forms are increasing in importance to the industry relative to the fresh form. The characteristics of per capita consumption of these products are examined in the following section.

Processed Orange Products. Canned, chilled, and frozen concentrate juice products account for the major portion of total oranges processed. Computed linear regression time trends for per capita consumption of these products are given in Table 2.

During the period 1951 to 1967 per capita consumption of frozen concentrated orange juice (FCOJ) has increased by an annual average rate of 0.3 pounds. Per capita consumption of canned orange juice over this same period decreased at an average annual rate of 0.2 pounds.

Chilled orange juice is a relatively new product. From 1955 to 1967 per capita consumption of this product increased by an annual average of 0.2 pounds per year. Examination of the data in Table 1 reveal that the level of per capita consumption remained relatively stable from 1955 to 1964. Since 1964 however, per capita consumption has increased substantially with the introduction of new processing technology in this product.

Fresh-Processed Relationship. Examination of fresh and processed product data reveals the changing relationship between the consumption of fresh and processed product forms (table 3). While per capita consumption of processed products has been increasing, the net increase of the three major processed products has not been large enough to offset the decline in per capita consumption of fresh oranges. It is evident, however, that per capita consumption of aggregate processed product forms has increased relative to fresh orange consumption.

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

As noted earlier, the pattern of fresh orange consumption is slightly declining with the degree of decline depending on the time period evaluated. This pattern considered in combination with recent increases in total production implies that processed orange products are gaining in relative importance. Of the three most important processed orange

Table 3. Average annual change in per capita consumption of fresh oranges and selected processed orange products, fresh weight basis.[1]

Product	*Annual Average Change*
Fresh oranges	—0.90
Canned single strength orange juice	—0.27
FCOJ	0.58
Chilled orange juice	0.27

[1] Fresh weight basis derived from product weight basis using the following conversion:
1 lb. single strength orange juice = 1.81 lbs. fresh fruit
Source: Table 2.

products, FCOJ and chilled juice consumption per capita are increasing while canned orange juice consumption per capita has declined. One important factor which may be associated with these observed changes in consumption patterns is an increasing consumer preference for convenience items. The increase in per capita consumption of chilled juices is a recent example of the continuing importance of this consumer preference.

The trends in consumption noted earlier as well as increases in production will likely continue. Given this environment, processed products will have increasing significance to the Texas orange industry in the future. It is apparent that in order to take advantage of this increasing consumer preference for processed orange products the Texas orange industry must expand its current capacity to produce these products. Expansion of processing facilities has the additional advantage of allowing more flexibility in marketing during large crop years, since processed products may be stored so that they may be marketed at a future time. This increased flexibility could allow for long run improvement in the competitive position of the Texas orange industry in the national market.

LITERATURE CITED

1. Connolly, Chan. Projected Citrus Supply and Utilization for the Rio Grande Valley, Texas, for the Six Year Period 1969-70 to 1974-75. Unpublished Research Survey. Texas Agricultural Experiment Station, Substation 15, Weslaco, Texas. 1969.
2. Tefertiller, E. H. Production and Price Projections for Texas Grapefruit—1975. Unpublished Thesis, Department of Agricultural Economics and Sociology, Texas A&M University. January 1969.
3. United States Department of Agriculture. Fruit Situation. Economic Research Service, Washington, D. C. August 1968.

Ethylene Production in Freeze-Injured Citrus Trees

W. C. Cooper, G. K. Rasmussen, and E. S. Waldon[1]

Abstract: Prior to the freeze of December 16 and 17, 1968, auxin and ethylene levels were higher in immature green leaves than in middle-aged leaves of Marsh (*Citrus paradisi* Macf.) grapefruit. No auxin analysis was made on old leaves. Ethylene production was greater in old leaves than in middle-aged and immature leaves. The freeze significantly increased evolution of ethylene from injured fruit and leaves and, in some instances, it did so before injury became visible. The desiccation of citrus leaves and the drying of juice vesicles induced by freezing resemble in many ways the symptoms resulting from drought. In both instances ethylene evolution from the affected tissues increases significantly. The ethylene production by freeze-injured fruit and leaves is the probable mechanism for abscission of frozen plant parts.

INTRODUCTION

Living tissues produce ethylene in their growth processes (1). The production of ethylene by citrus leaves and fruit can be increased by application of growth-promoting substances that prevent abscission (2) and by chemicals which have no growth-promoting activity. The latter include ascorbic acid (AA), iodioacetic acid (IOAC), beta-(3-5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl) glutarmide (cycloheximide or Cyh), and 2-chloroethylphosphonic acid (Ethrel)[2], which have no growth-promoting activity (2). These chemicals have been used successfully to accelerate abscission of citrus fruit as aids to mechanical harvesting (2). AA, IOAC, and Cyh cause pitting of the rind, and we think that the chemical wounding of the rind tissue is associated with the ethylene production by the tissue. Ethrel is less likely to cause rind-pitting than the other compounds used; and it actually breaks down on the leaf and rind of fruit to produce ethylene (2, 6).

Ethylene production by citrus fruit can be increased not only by chemicals (some of which cause rind injury) but also by bruising (9); by gamma radiation (5) and by chilling temperatures (below 40°F) (3). The shift from green to yellow or orange coloring of citrus peel with the onset of cool weather in the fall is associated with an increase in production of ethylene by the chilled fruit (3). Chilling did not increase ethylene production of mature 5-month-old leaves (herein referred to as middle-aged leaves) of orange and grapefruit. However, it increased production of ethylene and abscission of 12-month-old leaves (herein

[1] Plant Physiologists and Biological Lab Technician, respectively, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Orlando, Florida 32803.

[2] Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the USDA, and does not imply its approval to the exclusion of other products that may also be suitable.

referred to as old leaves), varying in color from green to greenish-yellow.

Freezing temperatures of 23° F for 4 hr without frost occurred in the early morning of December 16, 1968. A very heavy frost occurred the following morning over a wide area of the citrus growing region of Florida. In some groves, the middle-aged leaves on terminal growth exposed to the sky curled, and so did many old leaves throughout the canopy. Some of these leaves showed a slight loss of chlorophyll, appeared dessicated, and returned to their normal position slowly. Many of the old leaves dropped during the following week. Ice and slush were observed in many fruit on the mornings of December 16 and 17. These plant materials were available for studies on the effect of freezing temperatures on ethylene production of citrus leaves and fruits. The object of these investigations was to enlarge our knowledge of: (1) the influence of freezing injury to citrus on ethylene production; (2) the relation of ethylene production to abscission of fruit; and (3) the relation of ethylene production to freezing injury of tissues.

MATERIALS AND METHODS

Tissues used for auxin and ethylene analyses consisted of young immature green leaves and fruit, middle-aged leaves, and old leaves. The auxin analysis was conducted only on grapefruit plant tissues prior to the freeze; ethylene analyses were made on many varieties of citrus before and after the freeze.

Auxin was extracted from freshly harvested leaves and fruit with ether according to van Overbeek's technique (7), and the auxin content was measured by the standard *Avena* test (8).

Sixteen fruits were collected for each ethylene analysis. Four fruits were sealed in each of 4 polyethylene bags and incubated at room temperature for 1 day. By use of a hypodermic syringe, a 2-ml sample of air was removed from the air in each bag and was analyzed for ethylene. Likewise, a 2-ml sample of air was collected from under the rind of each of the 4 fruits in each bag and was analyzed for ethylene. The ethylene analyses were made by flame-ionization-gas chromatography. For each fruit sample the amount of ethylene in the gas phase of the air under the rind, and the amount of ethylene in the air surrounding the fruit, are the average of 16 and 4 determinations, respectively.

We determined ethylene evolution from leaves held at laboratory temperature in sealed polyethylene bags (containing 50-ml air space) or in 125-ml Erlenmeyer flasks sealed with vicine caps. For each analysis, 20 leaves were collected and 5 were placed in each of 4 bags or flasks in the manner described above for fruit. The amount of ethylene in the air surrounding the leaves in the containers is the average of four determinations.

RESULTS AND DISCUSSION

Our data in Tables 1 to 5 and 7 for ethylene are not indicative of actual ethylene levels in the internal atmosphere of the fruit or leaves while

attached to the tree. Ethylene produced by the fruit escapes rapidly through the rind. Some gas may escape through the vascular tissue of the stem end of the detached fruit and through the petioles of leaves. When gas samples were taken directly from under the rind of freshly harvested fruit, little ethylene was present. When the fruit was incubated overnight in sealed polyethylene bags, substantial ethylene was detected both in the atmosphere external to the fruit and in the internal atmosphere of the fruit. These 2 values were approximately the same, indicating an equilibrium between ethylene levels inside and outside of the fruit in the bags. Thus, the ethylene values given are more indicative of production potential for a given period than actual levels of the gas inside the fruit on the tree. The controls were unfrozen leaves, fruit, and stems incubated for the same period and under the same conditions. Since the unfrozen control samples contained little ethylene, as compared to high concentrations in samples from frozen tissue, we concluded that the large evolutions of gas were caused by freezing injury.

The concentration of ethylene in the terminal shoots of Marsh grapefruit on greenhouse-grown plants in January was the highest in the immature leaves where the natural auxin level was also the greatest (Table 1). No auxin was detected in middle-aged mature leaves on any shoots, and only minute amounts of ethylene were detected in these leaves. No auxin analyses were made on old leaves. Ethylene production, however, was greater in the old leaves than in the immature leaves. These results for high ethylene evolution from old leaves are not in agreement with the low ethylene rate in aging pea (*Pisum sativum*) leaves on plants grown under controlled environmental conditions (1). Leaves from field-

Table 1. Distribution of auxin in vegetative and fruiting Marsh grapefruit shoots in relation to ethylene evolution from shoots.

Type of shoot	*Part analyzed*	*Auxin conc*	*Ethylene evolution in 125 ml flask during 24-hr period*
		(ug IAA equiv/kg fr wt)	*(ppb/10 g fr wt)*
Terminal shoot/dormant buds	Middle-aged leaves	0	3
Terminal shoot/new flush	"	0	3
Terminal shoot/new flush	Immature leaves	97	86
Terminal shoot/green fruit	Middle-aged leaves	0	3
Terminal shoot/green fruit	Green fruit	8	20
One-year old wood	Old leaves	No record	100

grown trees frequently show a loss of chlorophyll; curling or folding of the leaf blades (a form of epinasty); and abscission. All are symptoms of ethylene injury (4, 10).

On the first morning after freeze, blades on middle-aged leaves of 3-year-old Rough lemon (*Citrus limon* [L.] Burm. f.) seedlings were watersoaked. Some had live, apparently uninjured petioles. These leaves were producing large quantities of ethylene (Table 2). Three days later, most of the leaves on these Rough lemon seedlings were brown. Those that had dead petioles with the whole leaf hanging from the stem showed less ethylene production than brown leaves with live petioles and in the process of abscising (Table 2). The green leaves left on the tree showed leaf roll and a desiccated appearance. These leaves were producing large amounts of ethylene (Table 2).

On the mornings of December 16 and 17, we saw ice crystals in the flesh of a Wilking X Fortune tangerine hybrid and an Orlando (*Citrus reticulata* Blanco X *Citrus paradisi* Macf.) tangelo at Foundation Farm, Leesburg, Florida (Table 3). We also saw ice in Pineapple, Hamlin, and

Table 2. Ethylene evolution from Rough lemon leaves exposed to 22°F for 4 hr. on each night of Dec. 15 and 16 at Leesburg, Fla. Leaves sealed in polyethylene bags (50 ml air space) and incubated at room temp for 24 hr.

Condition of leaves	*Date leaves harvested*	*Ethylene content of air in bags (ppb/g fr wt)*
Blade watersoaked but petiole not killed and blade was abscising	Dec. 16	670
Brown leaves with blade and petiole injured and hanging to stem	Dec. 19	87
Brown leaves with live petioles about ready to abscise	Dec. 19	560
Green leaves with leaf roll	Dec. 19	600

Table 3. Ethylene content of internal atmosphere of frozen fruit of two citrus varieties on various dates during the month following the Dec. 15 and 16 freeze at Foundation Farm, Leesburg, Fla.

Variety	*Date*	*Freeze symptoms*	*ppb C_2H_4 in air under rind*
Wilking X Fortune #1-2-85	Dec. 16	Ice slush	100
"	Dec. 17	Some dry juice vesicles	107
"	Jan. 16	100% dried juice vesicles and some fruit abscising	1150
Orlando tangelo	Dec. 16	Trace ice crystals	41
"	Jan. 16	50% dried juice vesicles	97

Valencia (*Citrus sinensis* [L.] Osbeck) oranges at Gibb's Grove, Ocoee, Florida. Abnormally high ethylene concentrations occurred in the internal atmosphere of the freeze-injured fruit of Wilking X Fortune tangerine and Orlando tangelo on the morning after the freeze (Table 3). The ethylene content in the Wilking X Fortune variety increased tenfold during the next 4 weeks, as all the juice vesicles in the fruit dried out (Table 3). The fruits began to drop 4 weeks after freeze injury. Fruit injury and ethylene accumulation were less severe in the Orlando tangelo fruit than the Wilking X Fortune tangerine.

There was a small amount of defoliation of Red grapefruit trees. This was confined largely to old leaves and middle-aged leaves with chlorosis or freeze lesions. Four weeks after the freeze, unfrozen middle-aged leaves from Red grapefruit trees showed 10 ppb ethylene per g fresh weight (fr wt), middle-aged chlorotic leaves, 90 ppb; and middle-aged leaves with prominent freeze lesions, 700 ppb. The leaves with freeze lesions were abscising.

We collected Pineapple, Hamlin, and Valencia leaves and fruit from several locations in Florida 4 weeks after the freeze. Trees of all three varieties at Ocoee showed substantial fruit and leaf injury (Table 5). Approximately 1,000 leaves were on the ground under all of these trees, and the middle-aged leaves were rolled. The rolled leaves produced 100 to 360 ppb ethylene per g fr wt in the bags, the highest amount by Hamlin leaves and the lowest by Valencia leaves. Extensive drying of juice vesicles occurred in all fruit, but it was less in fruit of Valencia than in the other varieties. The fruits of all three varieties were producing more than normal amounts of ethylene. At Leesburg, no evidence of leaf damage was observed, but the fruit contained dry juice vesicles, and ethylene levels were high.

At Haines City, the trees heated during the freeze showed no visible freeze damage of the fruit right after the freeze, and were selected as controls. Considerable ethylene was produced, however, in the Pineapple and Hamlin fruit, but very little in the Valencia fruit (Table 5). Two weeks later, the Hamlin and Pineapple fruit showed 10 and 20%, respectively, of dried juice vesicles (Table 6). The amount of ethylene evolution from citrus fruits is easily measured and may detect injury before injury becomes visible. This hypothesis, however, needs further investigation.

Concurrently with these studies in Florida, leaves, stems, and fruit were collected from Redblush (*Citrus paradisi* Macf.) grapefruit trees at Weslaco, Texas, exposed to a temperature of 23°F for 4 hr and allowed

[3] The trees were frozen with a portable tree freezer by Ascension Peynado, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Weslaco, Texas, and the ethylene analyses were made by Fil Meredith, Utilization Division, Agricultural Research Service, U. S. Department of Agriculture, Weslaco, Texas.

to thaw for 24 hr. Ethylene analysis of these tissues revealed that frozen leaves, stems, and fruit produced more ethylene than unfrozen controls (Table 4).

Table 4. Ethylene evolution from frozen and unfrozen fruit, leaves, and stems of Redblush grapefruit trees. Trees frozen at Rio Farms, Edcouch, Texas, on Jan. 21, 1969 for 4 hr at 23°F and thawed for 24 hr[1].

Treatment	*ppb C_2H_4 in 125 ml flsk/ g for wt of leaves*	*ppb C_2H_4 in 125 ml flask/ g fr wt of stem*	*ppb C_2H_4 in bags containing fruit*
Unfrozen controls	3	6	4
Frozen	68	53	59

1 Trees frozen artificially with tree freezer by Ascension Peynado, CRD, Weslaco, Texas, and ethylene analysis made by Fil Meredith, Southern Utilization Division, Weslaco, Texas.

Table 5. Ethylene evolution from leaves and ethylene content of internal atm of fruit 4 wk after freeze Dec. 15, 1968 (22°F for 5 hr) in Florida. Leaves[1] and fruit[2] sealed in polyethylene bags and incubated at room temp for 24 hr.

Variety and location	*Leaf condition*	*Fruit condition*	*ppb C_2H_4 in bag/g fr wt of leaves*	*ppb C_2H_4 in air under rind*	*ppb C_2H_4 in bags*
Hamlin (Ocoee)	leaf roll and lesions	75% dry	360	134	119
Pineapple (Ocoee)	leaf roll	95% dry	287	58	67
Valencia (Ocoee)	leaf roll	10% dry	100	80	75
Pineapple (Leesburg)	normal	90% dry	8	84	84
Valencia (Leesburg)	normal	10% dry	5	58	122
Hamlin (Haines City)[3]	normal	some dry juice vesicles	8	127	227
Pineapple (Haines City)	normal	"	4	256	319
Valencia (Haines City)	normal	normal	8	9	8

1 50 ml air space in bags around leaves.
2 Approximately 2 liters air space around 4 fruits in each bag.
3 The trees at Haines City were heated.

When citrus trees are under stress from lack of water, both old and middle-aged leaves develop leaf-roll symptoms similar to those of freeze injury. We produced water stress leaf-roll symptoms in detached middle-aged leaves by leaving them on the laboratory table overnight. Such detached leaves under water stress produce copious quantities of ethylene as compared to freshly harvested leaves (Table 7). Whether ethylene evolution, induced by freeze injury in citrus, differs from the naturally occurring auxin-related system for production of ethylene is not known. The leaf roll and desiccation of citrus leaves, and the drying of juice vesicles induced by freezing temperatures, resemble in many ways the symptoms resulting from drought. An enhancement of ethylene evolution results from both freezing and drought, but the effect of freezing and drought on auxin production in citrus is not known.

It appears that ethylene production by the freeze-injured leaves and fruit is the probable mechanism for abscission of frozen plant parts. The frozen leaves do not abscise as a direct result of freeze injury, but they abscise because of the increased production of ethylene in the injured tissue. In the injured leaves that were abscising, the ethylene levels were near 1 ppm, which is more than adequate to cause abscission (2, 4). The levels of ethylene were generally lower in injured fruit than in leaves, which accounts for most of the injured fruit remaining on the trees, even where leaves abscise. Most of the injured Wilking X Fortune fruit, in which levels of ethylene rose to 1000 ppb, fell to the ground. Thus, whether fruit or leaves drop to the ground appears to depend on the levels of ethylene released in the tissues as a result of the freeze injury.

Table 6. Fruit analyses[1] of Hamlin, Pineapple, and Valencia oranges in Haines City (grove heated on Dec. 16 and 17) showing development of freeze injury symptoms (dried juice vesicles and loss in juice volume) in Hamlin and Pienapple oranges.

Variety and date analyzed	*Dried juice vesicles*	*Volume of juice*	*Solids*	*Acids*	*Solids/ acids*
(1969)	(%)	(%)	(%)	(%)	*ratio*
Hamlin, Jan. 15	None	42	12.10	1.10	10.9
Hamlin, Jan. 25	10[2]	40	12.90	0.92	14.1
Pineapple, Jan. 15	4	43	11.45	1.11	10.3
Pineapple, Jan. 25	20[3]	37	11.60	0.99	11.7
Valencia, Jan. 15	None	44	11.75	1.37	8.6
Valencia, Jan. 25	None[4]	44	11.75	1.37	8.6

1 Average value on 25 fruits per variety.
2 60% slight granulation, flat taste.
3 25% slight granulation, flat taste.
4 40% slight granulation, good flavor.

Table 7. Comparison of ethylene evolution from fresh and air-dried detached mature leaves of terminal shoots of several orange varieties. Leaves incubated in sealed polyethylene bags (50 ml air space) for 24 hr.

Variety	*Fresh leaves ($ppb\ C_2H_4$ fr wt)*	*Leaves air-dried for 24 hr*[1]		
		ppb C_2H_4/ g fr wt	*ppb C_2H_4/ g air dry wt*[2]	*% loss of wt by air drying*
Pineapple orange	4	457	660	38
Valencia orange	8	265	370	29
Hamlin orange	7	550	740	25

LITERATURE CITED

1. Burg, S. P. 1968. Ethylene, plant senescence and abscission. Plant Physiol. 43:1503-1511.

2. Cooper, W. C., G. K. Rasmussen, B. J. Rogers, P. C. Reece, and W. H. Henry. 1968. Control of abscission in agricultural crops and its physiological basis. Plant Physiol. 43:1560-1576.

3. Cooper, W. C.; G. K. Rasmussen, and E. S. Waldon. 1969. Stimulation of ethylene release by leaves and fruits of certain species by chilling. (Submitted for publication in Plant Physiol.)

4. Doubt, S. L. 1917. The response of plants to illuminating gas. Bot. Gaz. 63:209-224.

5. Maxie, E. C., I. L. Eaks, N. F. Sommer, H. L. Rae, and S. El-Batal. 1965. Effect of gamma radiation on rate of ethylene and carbon dioxide evolution by lemon fruit. Plant Physiol. 40:407-409.

6. Osborne, D. 1968. Defoliation and defoliants. Nature 219:564-567.

7. Oberbeek, J. van. 1938. Auxin distribution in seedlings and its bearing on the problem of bud inhibition. Bot. Gaz. 100:133-165.

8. Went, F. W., and K. V. Thimann. 1937. Phytohormones. Macmillan, New York, N. Y. 249 pp.

[1] During the 1-day air drying the leaves developed a leaf roll similar to leaves on trees with deficient moistures.

[2] This calculation was based on the weight of the leaves after air drying for 24 hr on the laboratory table. The leaves still contained moisture, were alive, and pliable.

9. Vines, H. M., W. Grierson, and G. J. Edwards. 1968. Respiration, internal atmosphere, and ethylene evolution of citrus fruit. Proc. Am. Soc. Hort. Sci. 92:227-234.

10. Zimmerman, P. W., A. E. Hitchcock, and William Crocker. 1931. The effect of ethylene and illuminating gas on roses. Contrib. Boyce Thomp. Inst. 3:459-481.

Chaff Scale Control With Certain Pesticides During 1966-68[1]

H. A. Dean[2]

Abstract: Generally, fewer live scales were found following post-bloom or summer applications of GS-13005 than in treatments with azinphosmethyl or 412 oil (with zineb, dicofol or ethion). On several occasions, azinphosmethyl was not as effective as other materials in reducing chaff scales. The 412 oil did not provide the control of chaff scales as would have been expected with heavier 440 oils recommended for summer use. At Location 1, the increased parasite activity during the September-October period in 1966 and 1967 was associated with the reduction in scale populations.

Chaff scale, *Parlatoria pergandii* Comstock, has been the most abundant armored scale insect on citrus in the Lower Rio Grande Valley of Texas for many years. Investigations were conducted during the 1966-68 period to determine the effectiveness of various pesticides for the control of chaff scales.

MATERIALS AND METHODS

Spray materials were applied with a ground sprayer equipped with single nozzle guns at the ground level, and with a tower gun above the tops of the trees using a total coverage technique (3).

Rates of materials shown in the tables are expressed in quantities of the following formulations per 100 gallons of diluted mixtures: 40% WP or 40% EC GS-13005 (0,0-dimethyl-S-(2-methoxy-1, 3, 4-thiadiazol-5-(4H)-onyl-(4)-methyl)-dithiophosphate), 22.2% EC azinphosmethyl (Guthion), 46.5% EC ethion, 42% EC dicofol (Kelthane), 75% WP zineb, 12.3% EC tetradifon (Tedion), 80% WP carbaryl (Sevin), 25% EC chlorobenzilate, 50% WP Morocide, 80% WP Metiran (Polyram) and 99.75% oil (412°F—50% distillation temperatures at 10 mm Hg., 55°F—10-90% boiling range, 74%—carbon atoms in paraffinic structures, 96%—unsulfonated residue and +15°F—pour point).

A total of 32 scale-infected leaves were collected randomly from the quadrants of 2 trees at Location 1, and 4 trees at Location 2 for determination of scale populations in each plot of the 4 replications. Test trees were oranges at Location 1, and Orlando tangelos at Location 2. However, leaves were collected from 1 grapefruit and 1 tangerine tree in 1 replicate of each treatment at Location 1. Data were recorded from examination of scales and parasites under a stereoscopic microscope according to a described method (1). Parasites were Hymenoptera of the *Aphytis* complex (2).

RESULTS AND DISCUSSION

The data on the effect of various pesticides on chaff scales and their parasites are summarized in Tables 1 and 2 under post-bloom, summer and fall headings. Several records were deleted to conserve space since they did not alter the results as stated.

Post-bloom. Generally, fewer live scale insects were found after application of GS-13005 than were found after application of azinphosmethyl or 412 oil (with zineb, ½ rate dicofol or ethion). At Location 1, the numbers of live scales in all 3 records in 1967 and 1968 were greater from the azinphosmethyl plots than GS-13005 plots while in 1966 live scale numbers were about the same from these plots. Live scale numbers continued to increase after dicofol-chlorobenzilate application in 1966 and parasites were not in sufficient numbers to deter the increase of scales in these plots. The early May records showed fewer live scales in 412 oil-dicofol plots in 1967 and 412 oil-ethion plots in 1968 than in the azinphosmethyl plots; however, live scale numbers were larger in the June counts from the former plots. At Location 2, a greater reduction of live scales was found in the 412 oil-zineb plots in 1967 than in the GS-13005 or azinphosmethyl plots, but live scale numbers were greater in the June and July counts from the oil plots. The reduction of live scales was not as great following application of azinphosmethyl as compared to GS-13005 in 1967, but the increase in scale numbers was small in azinphosmethyl plots while a sharp increase was found in the July counts from GS-13005 plots. In 1968, live scale numbers remained small after the April 15 and May 28 applications of GS-13005 and azinphosmethyl. Live scale numbers were reduced to 29 on May 6 after 412 oil-zineb, increased on May 22 and continued to increase after the May 28 application of dicofol-zineb. Parasites were in small numbers in the counts from the combination plots and were not found in the GS-13005 or azinphosmethyl plots except on 3 occasions. The smaller numbers of scales per leaf and the difficulty experienced in collection of samples were indications that scale populations were smaller during each successive year.

Summer. Considerable variation in the size of scale populations was found after summer treatments were applied, particularly at Location 1. At this location, smaller numbers of live scales were found in the 4 counts after July 14, 1966 application of GS-13005 than after 1.6% 412 oil-dicofol-zineb or azinphosmethyl treatments. The largest numbers of live scales were found in azinphosmethyl plots. The increased number of parasites during October in the 412 oil-dicofol-zineb and azinphosmethyl plots was apparently a contributing factor for reduced scale numbers in these plots. In 1967, smaller numbers of live scales were found 41 and 76 days after application of 412 oil-ethion than after applications of GS-13005 or azinphosmethyl. Parasites were increasing in numbers on September 7 before the September 19-27 period when 12.99 inches of

[1] Technical Contribution No. 8009. Texas Agricultural Experiment Station, Texas A&M University, Weslaco. These investigations were partially supported by Geigy Chemical Corporation.

[2] Associate Professor, TAES, Weslaco.

Table 1. Chaff scale and chaff scale parasites following application of various pesticides to citrus at Location 1 during 1966-68.

Date	*AS*[1]	*LP*[2]	*SL*[3]	*AS*	*LP*	*SL*	*AS*	*LP*	*SL*
	GS-13005			*Azinphosmethyl*			*Combinations*		
4/7/66	16	0	6.6	30	0	5.0	84	0	4.9
4/18	1 lb GS-13005			710 ml azinphosmethyl			378 ml dicofol + 378 ml chlorobenzilate		
5/18	2	0	4.9	8	0	4.5	144	3	3.9
6/14	10	0	5.8	12	0	3.5	172	24	3.9
7/1	14	0	3.2	18	0	4.1	231	4	3.9
7/14	1 lb GS-13005			710 ml azinphosmethyl			1.6 gal 412 oil + 179 ml dicofol + .5 lb zineb		
8/23	7	0	4.0	50	0	3.8	34	0	4.0
9/12	10	0	4.2	34	2	5.2	74	15	4.4
10/5	56	7	3.9	92	25	3.6	67	49	4.1
10/25	5	10	3.5	72	33	3.6	21	18	4.8
10/25	1 lb GS-13005			710 ml azinphosmethyl			0.5 lb Morocide + 1 lb Metiram		
12/5	3	0	3.6	29	0	3.0	19	3	3.9
1/10/67	1	0	3.4	10	0	2.9	33	2	3.0
3/9	1	0	3.5	14	0	3.3	56	1	4.2
4/5	1 lb GS-13005			710 ml azinphosmethyl			1 gal 412 oil + 189 ml dicofol + 1 lb zineb		
5/9	2	0	4.0	57	0	3.6	20	1	4.3
5/31	20	0	3.2	49	0	2.5	62	0	3.2
6/20	65	0	2.9	114	0	4.1	131	0	4.2
6/23	1 lb GS-13005			1.5 lb.azinphosmethyl			1 gal 412 oil + 373 ml ethion		
8/3	53	2	3.0	72	0	3.7	28	2	4.7
9/7	84	48	2.3	94	14	3.0	47	24	3.1
9/28	27	14	1.7	76	22	3.7	25	14	2.9
10/16	58	5	1.8	82	19	2.9	44	6	3.6
10/26	1 lb GS-13005			1.5 lb.azinphosmethyl			1 gal 412 oil + 373 ml ethion		
12/1	4	0	1.3	22	0	3.0	25	2	3.8
2/6/68	12	0	2.1	33	1	3.1	38	0	3.4
4/3	35	1	1.5	50	0	2.2	51	1	5.6
4/8	1 lb GS-13005			710 ml azinphosmethyl			1 gal 412 oil + 473 ml ethion		
5/1	9	0	1.5	32	2	3.0	21	2	3.2
5/28	38	0	1.9	70	0	3.2	17	0	2.4
6/19	78	0	1.6	117	0	2.9	159	0	3.1
7/10	630 ml GS-13005			710 ml azinphosmethyl			1 gal 412 oil + 473 ml ethion		
8/15	10	0	1.2	49	0	3.0	37	0	2.3
9/2	70	1	2.0	52	0	2.5	52	0	1.6

(Continued)

Table 1. (continued)

Date	*AS*[1]	*LP*[2]	*SL*[3]	*AS*	*LP*	*SL*	*AS*	*LP*	*SL*
	GS-13005			*Azinphosmethyl*			*Combinations*		
9/17	115	6	2.5	86	2	2.4	195	8	3.6
9/19	1 lb GS-13005			710 ml azinphosmethyl			0.5 gal 412 oil + 473 ml ethion		
10/23	83	34	3.8	107	7	3.4	239	9	4.8
10/30	1 lb GS-13005 + 946 ml tetradifon			946 ml tetradifon			946 ml tetradifon		
11/13	57	10	2.4	93	7	2.8	188	20	3.5
12/19		[4]		151	15	2.7	158	17	3.0
2/28/69		[4]		122	19	1.9	160	25	2.3

[1] Number of live scales.
[2] Number of scales with live, immature parasites.
[3] Number of scales per leaf.
[4] Insufficient scales for valid count.

rain fell in association with Hurricane Beulah. Numbers of live scales decreased in all plots on September 28, but live scale numbers were larger in azinphosmethyl plots on September 28 and October 16. In 1968, live scale numbers were not reduced as much following azinphosmethyl as GS-13005 or oil-ethion, but sharper increases of live scales were found in the September counts from the latter 2 treatment plots. Materials were applied on September 19, 1968 because of infestations of Texas citrus mites. The numbers of live scales increased after the 0.5% 412 oil-ethion and azinphosmethyl treatments while only 28% reduction in live scales was found after GS-13005. The number of scales per leaf, at Location 1, was smaller during each successive year in all treatment plots. This number was smaller each year from GS-13005 plots and generally larger from combinations plots.

At Location 2, live scale numbers were much smaller before summer applications in 1968 than in 1967, except in the combinations plots. In 1967, only 38 of the 1600 scales examined during the August-October period from the GS-13005 plots were alive. Reduction of live scales following azinphosmethyl was not as great as following 1.6% 412 oil-carbaryl-zineb, but scale numbers were greater in the latter plots in the October counts. In 1968, the density of scales was so small on October 31 in the GS-13005 and azinphosmethyl plots that counts were not made. The numbers of live scales were greater than 100 after the 1.6% 412 oil-zineb application on August 8, however, counts were made from a small scale density which had an increasing number of parasites. The numbers of scales per leaf were much smaller in 1968 than in 1967 in all plots.

Fall. At Location 1, the October treatments for the combinations plots varied each year while other plot treatments were changed in 1968.

In 1966, an occasional live scale was found in the December-March records from the GS-13005 plots. Live scales generally remained in small numbers after application of Morocide-Metiram and azinphosmethyl, although an increase was found in plots of the former treatment in January and March. In 1967, fewer live scales were found in GS-13005 plots than in 1.0% 412 oil-ethion or azinphosmethyl plots which had about the same numbers of live scales in the December-April period. The October 30, 1968 applications were made to all plots for the control

Table 2. Chaff scale and chaff scale parasite populations following application of various pesticides to citrus at Location 2 at Weslaco during 1967-68.

Date	*GS-13005*			*Azinphosmethyl*			*Combinations*		
	AS[1]	*LP*[2]	*SL*[3]	*AS*	*LP*	*SL*	*AS*	*LP*	*SL*
4/10/67	97	23	8.9	85	36	8.0	112	28	8.5
4/28	1 lb GS-13005			710 ml azinphosmethyl[4]			1 gal 412 oil[5]		
5/18	31	1	9.5	46	1	9.5	24	1	8.5
6/29	32	0	8.5	66	2	9.5	92	2	8.7
7/20	91	0	8.9	70	0	7.7	106	6	9.3
7/31	1 lb GS-13005			710 ml azinphosmethyl			1.6 gal 412 oil[5,6]		
8/25	14	0	7.1	45	0	9.1	31	0	8.5
9/14	3	4	8.9	16	5	9.1	5	2	8.9
10/9	16	0	6.2	31	6	8.7	76	10	8.5
10/30	5	0	6.0	31	0	7.7	75	3	8.2
11/1	1 lb GS-13005			710 ml azinphosmethyl			378 ml dicofol[5]		
12/11	0	0	7.1	5	0	8.0	58	16	7.5
1/10/68	0	0	6.2	2	0	7.0	71	10	6.9
4/4	1	0	5.6	8	0	6.6	148	8	4.5
4/15	1 lb GS-13005			710 ml azinphosmethyl			1 gal 412 oil[5]		
5/6	1	0	6.1	2	0	6.5	29	6	4.9
5/22	1	0	5.5	9	0	5.0	47	4	4.8
5/28	1 lb GS-13005			710 ml azinphosmethyl			378 ml dicofol[5]		
6/25	30	0	4.1	2	0	4.2	85	5	3.9
7/18	0	0	3.7	2	0	4.4	113	3	6.5
8/8	1 lb GS-13005			710 ml azinphosmethyl			1.6 gal 412 oil[5]		
9/27	25	1	2.9	55	4	4.5	104	8	4.4
10/31		[7]			[7]		122	47	3.3
11/21	1 lb GS-13005			710 ml azinphosmethyl			473 ml dicofol[5]		
12/30		[7]			[7]		181	31	3.2

[1] Number of live scale.
[2] Number of live, immature parasites.
[3] Number of scales per leaf.
[4] Replicates 3 and 4 sprayed on May 9 after sprayer repair.
[5] 1 lb zineb.
[6] 0.33 lb carbaryl.
[7] Insufficient scales available for count.

of Texas citrus mites. The November 13 record was the last made following GS-13005 (4 applications during 1968) because of the difficulty in finding sufficient scale-infested leaves. Considerable time was necessary to collect scale samples from the other treatment plots, but a few more live scales were found in the combinations plots. Some increased parasite activity was found in the latter treatment plots. In general, the numbers of scales per leaf were progressively smaller each year following application of fall treatments to all plots.

LITERATURE CITED

1. Dean, H. A. 1961. *Aphytis lepidosaphes* (Hymenoptera: Chalcidoides), an introduced parasite of purple scale. Ann. Entomol. Soc. Amer. 54:918-20.
2. Dean, H. A. 1965. An *Aphytis* complex (Hymenoptera: Eulophidae) of chaff scale. Ann. Entomol. Soc. Amer. 58:142-5.
3. Riehl, L. A. 1961. A routine system for spray application manually to citrus. J. Rio Grande Valley Hort. Soc. 15:3-9.

Implications of Insect Resistance to Pesticides in the Rio Grande Valley Area[1]

W. G. HART[2]

Resistance to pesticides begins when the susceptible members of a population of organisms are killed and those members that are left have the genetic capability of producing offspring like themselves which are not adversely affected by the pesticide. For the purpose of this discussion, the organisms in question are mites, insects, and ticks, but many of the basic principles of resistance relating to these organisms apply to other organisms such as bacteria. Therefore, resistance in this context involves the effects of a pesticide on a population and not on individuals. Thus, applications of nonlethal doses of pesticides to individual insects, mites, or ticks will not build up resistance; it can only be brought about by a process of selection in which the weak are eliminated and the strong survive.

The resistance to insecticides and miticides of most pest species is associated with the development of synthetic organic insecticides during and since World War II. However, some clearcut cases of resistance were recorded much earlier. For example, in 1908 (7), the San Jose scale, *Aspidiotus perniciosus* (Comstock), in California became resistant to lime sulfur; in 1916 (8), the California red scale, *Aonidiella aurantii* (Maskell), became resistant to hydrogen cyanide; and in 1928 (6), the codling moth, *Carpocapsa pomonella* (L.), a pest of apples, became resistant to lead arsenate. Also, before 1946 (3), two species of cattle ticks, *Boophilus microplus* (Canestrini) and *B. decoloratus* (Koch), were found to be resistant to sodium arsenite and two species of thrips, *Scirtothrips* spp. and *Taeniothrips* spp., to tartar emetic. Still, the real significance of resistance was probably not recognized until the synthetic organic insecticides became available. Then almost as rapidly as they were developed, resistance followed. DDT was introduced during World War II, and resistant house flies, *Musca domestica* (L.), were first reported in 1946 (10). The organophosphates, products of the German poison gas studies during World War II, came into use shortly after the war, and by 1946 (9), resistance to organophosphates had developed in spider mites, *Tetranychus cinnabarinus* (Boisduval), in greenhouses. Also, house flies had become resistant to the dieldrin or cyclodiene group of compounds by 1949 (2). Finally, resistance to the carbamate compounds, a much newer group of insecticides, has been reported very recently in house flies and several other pests (3).

The ability of insect species to overcome the harmful effects of chemical control is not confined to insecticides and miticides. Mosquitoes and house flies have developed resistance to three different types of chemosterilants during the period from 1964 to 1967 (3) and house flies resistant to bacterial toxicants such as thuricide were reported in 1965 (3). Thus, the dates of development of the various groups of pesticides and the dates when resistance became clearly evident prove that insects and mites were able to overcome the toxic effects in a very short time.

Fortunately, resistance does not develop completely throughout populations of a species in all areas at one time. It may occur simultaneously in several locations in a general area, and these pockets may merge later, or it may develop in one location and spread out from there. Meanwhile, the species may still be controlled in some areas by a pesticide to which it is resistant in others. Organisms that are usually first to show indications of resistance are those with short life cycles, that is, species that produce several generations per year. Naturally, such species would be more likely to develop resistance because the generations that succeed each other so rapidly have more and more survivors with the characteristics for resistance.

As noted, one of the more advanced cases of resistance is the house fly which, by 1955, was resistant to all 3 groups of pesticides. The species was first reported resistant to DDT, then to dieldrin, and then finally to the organophosphates; since that time, resistance has also been found to carbamates, at least in the laboratory (3). The resistance of spider mites to the chlorinated hydrocarbons and organophosphates occurred in reverse order to that of house flies. Probably the first resistance against these mites was reported by Compton and Kearns (4) who found that *Tetranychus cinnabarinus* (Boisduval) on roses were much harder to kill with selenium compound than the same species on snapdragons. (It has since been shown that mite strains, not hosts, determine the level of toxicity.)

Table 1 shows the periods of effectiveness of pesticides used against the two spotted spider mite in the greenhouse (9). The first 5 com-

Table 1. Periods of effectiveness of selected pesticides on the two spotted spider mite in greenhouses.

Hexaethyl Tetraphosphate	1946-1947	Demeton	1950-1953
TEPP	1947-1947	Biphenyl	1950-1954
Parathion	1947-1947	Ethoxyquin	1953-1954
Sulfotepp	1948-1950	Chlorbenside	1953-1954
Schradan	1949-1953	Dicofol	1954-1956
Ovex	1949-1953	Tetradifon	1956-1957

[1] Talk given January 21, 1969 at the Annual Rio Grande Valley Horticultural Institute, Weslaco, Texas.

[2] Research Entomologist, Entomology Research Division, Agricultural Research Service, USDA, Weslaco, Texas.

pounds are organophosphates; their useful life varied from one year or less to 4 years. Ovex, a chlorinated hydrocarbon, lasted 4 years; demeton (Systox®), an organophosphate with systemic action, was effective 3 years. The remaining compounds are hydrocarbons or chlorinated hydrocarbons that also had varying periods of effectiveness. I was working in the development of greenhouse aerosols during this period, and it was very frustrating to work on the formulation, biological efficiency, registration, and marketing of these products only to find that the mites were resistant shortly after the products appeared. The situation became so acute in some eastern greenhouse rose ranges that growers were advised either to resort to such old-fashioned practices as washing the mites off with a strong stream of water or to change to crops that were less susceptible to mite injury. Some heavily infested rose ranges during this period appeared to have been burned out, the mite damage was so severe.

Among cockroaches (Blattidae), the German roach, *Blattella germanica* (L.), had become resistant to the DDT and dieldrin groups by 1956 (2) and became resistant to some organophosphorous compounds a little later (3). There was also an indirect effect noted by some observers. Although roaches normally tend to be found around kitchens and wash areas, they began to appear throughout the house, in closets, in furniture, and in other places, once resistance had set in. The oriental roach, *Blatta orientalis* (L.), has been slower in becoming resistant, and, to date, the only clearly defined resistance in the species is to dieldrin-type insecticides (3). However, with roaches, as with other household and agricultural pests, there is a tendency to blame poor control on resistance when the difficulty actually results from inadequate or improper treatment. Standard tests for many pest species have been established that will provide definite proof of resistance, and unless these tests or similar procedures are followed, it is difficult to be certain of the source of difficulty.

As each year passes, many new pests are added to the list of insects and mites that have developed resistance. Also, the production of cocoa, cotton, sugarcane, rice, apples, forest trees, and cattle, all principal crops of countries or regions, have been adversely affected by major problems with resistant insects. Resistance is a factor in controlling insects pests of most agricultural crops, pests of stored products, and insects of medical importance. Table 2 (3) shows the number of species of insects in the various orders that are resistant to the various groups of pesticides. The Diptera (flies) have 88 resistant species with some resistant to each of the 3 major groups of pesticides plus some resistant to a 4th category which includes inorganic and botanical insecticides; Lepidoptera (moths and butterflies) have 34 resistant species; Hemiptera (true bugs) have 36; Acarina, which includes mites and ticks, have 25; Coleoptera (beetles) have 22; and the less important or smaller orders have 19. These figures represent the situation in 1967. Since that time, the list has undoubtedly expanded. (It is interesting that at least one species in each order is resistant to all 4 groups of pesticides.)

When resistance starts to appear in a pest species, the usual first step is to increase the dose. This step is then followed by more frequent applications of the pesticides, and such increases in doses and frequency of treatment can become extreme. A local example would be the use of methyl and ethyl parathion for control of *Heliothis* spp. on cotton: As much as 3 pounds of insecticide per acre may be applied more than 20 times during the growing season, but the evidence of resistance only becomes increasingly apparent. It is doubtful if the toxicants will be useful much longer. These heavy applications of pesticide upset other species present on the target crop because they destroy beneficial parasites and predators. In addition, the drift of these pesticides into adjacent crops causes large-scale destruction of parasites and predators there with accompanying upsurges of pest species in these crops. Thus, there is a problem with brown soft scale, *Coccus hesperidum* (L.), on citrus in the Rio Grande Valley because of the drift of pesticides from cotton into citrus. (Bioassays have revealed that parasites and predators have been destroyed in citrus groves that are as much as 1500 feet from the flight line of insecticides that are applied annually.) Moreover, the pesticides have had a stimulating effect on the populations of brown soft scale (5).

Figure 1 shows the rate of increase that occurred in test plots in a citrus grove where methyl parathion and 2 doses of malathion were applied compared with a check. Methyl parathion had been unwisely applied previously in this grove by the grower to control aphids. The control of aphids was quite good, but the resulting infestation of brown soft scale was among the worst encountered in the area. It occurred partly, at least, because the application of methyl parathion had so reduced the populations of parasites and predators. However, the increase of brown soft scale was so extreme that investigators at the Brown Soft Scale Investigations Laboratory at Weslaco, Texas were led to investigate the possibility of a stimulatory effect. The subsequent observations on potted citrus in the laboratory and greenhouse substantiated the evidence of stimulation. Also, other investigators reported stimulatory effects on mites and aphids succeeding the buildup of re-

Table 2. Numbers of species in the various orders with resistances of various types, 1967.

	DDT	*Dld*	*OP*	*Other*	*Total*
Diptera	44	68	14	3	88
Lepidoptera	14	14	6	5	34
Hemiptera	10	15	14	4	36
Acarina	3	7	16	4	25
Coleoptera	5	19	1	1	22
Other orders	15	12	3	2	19
Total	91	135	54	20	224

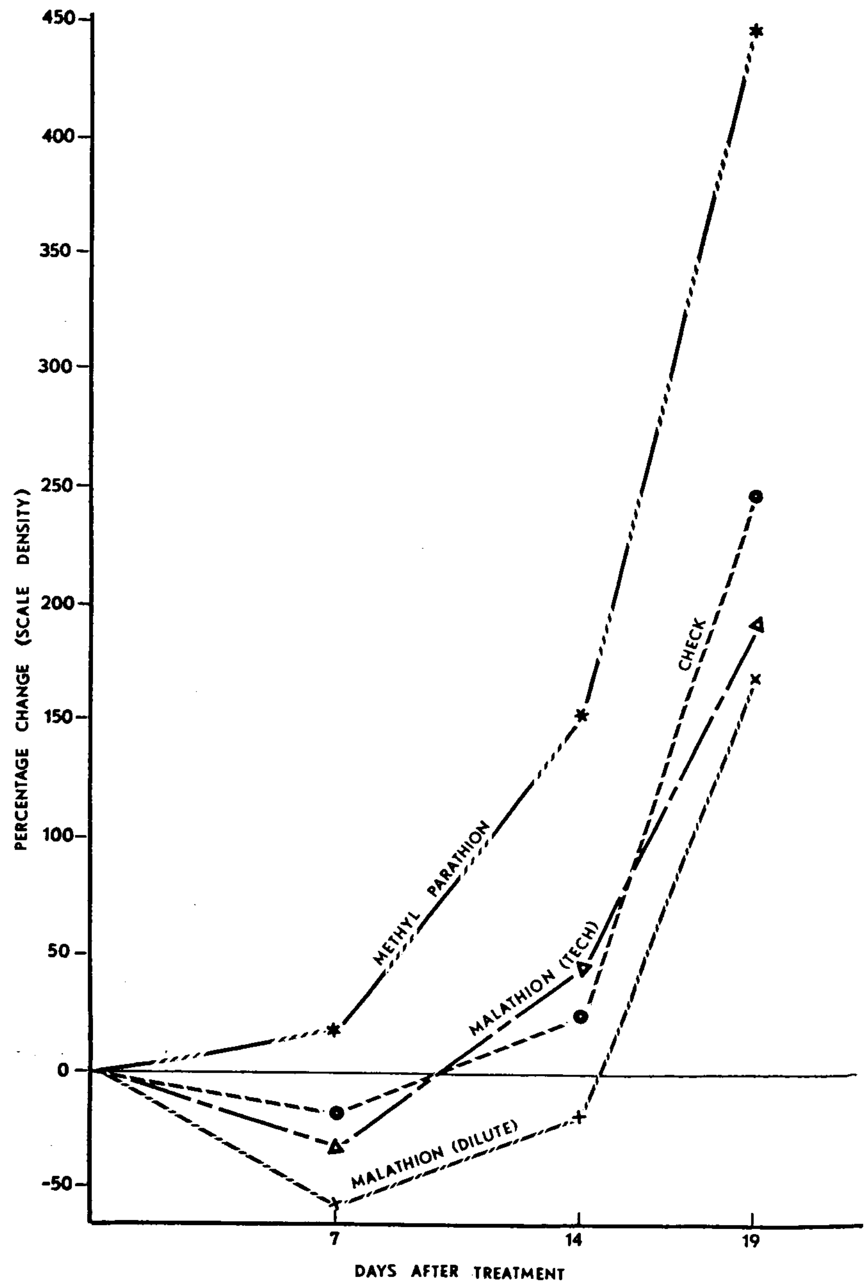


Figure 1. Effect of aerial applications of insecticide on brown soft scale on citrus

sistance in these pests (1). For example, before the use of DDT, many mite species that are now problems were not considered pests.

On the bright side, there is evidence that resistance has developed in some beneficial species (3). Honey bees, *Apis mellifera* (L), in California, parasitic wasps, *Macrocentrus ancylivorus* (Rohwer), in Ontario, and mayfly nymphs, *Heptagenia* spp. and *Stenonema* spp., in New Brunswick have been reported resistant to DDT, and a predaceous mite, *Typhlodromus* sp., has been reported resistant to parathion in British Columbia. Also, fish, frogs, and mice have been found resistant to chlorinated hydrocarbon insecticides.

Locally, cotton has been the crop most severely plagued by resistant insects. Spider mites, *Tetranychus* spp., tobacco budworm, *Heliothis virescens* (F.), and cabbage loopers, *Trichoplusia ni* (Hubner), have all become resistant to pesticides in all 3 of the groups, and cotton fleahoppers, *Psallus seriatus* (Reuter), pink bollworms, *Pectinophora gossypiella* (Saunders), and bollworms, *Heliothis zea* (Boddie), are resistant to the chlorinated hydrocarbons (M. L. Lukefahr, personal communication). In vegetables, the diamond back moth, *Plutella maculipennis* (Curtis), on cabbage and the beet armyworm, *Spodoptera exigua* (Hubner), have become resistant as has a spotted looper, *Pseudoplusia includens* (Walker), which is a pest of both cotton and vegetables. This spotted looper was prominent in cotton plantings throughout the area this past season and showed little effect from the spray of methyl parathion. The picture among citrus pests is not as well defined, though, as noted, it seems reasonable to assume that the increase in brown soft scale is at least related to resistance. However, whether the resistance of brown soft scale to methyl parathion is acquired or natural, it has certainly been complicated by the use of this insecticide on cotton to replace other pesticides to which cotton pests had become resistant (and the present increase in frequency of application and dose that began when it became more difficult to kill the budworm).

Among the possible solutions to the local problems of resistance (without reference to large-scale eradication-type programs) might be: (a) laboratory development of resistant strains of beneficial species (parasites and predators); b) greater emphasis on integrated control which would involve more care in selection of pesticides having the least harmful effect on the parasite-predator complexes of pest species (particularly pest species other than those for which the spray is intended); selection and development of more specific pesticides would also be involved; (c) development of pesticides with distinctly different chemical configurations and with new modes of action (there are some now on the horizon that may lend themselves to the specificity mentioned); and (d) the development of plant varieties having resistance to pests.

SUMMARY

Resistance to pesticides occurs when the pest insect in question can survive more frequent applications and increased doses of a pesticide and

it becomes necessary to try any and all available materials to avert crop injury. This crisis is usually followed by indirect problems such as abnormal increases in the populations of other pests, some of which may not have been of economic significance and by increased drift into adjacent crops with resulting complications that become more acute as the intensity of the spraying rises. The increase in pest species may result from the destruction of parasites and predators or, as recent evidence indicates, from the stimulation of the reproductive rate of some pests exposed to pesticides.

LITERATURE CITED

1. Bartlett, B. R. 1968. J. Econ. Entomol. 61(1):297-303.
2. Brown, A. W. A. 1961. Bull. Entomol. Soc. Amer. 7(1):8.
3. Brown, A. W. A. 1968. Bull. Entomol. Soc. Amer. 14(1):3,4,6,8,9.
4. Compton, C. C. and C. W. Kearns. 1937. J. Econ. Entomol. 30:512-522.
5. Hart, W. G., S. Ingle, M. Garza, and M. Mata. 1966. J. Rio Grande Valley Hort. Soc. 20:64-68.
6. Hough, W. S. 1928. J. Econ. Entomol. 21:325-329.
7. Melander, A. 1914. J. Econ. Entomol. 7:167-172.
8. Quayle, H. 1916. Univ. Calif. J. Agr. 3:333-334, 358.
9. Smith, F. F. and R. A. Fulton. 1951. J. Econ. Entomol. 44:229-233.
10. Weismann, R. 1947. Mitt. Schweiz. Entomol. Ges. 20:484-504.

Control of Citrus Mites with Certain Pesticides During 1966-68[1]

H. A. Dean[2]

Abstract: Texas citrus mites increased in numbers at an earlier date after post-bloom or summer applications of GS-13005 than after azinphosmethyl or 412 oil with zineb, ethion or ½ rate dicofol. Texas citrus mite control during the first 60 days after post-bloom application of azinphosmethyl in 1966 and 1967 was better than with the 412 oil combinations treatments. However in 1968, control with azinphosmethyl was inferior to that with other treatments applied at post-bloom. Fewer mites were found for 5 to 8 weeks after summer application of 412 oil mixed with dicofol or ethion at Location 1. Control of this mite after summer application at Location 2 was best with azinphosmethyl in 1967, but was just as good with azinphosmethyl or 412 oil-zineb in 1968. Mite numbers were much greater in 1968 than in 1966 and 1967 following post-bloom and summer applications of GS-13005 or azinphosmethyl. Very small mite populations were found after fall application of all treatments.

The effectiveness of several pesticides for the control of the Texas citrus mite, *Eutetranychus banksi* (McGregor), has decreased in past years. For example, tetradifon (Tedion) failed to control this mite after 4 or 5 applications at the rate which was effective in previous years (1), and only partial control of Texas citrus mite infestations is now obtained with sulfur. This lack of control would suggest the development of resistance of this mite to these chemicals. Investigations were begun in 1966 to determine the effectiveness of certain pesticides used singly and in combination against this mite.

MATERIALS AND METHODS

Spray materials were applied at ground level with a ground sprayer equipped with single nozzle guns, as well as with a tower gun above the tops of the trees using a total coverage technique (2).

Rates of materials shown in the tables are expressed in quantities of the following formulations per 100 gallons of diluted mixtures: 40% WP or 40% EC GS-13005 (0,0-dimethyl-S-(2-methoxy-1, 3, 4-thiadiazol-5-(4H)-onyl-(4)-methyl)-dithiophosphate), 22.2% EC azinphosmethyl (Guthion), 46.5% EC ethion, 42% EC dicofol (Kelthane), 75% WP zineb, 12.3% EC tetradifon (Tedion), 80% WP carbaryl (Sevin), 25% EC chlorobenzilate, 50% WP Morocide, 80% WP Metiram (Polyram) and 99.75% oil (412°F–50% distillation temperature at 10mm Hg., 55°F – 10-90% boiling range, 74%-carbon atoms in paraffinic structures, 96%-unsulfonated residue and +15°F-pour point).

[1] Technical Contribution No. 7999. Texas Agricultural Experiment Station, Texas A&M University, Weslaco. These investigations were partially supported by Geigy Chemical Corporation.

[2] Associate Professor, TAES, Weslaco.

Mite populations were determined from 40-leaf samples taken in each of the replications. At Location 1, trees were principally oranges, but 1 grapefruit tree and 1 tangerine tree were sampled from each treatment plot. Test trees were Orlando tangelos at Location 2. Mature terminal flush leaves were randomly-sampled 5 to 7 feet above the ground in each quadrant. Mites were brushed from the leaves onto a 5-inch plate with a mite-brushing machine and were counted on ½ the area with a stereoscopic microscope.

RESULTS AND DISCUSSION

The data on numbers of Texas citrus mites and their eggs following applications of various pesticides at the 2 locations are summarized in Tables 1 and 2. Only those records which contributed to an explanation of the effectiveness of various materials in control of Texas citrus mites are shown; other records were deleted to conserve space. Results will be discussed under post-bloom, summer and fall headings.

Post-bloom. Greater increases in Texas citrus mite populations were found in 1966 and 1967 during the first 8 weeks after application of GS-13005 than after application of azinphosmethyl, 412 oil (mixed with zineb, ethion or ½ rate dicofol) or dicofol-chlorobenzilate. Mite populations were generally greater from azinphosmethyl plots in 1968. At Location 1, mite numbers were largest from dicofol-chlorobenzilate plots after 68 days in 1966, from GS-13005 plots after 44 days in 1967 and from azinphosmethyl plots after 43 days in 1968. Egg numbers were greater than motile mite numbers in almost all counts and such larger egg numbers were usually followed by increases in mite populations. A much larger increase in mite and egg numbers was found in 1968 soon after April application of GS-13005 and azinphosmethyl than in prior years at both locations, indicating some degree of resistance. Mite populations were larger in the May records after April 15, 1968 application of azinphosmethyl than GS-13005 or 412 oil-zineb at Location 2. Materials were applied again at this location on May 28. The total numbers of mites and eggs were smaller during the May-July period in 412 oil-zineb plots than in GS-13005 or azinphosmethyl plots.

A smaller reduction of mite populations occurred in the combinations plots than in other plots during June or July at Location 1. In 1966 and 1968, these reductions followed periods in which rainfall was recorded on 9 of 11 days. However, only .03 inch of rain fell between May 19 and June 1, 1967; so rainfall could not have been associated with the decreased mite populations recorded on June 1. No reason can be given for the decrease in mite populations recorded on July 31, 1967 at Location 2.

Summer. Texas citrus mites began increasing in numbers at an earlier date after summer application of GS-13005 than after applications of azinphosmethyl or 412 oil plus zineb, ethion or ½ rate dicofol during each year. During the first 60 days after application of GS-13005 at Location 1 in 1966 and 1967, Texas citrus mites were more numerous

Table 1. Number of Texas citrus mites per 80 leaves following various pesticides at Location 1, Weslaco, Texas during 1966-68.

	GS-13005		*Azinphosmethyl*		*Combinations*	
Date	*TCM*[1]	*TCME*[2]	*TCM*	*TCME*	*TCM*	*TCME*
4/4/66	0	0	4	0	0	0
4/13	1 lb GS-13005		710 ml azinphosmethyl		378 ml dicofol + 378 ml chlorobenzilate	
6/4	154	110	20	28	37	32
6/20	252	400	205	239	506	539
7/7	26	10	74	149	182	254
7/14	1 lb GS-13005		710 ml azinphosmethyl		1.6 gal 412 oil + 189 ml dicofol + .5 lb zineb	
8/19	47	131	5	11	11	12
9/12	265	597	67	73	32	67
10/5	310	841	108	190	283	627
10/24	99	189	50	116	275	619
10/25	1 lb GS-13005		710 ml azinphosmethyl		.5 lb Morocide + 1 lb Metiram	
12/5	6	5	1	1	0	1
3/3/67	22	47	5	12	236	1224
3/29	260	409	329	1822	710	1383
4/5	1 lb GS-13005		1 lb azinphosmethyl		1 gal 412 oil + 189 ml dicofol + 1 lb zineb	
4/19	50	209	0	0	9	24
5/6	546	1078	0	0	97	225
5/19	377	816	5	9	181	509
6/1	70	200	5	18	48	201
6/20	781	1040	1039	3523	2203	3048
6/23	1 lb GS-13005		1 lb azinphosmethyl		1 gal 412 oil + 373 ml ethion	
8/1	82	322	1	2	2	2
8/22	435	843	124	322	73	237
9/7	252	360	836	1344	55	163
9/28	9	9	25	25	13	7
10/16	10	18	113	25	17	121
10/26	1 lb GS-13005		1 lb azinphosmethyl		1 gal 412 oil + 373 ml ethion	
12/1	5	1	1	0	1	1
2/6/68	59	34	6	10	5	4
4/3	75	156	20	41	4	15
4/8	1 lb GS-13005		710 ml azinphosmethyl		1 gal 412 oil + 473 ml ethion	
5/1	286	225	33	47	2	2
5/21	802	1741	893	3566	4	36
6/18	1244	1555	1966	3254	277	809
6/27	1102	1536	2333	1573	1028	1203

(Continued)

Table 1. *(Continued)*

Date	GS-13005 TCM[1]	GS-13005 TCME[2]	Azinphosmethyl TCM	Azinphosmethyl TCME	Combinations TCM	Combinations TCME
7/8	77	49	240	152	314	320
7/10	630 ml GS-13005		710 ml azinphosmethyl		1 gal 412 oil + 473 ml ethion	
8/6	102	73	74	48	22	79
8/15	123	240	126	176	49	159
9/2	191	248	743	1694	918	1799
9/17	134	110	195	260	725	885
9/19	1 lb GS-13005		710 ml azinphosmethyl		.5 gal 412 oil + 473 ml ethion	
9/26	29	2	3	4	8	5
10/11	289	385	31	48	25	41
10/29	2089	1958	225	378	136	227
10/30	1 lb GS-13005 + 946 ml tetradifon		946 ml tetradifon		946 ml tetradifon	
11/27	10	54	1	8	5	12
1/15/69	64	182	6	4	8	27

[1] Motile Texas citrus mites.
[2] Texas citrus mite eggs.

than in other treatment plots. On the other hand, in 1968 their numbers were smaller 55 days after application of the emulsifiable GS-13005 than in other treatment plots. Fewer mites were found 60 days after treatment with 412 oil-½ rate dicofol in 1966 and 412 oil-ethion in 1967 than after application of azinphosmethyl. Treatments were applied on September 19, 1968. GS-13005 plots had much larger mite populations during October than azinphosmethyl or .5% 412 oil-ethion plots. At Location 2, mite populations were smaller 46 days after application of azinphosmethyl in 1967 than after 412 oil-zineb-carbaryl or GS-13005 treatments. The addition of carbaryl to the oil was, no doubt, an associating factor with this increase in mite numbers. In 1968 at the same location, mite numbers were the same 62 days after application of either azinphosmethyl or 1.6% 412 oil-zineb. A sharp increase in numbers occurred thereafter in these plots. In most instances, more eggs were found in treatment plots having the largest number of motile mites.

The degree of decrease in mite and egg numbers varied each year following several days of rainfall. Following the October 5, 1966, August 22, 1967 and September 2, 1968 records at Location 1, the total inches of rain which fell on the respective number of days were as follows: 4.99-4, 1.98-9 and 1.16-4. In GS-13005 plots, the greatest reduction occurred following the greater amount of rain in 1966 while the least reduction occurred in 1968. In azinphosmethyl plots, the greatest reduction in numbers of mites occurred in 1968 while populations increased sharply in 1967. Very little reduction in mite numbers occurred in the

combinations plots. Very sharp reductions in mite populations were found in all treatment plots at both locations following the September 19-27, 1967 period, when 12.99 inches of rain fell in association with hurricane Beulah. Large increases in mite populations were found in all plots, however, on October 30 at Location 2.

Fall. The increase in mite populations following fall applications of all materials usually was very small. An earlier increase in mite popu-

Table 2. Number of Texas citrus mites per 80 leaves following various pesticides at Location 2, Weslaco, Texas, during 1967-68.

Date	GS-13005 TCM[1]	GS-13005 TCME[2]	Azinphosmethyl TCM	Azinphosmethyl TCME	Combinations TCM	Combinations TCME
4/21/67	196	481	278	797	427	904
4/28	1 lb GS-13005		710 ml azinphosmethyl[3]		1 gal 412 oil[4]	
6/5	12	36	0	1	3	14
6/26	219	349	19	34	94	149
7/20	529	1227	388	315	146	308
7/31	83	192	161	236	48	62
7/31	1 lb GS-13005		710 ml azinphosmethyl		1.6 gal 412 oil[4 5]	
8/25	15	46	1	0	1	20
9/15	360	594	51	99	209	305
10/9	10	25	20	20	18	44
10/30	571	294	398	322	837	370
11/1	1 lb GS-13005		710 ml azinphosmethyl		378 ml dicofol[4]	
1/10/68	2	3	15	60	1	0
3/12	1	2	78	116	4	14
4/4	74	116	316	360	3	31
4/15	1 lb GS-13005		710 ml azinphosmethyl		1 gal 412 oil[4]	
5/3	36	79	88	187	25	49
5/23	307	754	875	1780	119	356
5/28	1 lb GS-13005		710 ml azinphosmethyl		1 gal 412 oil[4]	
6/14	32	28	0	0	6	8
7/11	1626	1668	18	63	64	116
7/30	1126	1505	1185	2107	747	1408
8/8	1 lb GS-13005		710 ml azinphosmethyl		1.6 gal 412 oil[4]	
9/27	29	68	7	19	12	29
10/9	111	199	63	181	63	213
10/31	512	565	671	878	438	833
11/14	236	355	229	525	458	110
11/21	1 lb GS-13005		710 ml azinphosmethyl		473 ml dicofol[4]	
12/21	0	1	5	3	0	0

[1] Motile Texas citrus mites.
[2] Texas citrus mite eggs.
[3] Trees in replicates 3 and 4 treated 5/5 after sprayer repair.
[4] 1 lb zineb added.
[5] .33 lb carbaryl added.

lations was found after application of Morocide-Metiram in 1966 and GS-13005 in 1967 and 1968 at Location 1, and after use of azinphosmethyl in 1967 at Location 2.

LITERATURE CITED

1. Dean, H. A. and C. E. Hoelscher. 1966. Indications of resistance of Texas citrus mites to tetradifon (Tedion). J. Rio Grande Valley Hort. Soc. 20:55-9.

2. Riehl, L. A. 1961. A routine system for spray application manually to citrus. J. Rio Grande Valley Hort. Soc. 15:3-9.

Effect of Psorosis, Exocortis and Xyloporosis Viruses on Performance of 11-Year-Old Grapefruit and Sweet Orange Trees

E. O. Olson, H. K. Wutscher, and A. V. Shull[1]

Abstract: Nucellar Redblush and old-line Valencia orange trees on sour orange rootstock were bud-inoculated before planting with one or more viruses (exocortis, xyloporosis, psorosis, and blind pocket). There was no significant effect of inoculation on tree size and cummulative yield after 9 years. Fruit size was increased by virus infection in 1969. Nine-year-old old-line red grapefruit trees, on sour orange rootstock and carrying exocortis and xyloporosis viruses, outyielded juvenile nucellar red grapefruit trees on the same rootstock.

INTRODUCTION

In the 1950's it became apparent that most commercial citrus trees in Texas carried one or more viruses (2). All the old-line red grapefruit trees carried at least the xyloporosis (Cachexia) virus and most Valencia sweet orange trees carried exocortis and xyloporosis viruses. Xyloporosis and exocortis viruses were latent in grapefruit and sweet orange trees on sour orange rootstock, but the presence of these viruses could be determined by indexing on suitable indicator plants. Psorosis A and blind pocket viruses occurred at random but could be identified by bark and leaf symptoms of grapefruit and sweet orange trees. Research workers in California, Florida and Texas also found that the viruses in most commercial trees made it impossible to use certain rootstocks. Where sour orange rootstock had to be abandoned because of tristeza, latent viruses, especially exocortis, became a problem and forced the growers to use nucellar, virus-free budwood, but in Texas this hasn't been necessary. Old-line selections have been more productive than nucellar trees (2). We thought that virus infection might be the cause of the difference in productivity and set up this test to determine the effect of several viruses present in old-line trees.

MATERIALS AND METHODS

Sources of inoculum: Trees were selected to provide sources of the viruses listed in Table 1. Viruses were identified by using Orlando tangelo seedlings as indicator plants for xyloporosis and Rangpur lime and Morton citrange seedlings for exocortis. The presence of Psorosis A virus was determined by repeated foliage inspections in spring by us

[1] Plant Pathologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, formerly at Weslaco, Texas, now at Indio, California; Horticulturist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Weslaco, Texas; and Manager, Citrus Department, Rio Farms, Inc., Monte Alto, Texas, respectively.

and trained inspectors of the Texas Department of Agriculture. Blind pocket was detected by inspection for bark and foliage symptoms.

Sour orange seedlings were grown in a nursery near Monte Alto, Texas, and budded in 1958 with the following clones: 1) CES No. 3 nucellar Redblush grapefruit, grown from seed planted about 1940; 2) Rio Farms nucellar Redblush, grown from seed planted about 1950; 3) Rio Farms old-line Valencia orange, originally brought to Texas from Armstrong Nurseries in California. A few old-line Redblush trees, carrying exocortis and xyloporosis viruses, were also propagated at the same time.

When about 3 feet tall some CES No. 3 Redblush trees, Rio Farms nucellar Redblush trees and Valencia orange trees were set aside to serve as uninoculated controls for the experiment; the other trees were bud-inoculated from the virus-infected trees listed in Table 1.

In the spring of 1960 the trees, grapefruit trees alternating with orange trees, were planted in the field according to randomized complete block design. There were 6 virus treatments and an uninoculated control treatment with 7 replications of CES No. 3 grapefruit and 5 replications of Valencia orange.

The Rio Farms nucellar Redblush trees, inoculated from 2 virus sources, were compared with uninoculated trees and with old-line Redblush trees infected with xyloporosis and exocortis viruses. There were 5 treatments with 5 replications in a randomized complete block design. Yields in units of 70-lb boxes of fruit were recorded from 1966 to 1969. Tree size was determined by measuring height and width of the canopy and calculating tree volume using the formula

$$\frac{\text{Width}^2 \times \text{Height.}}{4}$$

The fruit size data are based on measurement of the diameters of 30 fruits per tree.

RESULTS

Visual symptoms of infection: All trees inoculated with buds from trees with psorosis A or blind pocket psorosis showed the leaf symptoms

Table 1. Sources of old-line budwood for inoculation.

Varieties	*Location*	*Viruses prseent*
Thornton tangelo	Weslaco	Blind pocket psorosis
Clementine tangerine	Weslaco	Exocortis
Valencia orange	Monte Alto	Psorosis A
Shamouti orange	Weslaco	Xyloporosis
Redblush grapefruit	Mercedes	Exocortis and Xyloporosis
Marsh grapefruit	Weslaco	Xyloporosis

of psorosis during one or more spring flushes. At the present time, the bark-shelling symptoms of psorosis, which cause the damage from psorosis, have not become evident. There are no visual symptoms of exocortis or xyloporosis.

Effects on tree size and yield: Inoculation with xyloporosis, exocortis, psorosis, blind pocket psorosis viruses singly and a combination of xyloporosis and exocortis viruses had no significant effects on tree size and yield of CES No. 3 nucellar Redblush grapefruit trees and Valencia orange trees on sour orange rootstock during the 9-year period since the trees were planted (Table 2). Inoculation with xyloporosis, exocortis, and psorosis viruses caused no response in tree size or yield of a juvenile strain of Rio Farms nucellar red grapefruit on sour orange rootstock. These nucellar trees were larger than comparable old-line trees carrying two viruses, but produced less fruit (Table 3). The latter difference was not large enough to be statistically significant.

Effects on fruit size: CES No. 3 Redblush grapefruit trees inoculated with xyloporosis virus alone and psorosis virus alone had larger fruit than the control trees in 1969 (Table 2). Rio Farms nucellar Redblush grapefruit trees inoculated with exocortis virus had larger fruit than those in any other treatment with comparable tops (Table 3). Trees of an old-line selection carrying exocortis and xyloporosis viruses bore smaller fruit than nucellar trees, but had higher total yields.

DISCUSSION

Inoculation with exocortis, xyloporosis and psorosis viruses had little effect on the performance of Redblush grapefruit and Valencia orange trees on sour orange rootstock during the first 11 years of growth. The damage from psorosis and blind pocket psorosis infection often cannot be evaluated on young trees, since the bark shelling which partly or wholly girdles the tree usually develops in the second decade after planting.

The observed increase in fruit size associated with virus inoculation is noteworthy but inconclusive. Fruit size was determined at only one harvest, so further observations are needed to determine the consistency of the effect.

The data presented here are evidence that the differential behavior of old-line and nucellar trees of Redblush grapefruit is due to factors other than the viruses or virus combinations tested.

The evidence from these trials does not support the hypothesis that a virus-free tree is superior to a tree infected with any virus, even if the tree is composed of a top and a rootstock which express no symptoms for the virus in question.

The use of virus-free nucellars in other areas (Brazil and California) was due to the necessity of using new exocortis-sensitive rootstocks in order to have tristeza-tolerant trees. Virus-free nucellars could

Table 2. Yield, fruit diameter, and tree size of CES No. 3 nucellar Redblush grapefruit and old-line Valencia trees in relation to virus inoculation.

	Cumulative yield 1966 - 1969		*Fruit diameter (mean) 30 fruit, 1969*		*Tree size (1969) Canopy volume*	
Viruses used in 1960 inoculations: statistical significance	*CES No. 3 grapefruit (boxes)*	*Valencia orange (boxes)*	*CES No. 3 grapefruit (cm)*	*Valencia orange (cm)*	*CES No. 3 grapefruit (cu. ft.)*	*Valencia orange (cu. ft.)*
Control (no virus)	5.7	1.6	9.9	6.7	479	278
Xyloporosis	5.6	1.0	9.9	6.3	440	244
Exocortis	5.3	1.7	9.9	6.3	432	224
Psorosis	5.5	1.5	10.2	6.6	476	236
Blind pocket	5.9	1.1	9.7	6.5	451	222
Xyloporosis	5.1	1.0	10.2	6.5	485	221
Exocortis and xyloporosis	71	1.4	9.8	6.3	408	180
LSD[1]	NS	NS	0.3	NS	NS	NS

[1] LSD = Least significant difference between means at 0.05 level; NS = not significant.

Table 3. Performance of old-line Redblush trees carrying exocortis and xyloporosis viruses and Rio Farms nucellar Redblush grapefruit trees grown on sour orange rootstock and inoculated with different viruses.

Budline of Redblush trees and statistical significance	*Inoculation with indicated virus or, an old line tree with indicated virus*	*Cumulative yield per tree, 1966 - 1969 (boxes)*	*Fruit diameter (mean of 30 fruit, 1969) (cm)*	*Tree size (Canopy volume) (cu. ft.)*
Nucellar	Control (no virus)	8.0	10.5	549
	Xyloporosis	8.2	10.7	497
	Exocortis	8.6	11.0	545
Old-line	Psorosis	8.4	10.6	602
	Exocortis and xyloporosis	9.7	10.0	408
LSD[1]		NS	0.3	113

[1] See Table 2 for explanation.

be found easier than virus-free old-line trees. In Texas, sour orange rootstock is still used because tristeza has not been a problem. Old-line trees carrying exocortis and xyloporosis viruses are more productive on sour orange rootstock because the trees are not sensitive to these viruses.

LITERATURE CITED

1. Olson, E. O., Bailey Sleeth, and A. V. Shull. 1958. Prevalence of viruses causing xyloporosis (Cachexia) and exocortis (Rangpur lime disease) in apparently healthy citrus trees in Texas. J. Rio Grande Valley Hort. Soc. 12: 35-43.
2. Young, Roger, E. O. Olson, and Art Shull. 1968. Comparative performance of juvenile and old-line Redblush grapefruit. J. Rio Grande Valley Hort. Soc. 22: 16-25.

Increasing Farm Income Through Marketing[1]

DR. CHAN CONNOLLY
Associate Professor
Texas A&M University Agricultural Research and Extension Center at Weslaco

Research in respect to marketing of fruit and vegetables produced in the Rio Grande Valley has been impeded due to limited resources. This past year Texas A&M University, using the task force approach, organized a Market Research and Development Team consisting of four (4) Agricultural Economists with Dr. Robert E. Branson as team leader. Three of the team members are stationed at Texas A&M University at College Station. In order to be in the proximity of the Rio Grande Valley Fruit and Vegetable Industries, the fourth member is stationed at the Texas A&M University Agricultural Research and Extension Center at Weslaco.

The Texas A&M Market Research and Development Team currently have the following three Texas citrus market research projects in progress.

Sub-Project No. 1

Title: Analysis of the comparative demand for Texas Citrus sold under various U. S. Grade Designations.

Leader: Dr. John Nichols

Sub-Project No. 2

Title: Market test of the sales effectiveness of Texas Sweet in-store point of sale, Promotion Displays.

Leader: Dr. Thomas Sporleder

Sub-Project No. 3

Title: Effect of Supply Variations on the Marketing of Texas Citrus.

Leader: Dr. Chan Connolly

All three research projects are being conducted under a joint effort with the Texas Valley Citrus Committee, Texas A&M University Agricultural Research and Extension Center at Weslaco. Results from these research projects will be available July 1, 1969.

With no market research results to present to you at this point in time, let us discuss how marketing of fruit and vegetables in the Rio Grande Valley can increase farm income.

[1] Talk given January 21, 1969, before members of the Rio Grande Valley Horticultural Society, Texas A&I University, Weslaco, Texas.

The supply of fruit and vegetables from the Rio Grande Valley is now being marketed in a *buyers market.* A buyers market may be described as a market where supplies are plentiful and buyers are able to select from an array of products offered. For example, a wholesale buyer of fresh grapefruit today has the choice of buying either Florida, Arizona, California or Texas grapefruit. He will buy that pack of grapefruit which best satisfies his customers and this pack of grapefruit will automatically generate the greatest profit to him.

Under these conditions a grapefruit marketing firm in the Valley must be market-oriented in order to maximize income to the grove owners and shippers. A market-oriented firm tries to create *value-satisfying grapefruit* that consumers want to buy. What is offered for sale is determined not by the seller, but by the buyer. A selling-oriented firm focuses on the needs of the seller, where a marketing-oriented firm focuses on the needs of the buyer. A selling-oriented firm today is headed for certain disaster. Only a marketing-oriented firm can survive in a buyers market. The first business of any market-oriented firm today is to *get* customers and to *keep* customers.

Individual fruit and vegetable growers in the Rio Grande Valley can do a good job of producing as individual firms, but individual firms can not do a good job of marketing unless firms producing a given commodity work together as an industry. Working together is a very difficult task for independent farmers in the United States. Congress recognized this behavior pattern among farmers and passed an act in 1937 to minimize this constraint. This act is known as the *Agricultural Marketing Agreement Act of 1937* and has been amended several times since its original enactment.

Congress, through the Agricultural Marketing Agreement Act of 1937, gave individual farm producers the right to band together in the marketing of their output by exempting them from violations of the Anti-Trust Act. This is a special right given to individual farm producers and groups of farm producers for the sole purpose of enhancing farm income.

There are now 47 marketing orders in the United States which have been organized by groups of individual farm producers to enhance their marketing position. Sixteen (16) of these market orders are found in California and contiguous states, seven (7) in Florida and four (4) in Texas. Two (2) of the marketing orders in Texas covering fresh market tomatoes and lettuce are now inactive. The two (2) active marketing orders cover citrus and onions.

Individual farm producers in Texas are given the same right as individual producers in California and Florida to market their output under a marketing order to improve their farm income position. California and Florida producing firms have exercised this right to a greater degree than have Texas producing firms.

Marketing orders are not a cure-all for marketing solutions. They are nothing more than a set of tools which are used to assist an industry to improve its marketing position. A marketing order may be compared to a farm tractor. The driver of the tractor is represented by the administrative committee, and the work which the tractor does is determined by the tools designed by the industry to hitch to the tractor. The kind of tool used behind the tractor depends upon the job to be done. If the wrong tool is designed or used, the job will not be done in a satisfactory manner. This is what happened to the marketing order for carrots in the Valley. The proper tools were not used for the solution of marketing problems associated with Texas carrots. Rather than redesigning the tool to fit the marketing problems associated with carrots, the industry eliminated the order. This, in my opinion was an error. A Marketing Order can only be as effective as man makes it within the framework of the Act.

Individual producers of other commodities in South Texas have the right to band together to market their output in order to increase farm income. The pepper, watermelon, cantaloupe, carrot, okra and cabbage industries are examples of potential commodity groups who may use marketing orders to improve their market position.

A Marketing Order is only one way of increasing farm income. It is not possible to use a Marketing Order for all farm commodities marketed in the United States. Commodities produced in some areas of the United States do not lend themselves to marketing orders, and other solutions must be found.

A group of individual produces are also given the right by Congress to band together to market their output through a cooperative type of marketing organization. The *Capper-Volstead Act* (1922) permits farmers and associations composed of farmers to form marketing agencies in common, without being subject to federal anti-trust laws for so doing. History of cooperative marketing in South Texas reveals that many have failed. These failures were not due to cooperatives per se. The cooperatives were either designed to perform an impossible marketing function, such as selling junk produce, a variable supply, or were not designed to fit the marketing function needed to solve the particular marketing problem. A cooperative is just another way of doing business. If a cooperative can be used to enhance the profit position of an industry, use it; if it cannot enhance the profit position – use something else. A farmer controlled corporation may be better suited to provide the solution.

It is very difficult to make an unbiased decision as to whether a marketing order, cooperative or a producer controlled corporation is a best fit for enhancing the profit position for a group of producers. An economic analysis of the industry must first be made. Using these findings an unbiased decision then may be made. Too often a decision is made without or with only a partial economic analysis. Mr. Kenneth Stewart, Texas A&M Agricultural Extension Marketing Specialist at

Weslaco and the author are available to assist with this type of economic analysis to the extent resources permit. Mr. Dave Fitz, United States Department of Agriculture, Consumer and Marketing Service, whose field office is situated in McAllen, Texas, is available to provide all necessary information associated with marketing orders.

There are solutions to marketing problems that may be found through the use of Marketing Orders, while other solutions must be found outside the marketing order framework.

Our own Texas Citrus Industry serves very well to illustrate this point. Texas fresh grapefruit and oranges have been marketed under a Marketing Order since 1960. This Marketing Order has been of great value to the Texas Citrus Industry. Both grove owners and shippers have benefited.

However, there are still problems to which solutions need be found. Some of these solutions can be found within the framework of the marketing order, while other solutions must be found outside this framework. Let's briefly make an economic analysis of the Texas Citrus industry.

According to recent statistics, the United States produced about 30% of the world's supply of citrus in 1967. The United States supply is produced primarily in four (4) states, table 1.

Since Texas has about 6 percent of the United States 202,000,000 population, any marketing problem that may now exist in the marketing of Texas Citrus is *man made!* Texas aggregate supply of oranges is insufficient to meet Texas indigenous demand for oranges. In fact Texas' supply of oranges only satisfies about 50% of Texas' aggregate demand for oranges. Yet we find the Texas Citrus industry faced today with a serious marketing problem in respect to oranges which we consider to be good oranges. How can this be possible? Texas supply of grapefruit is almost double Texas aggregate demand for grapefruit. Individuals associated with the Texas Citrus industry believe that the Texas ruby red grapefruit is the best quality grapefruit produced in the world. A

Table 1. Percentage of United States orange and grapefruit supply by states, 1968-69.

State	*Tons Oranges*	*%*	*Tons Grapefruit*	*%*
California	1,538,000	20	189,000	8
Florida	5,625,000	75	1,784,000	77
Texas	211,500	3	260,000	11
Arizona	154,000	2	96,000	4
	7,528,500	100	2,329,000	100

Source: Texas Citrus, Texas Department of Agriculture and U. S. Department of Agriculture, Statistical Reporting Service, January 13, 1969.

market research project is required to test this bias. The midwest tomato producers believe that their tomatoes are the best because they have an acid taste. California tomato producers believe their tomatoes are the best because they have a sweet taste. Each group of tomato growers have a bias concerning their tomatoes. A market research project is required to determine consumers preference concerning taste. Consumers of tomatoes are the actual judges. Assuming the quality of ruby red grapefruit is the best in the world, then why is the Texas citrus industry having difficulty in selling its output? Why isn't Texas ruby red grapefruit being sold at a premium in the market? This reveals inconsistency.

Last week in Tulsa, Oklahoma, Dr. Thomas Sporleder, Assistant Professor, Texas A&M University, who is project leader for sub-project No. 2, reported that Texas ruby red grapefruit, 48 size, were retailing 4 for 29c and Florida ruby red's, 40 size, were retailing for 19c each and moving at a higher volume than Texas ruby reds. Dr. Robert E. Branson, Professor, Texas A&M University also reported that the quality of Texas grapefruit in many midwestern stores, which he had visited is setting up sub-project No. 1, had a considerable variation in quality. Some No. 2 Texas labels were superior to other Texas No. 1 labels. In general Florida grapefruit was definitely of higher quality as compared to Texas. If Texas has the best grapefruit in the world, how can Florida market a better grapefruit than Texas? We shall find answers to these questions as we continue to analyze the Texas citrus industry.

The market structure for Texas grapefruit and oranges at the shipping level consists of about 28 firms on the selling side. These firms are using over 100 different labels in the aggregate. Grapefruit is currently being packed in approximately 31 packing sheds in the Valley. Each shipping firm in the Valley is in love with its labels. The chain buyers who buy about 80% of all grapefruit in the United States are interested in buying from shipping firms which can perform in the following matter:

1. Supply grapefruit of uniform quality in carload or multi carload lots.
2. Supply merchantable quality.
3. Supply be consistent throughout shipping season.
4. Supply be price competitive.

Note that label or brand image is not mentioned, although it is indirectly related to the supply of a merchantable quality to some degree. The consumer has no knowledge whatsoever of the label when grapefruit is sold in the bulk display at the retail level.

The majority of Texas Citrus Brands and Trademarks are registered as a No. 2 and better. Under today's marketing environment, a minimum No. 2 grade pack is a junk pack. In fact a minimum No. 1 pack under present Texas grade standards is a junk pack! A combination pack for Texas grapefruit was eliminated this marketing season for the first time. However, it was only eliminated on paper. The combination pack is still being packed. It's now called No. 2 and better grade. A typical No. 2 and better pack in the Valley now has from 40% to 80% No. 1's, balanced out with No. 2's.

The author has visited over half of the packing sheds in the Valley and has found only two labels identified in printing as "U. S. No. 1 quality". A few shippers were stamping a "No. 1" on their cartons which was difficult to find. No grade identification existed on most packs. One week ago the author was informed that some retail stores were making bulk displays using Texas No. 2 and better. In comparison to Florida, Texas No. 2 grapefruit looks terrible. How is the produce retail manager to know a pack of Texas grapefruit is No. 1 or No. 2 when most Texas labels have no such identification?

Let's analyze Texas standards for grapefruit grades. The grapefruit produced in the eastern area of the Valley is very smooth and good in appearance as compared to most of the grapefruit produced in the western area of the Valley which is more coarse textured and not as good in appearance. The Texas Grapefruit industry over time has gradually moved west because yields in the western area are greater than in the eastern area. Subsequently the western supply area was having difficulty making grade due to the rough or coarse textured appearance. The solution to this problem was found by lowering the Texas standards for grades for grapefruit in 1955. There are now three U. S. Standards for grapefruit in the United States. The grade standards for Texas grapefruit has the lowest requirement of the three. Florida and California standards for grades are both higher. The action taken to lower the grades in 1955 reveals that the Texas Citrus Industry is "selling-oriented". The grades were adjusted to fit the Texas Citrus Industry, not the market!

Now let us analyze the Texas Industry from the standpoint of fresh pack vs processed pack. Within the past year, about 2 million dollars have been allocated by grove owners through their cooperatives to acquire and construct additional fresh packing shed capacity. Is the market demanding more fresh citrus? Let's take a look at the United States per capita consumption trends for fresh and processed citrus, Figure 2.

This data clearly reveals that the market for fresh citrus is declining while the market for processed is expanding. With these facts, should the Texas citrus industry be allocating more resources for the expansion of fresh packing capacity or for more processing plant capacity when aggregate consumption for fresh is declining? Is it not profitable to process citrus products? Texas oranges are better suited for processing than for fresh pack due to lack of appearance.

Processing capacity for citrus products in the Rio Grande Valley is now limited. With the 1968-69 crop of 260,000 tons of grapefruit and

211,500 tons of oranges, processing capacity is not sufficient to process all of the Texas citrus that should be processed. The limited processing capacity that now exists in the Valley today is held by the private sector whose objective is to make a profit for the stockholders. This is done by buying raw stock citrus as cheap as possible.

Today our cash price for processed oranges is $30.00 per ton. In Florida these same oranges would sell for $71.50 per ton[2]! Due to insufficient processing capacity in the Valley, a buyers market for raw citrus stock now exists. The price being paid for Texas raw stock does not reflect its true market value, but rather a price the private processing firms need offer in order to obtain their supply. Whenever supply of processing citrus stock exceeds demand, a buyers market exists and the price is low.

Let's take a quick look at citrus grove owners and observe how they are doing in respect to returns on investment under the present marketing environment. First, what is a satisfactory return on investment for Texas citrus? With the probability of Texas freezes, the returns need be higher than normal in order to cover the cost of the freeze risk. To cover the freeze risk and interest on investment, it is my judgement that grove owners are entitled to a 20 percent annual return. That is,

Table 2. United States per capita consumption annual average change for selected citrus fruits and products, 1951-67.

Fresh Citrus	*Annual Change*
Oranges	— 0.90 pound
Grapefruit	— 0.23 pound
Total Fresh	— 1.26 pound
Processed Citrus	*Annual Change*
Frozen Juice	
Orange	+ 0.32 pound
Grapefruit	+ 0.03 pound
Blend	— 0.01 pound
Canned Citrus	
Orange	— 0.15 pound
Blend	— 0.05 pound
Concentrate	— 0.03 pound
Grapefruit	— 0.05 pound
Total Canned	— 0.30 pound
Chilled Juice	
Orange	+ 0.15 pound
Grapefruit	+ 0.01 pound
Blend	+ 0.20 pound

Source: U. S. Department of Agriculture, Economic Research Service, Food Consumption Prices Expenditures, Agricultural Economic Report No. 138, July 1968.

[2] Current price of concentrate in Florida is 55c per pound. Current yield of Texas oranges is 130 lbs per ton. 130 × 55c = $71.50.

for every $10,000.00 invested, a $2,000.00 annual net return over expenses is needed. This is in line with Florida's 30 year (1937-66) average return of 16 percent on investment. Although there is no research in this area for Texas, the author estimates that for the 1968-69 season, at least 25 percent of the Texas citrus grove are sub-marginal; 25 percent have returns of less than 20 percent; and no more than 25 percent have returns equal to or greater than 20 percent.

With the foregoing analysis, what course of action need be taken at this point in time to provide grove owners with a price structure for their output in the future that is in accordance with the true value received on the retail market for Texas citrus? How can we avoid Texas citrus from being discounted on the market?

Let me offer my prescription as a cure for the marketing ills now associated with the Texas citrus industry. First, increase processing capacity in the Valley for citrus products. It is highly desirable that grove owners control this increased processing capacity through a corporate type structure in order to provide maximum flexibility for buying raw stock citrus from other areas at the time of the next freeze. The reason for suggesting a corporate type structure rather than a cooperative is that a cooperative is limited by law to the purchase of raw stock from non-members not exceeding 50 percent purchased from its members. When a freeze occurs, all members have a reduced supply which automatically limits the amount of raw stock a cooperative can buy from non-members. This is the reason Texsun was transformed from a cooperative to a corporation in the early 50's. A corporate type structure does not have this constraint. A corporate structure can purchase either raw or finished citrus products from other production areas in unlimited quantities in order to maintain its markets. When grove owners receive a price for their processing citrus raw stock that reflects the true market value, many grove owners will find it economically feasible to employ freeze control measures which will decrease the variation in supply at the time of a freeze.

Since tomato juice is a fairly close substitute for citrus juice, consumption of tomato juice always increases after a freeze. Consequently tomato juice is a complementary product to citrus products. By adding a tomato juice line to the citrus processing facility, tomato juice output could be increased at the time of a freeze to substitute for the decrease in output of citrus products. This would enable a citrus processing plant to stay in business during the recovery period.

A marketing order can be of assistance in establishing a processing facility by setting up a trust fund through the marketing order to accumulate capital for the construction of a processing facility.

Second, Texas standards for grades for citrus need be reworked so that they reflect market demand rather than the demands of the Texas citrus industry. This can only be accomplished when processing capacity is increased. By up-grading the standards, supply of raw stock for

processing will increase. This may be accomplished by working through the marketing order.

Third, develop a Texas brand image for Texas fresh citrus, promote it and give all shippers the right to pack under this label. Fresh pack only "U. S. No. 1" grapefruit and oranges *with quality levels equal to or greater than Florida's,* then process the balance. Identify Texas fresh pack with "U. S. No. 1 quality" in large readable letters. This activity can also be accomplished through the marketing order.

Fourth, police the quality level of the fresh pack. This is absolutely necessery as the world is full of chiselers and the produce industry has its fair share. This activity can also be accomplished through the Marketing Order.

Although the new central sales organization (TCX) is a necessary condition for contemporary marketing of Texas citrus, it is not a sufficient condition. The sufficient condition is to increase processing capacity controlled by the grove owners, employ freeze control measures in citrus groves where it is economically feasible, upgrade standards for grades, pack under one promoted label, and police the pack for quality. By initiating this program today, income to citrus grove owners and shippers will increase tomorrow. Grove owners can then well afford to produce a maximum quantity of U. S. No. 1 bright fruit which will bring premium prices. Employment of more freeze control protection measures will decrease the variation in citrus supply.

The Texas citrus industry has a great potential for the future. This potential will only be developed by the Texas citrus industry. The Texas citrus industry has the leadership capabilities to initiate this program. To meet future demand, the Texas citrus industry should not sell its output, but merchandise its output. The Texas A&M University, Texas A&M University Agricultural Research and Extension Center at Weslaco, and the U. S. Department of Agriculture are ready to assist the Texas citrus industry and any other fruit and vegetable industry in the Valley to initiate a merchandising program which will increase income to both producers and to shippers.

VEGETABLES

Influence of Variety and Soil Type on Cation Concentrations in Tomato Leaves

BILLY W. HIPP[1]

Abstract: Studies were conducted to determine the influence of variety and soil type on the concentration of cations in the foliage of 5 tomato varieties. There were differences in cation concentrations due to variety and soil type. The differences were generally large for magnesium and zinc during the early growth stages but decreased with increased growth time. Varietal differences in regard to manganese, calcium and potassium generally increased with length of growth period. Plants grown on Harlingen clay contained higher concentrations of magnesium, manganese, zinc and calcium than those grown on Willacy fsl but plants grown on Willacy fsl contained higher concentrations of potassium.

INTRODUCTION

Development of new varieties coupled with changing fertilizer practices and refinement of production practices raise questions as to the nutrient status of certain tomato varieties grown on soils having different chemical and physical characteristics. Differential absorption of nutrients by variety have been reported but the literature is limited mostly to corn (2, 3, 4). Foy and Barber (2) postulated that the difference in uptake of magnesium (Mg) by two corn varieties was not due to different root absorption capacities for Mg but was due to differences in mobilization of Mg in the plant stems. In light of findings involving cation uptake by other crops, an experiment was conducted to determine the influence of variety and soil type on the cation concentrations in tomato plants.

MATERIALS AND METHODS

Five tomato varieties and 2 soil types were used to determine the influence of soil type and tomato variety on the cation concentration in tomato plants at various growth periods. The soils used were Harlingen clay and Willacy fine sandy loam and are described in Table 1. The tomato varieties used were Chico, Chico Grande, El Monte, La Bonita and La Pinta (6, 7, 8, 9, 10). Twenty plastic pots were each filled with Willacy fine sandy loam soil (4000 g/pot). All pots were fertilized with 50 ppm P and 100 ppm N per pot. Tomatoes were seeded in the pots (5 varieties with 4 pots/variety) and watered to field capacity with distilled water. An additional 20 pots were treated identically but the soil used was Harlingen clay. After adequate germination was assured the plants were thinned to 8 plants per pot. Adequate moisture levels were maintained by adding distilled water as required. Samples of two

[1] Assistant Professor, Texas A&M University Agricultural Research and Extension Center at Weslaco.

plants per pot were taken 30, 44 and 64 days after planting by cutting them at the soil level. They were then rinsed in distilled water, dried at 70°C and ashed according to the methods of Chapman and Pratt (1). Cation determinations were made with an atomic absorption spectrophotometer. The whole plants from the 30 and 44 day cutting were used for analysis but only the 4th leaf branches from the terminals were used for analysis at the 64 day cutting. Appropriate statistical analyses were made to determine if differences in cation concentration in tomato plants exist between varieties grown on the same soil and if differences exist in a single variety grown on different soils.

RESULTS AND DISCUSSION

Magnesium (Mg): There were differences in Mg concentration between varieties grown on the same soil as indicated in Table 2. At the 30 day harvest, Chico, La Bonita and La Pinta contained a higher concentration of Mg in the leaves than Chico Grande when grown on Harlingen clay soil. Chico Grande also contained less Mg than Chico and La Bonita when grown on Willacy fsl. There was a sharp decrease in Mg content with length of growth period in all varieties grown on Willacy fsl but the reductions were not low enough to suggest Mg deficiency since the initial Mg levels were exteremely high. Magnesium concentrations in the plants were significantly (.05 level) lower when grown on Willacy fsl than those grown on Harlingen clay. High Mg levels in tomatoes grown on Harlingen clay have been attributed to the high level of soil exchangeable Mg and to the relationship between Mg uptake and P availability (5). The combined values from both soils (Table 2) indicate that the greatest differences in Mg concentration occurred during the early stages of growth and by 64 days all levels were very similar with the exception of La Pinta which was lower than the other varieties.

Manganese (Mn): The concentration of Mn in the foliage of La Pinta plants was much higher than in the other varieties when grown on Harlingen clay and sampled at 30 days but when grown on Willacy fsl there were no differences between varieties at 30 days (Table 3). By 44 days La Pinta grown on Harlingen clay contained higher Mn concentrations than Chico and La Bonita, but on Willacy fsl at 44 days Chico contained higher Mn concentrations than all other varieties. Chico and La Bonita

Table 1. Chemical Properties of the Soils Used in the Studies.

	pH	*Approximate CEC**	*ppm P by $NaHCO_3$ at pH 8.5*	*Me/100g* K	*Me/100g* Mg	*Predominant Clay Mineral*
Harlingen c	8.2	43	23	1.5	5.6	Montmorillonite
Willacy fsl	7.8	16	15	1.1	3.1	Mica

* Cation Exchange Capacity

Table 2. Influence of Soil and Date of Sampling on Magnesium Concentration in 5 Tomato Varieties.

Variety	*Harlingen c* Days After Planting 30	44	64	*Willacy fsl* Days After Planting 30	44	64	*Both Soils* Days After Planting 30	44	64
		% Mg			% Mg			% Mg	
Chico	1.12a*	1.13a	0.99ab	1.02a	0.74 b	0.62ab	1.07a	0.94ab	0.81a
Chico Grande	0.97 b	1.02 b	0.96ab	0.92 b	0.86ab	0.63ab	0.94 c	0.94ab	0.80a
El Monte	1.04ab	1.10ab	1.02a	0.99ab	0.90ab	0.66a	1.02 b	1.00a	0.84a
La Bonita	1.12a	1.05ab	1.00ab	1.06a	0.95a	0.70a	1.09a	1.00a	0.85a
La Pinta	1.08a	1.01 b	0.89 b	0.94 b	0.81 b	0.54 b	1.01 b	0.91 b	0.71 b
Soil									
Harlingen	1.06a	1.06a	0.97a						
Willacy	0.99 b	.86 b	0.63 b						

* Means in a column not having the same letter beside them are different at the 0.05 level of significance.

Table 3. Influence of Soil and Date of Sampling on Manganese Concentration in 5 Tomato Varieties.

	Harlingen c			*Willacy fsl*			*Both Soils*		
	Days After Planting			*Days After Planting*			*Days After Planting*		
Variety	*30*	*44*	*64*	*30*	*44*	*64*	*30*	*44*	*64*
		ppm Mn			*ppm Mn*			*ppm Mn*	
Chico	165 b*	157 bc	125 b	95a	117a	90a	130a	137a	108a
Chico Grande	162 b	173ab	138ab	87a	92 b	79ab	124a	132a	109a
El Monte	178 b	176ab	148a	96a	82 b	60 b	137a	129a	104ab
La Bonita	160 b	150 c	123 b	92a	80 b	59 b	126a	115 b	91 b
La Pinta	217a	180a	136ab	106a	95 b	72ab	162 b	138a	104ab
Soil									
Harlingen c	176a	167a	134a						
Willacy fsl	95 b	93 b	72 b						

* Means in a column not having the same letter beside them are different at the 0.05 level of significance.

contained a lower concentration of Mn than El Monte when grown on Harlingen clay and sampled at 64 days. Tomatoes grown on Willacy fsl contained a lower Mn concentration than those on Harlingen clay at all harvest dates regardless of variety. Although the concentrations are generally quite high and in the adequate range, a Mn deficiency would be expected to occur on Willacy fsl before Harlingen clay.

Calcium (Ca): The concentrations of Ca in the tomato foliage are shown in Table 4. La Pinta and Chico were lower in Ca than Chico Grande when grown on Harlingen clay and sampled 30 days after planting. La Bonita and La Pinta were lower in Ca than the other varieties at the 44 days sampling. There were no differences in Ca concentration in the plants due to varieties on the Willacy fsl at the 30 day cutting but La Pinta was lower than the other varieties when sampled at 44 days and was lower than all others except El Monte at 64 days. More differences in Ca concentrations due to varieties were observed as length of growing season increased, particularly when values for both soils were combined. Tomato plants grown on Harlingen clay contained a higher concentration of Ca in the leaves than those grown on Willacy fsl regardless of variety. This would be expected since the soil levels of Ca are much higher in Harlingen clay than Willacy fsl.

Zinc (Zn): Chico variety showed a tendency to contain less Zn than the other varieties (Table 5) grown on Harlingen clay and at the 44 day sampling period contained significantly less Zn than all the other varieties. El Monte plants grown on Willacy fsl contained less Zn than La Pinta when sampled at 30 days. There were no differences between varieties at 64 days on either the Harlingen clay or Willacy fsl. Differences between varieties became smaller with increased growing time when values for the two soils were combined. The mean Zn values obtained for all varieties on Willacy fsl at 44 and 64 days were significantly less than for those grown on Harlingen clay. Although critical leaf zinc concentrations are not available for tomatoes, the levels of zinc on some varieties appear to be approaching a deficient level and further investigation is warranted to determine the critical levels of zinc in tomato leaves at various growth stages and to determine if deficiencies do exist in tomatoes grown in the Lower Rio Grande Valley of Texas.

Potassium (K): There were no differences in K concentration due to varieties on Harlingen clay (Table 6) at the first cutting but Chico Grande contained a higher K concentration than El Monte and La Bonita varieties at the 44 day harvest. El Monte was lower in K than all other varieties except Chico at the 64 day cutting. On Willacy fsl Chico generally contained less K than the other varieties at all harvest dates. Values obtained by combining all varieties indicated that plants grown on Willacy fsl contain a higher concentration of K than plants grown on Harlingen clay but plants grown on both soils were high in K at all cutting dates.

Table 4. Influence of Soil and Date of Sampling on Calcium Concentration in 5 Tomato Varieties.

	Harlingen c *Days After Planting*			*Willacy fsl* *Days After Planting*			*Both Soils* *Days After Planting*		
Variety	*30*	*44* *% Ca*	*64*	*30*	*44* *% Ca*	*64*	*30*	*44* *% Ca*	*64*
Chico	4.1 b*	5.3a	3.9ab	3.9a	3.4a	2.5a	4.0a	4.4a	3.2a
Chico Grande	5.0a	5.2a	3.7 b	4.0a	3.3a	2.4ab	4.4a	4.2ab	3.0 b
El Monte	4.7ab	5.3a	4.1a	3.7a	3.1a	2.2 bc	4.2a	4.2ab	3.2a
La Bonita	4.6ab	4.7 b	4.1a	3.9a	3.2a	2.4ab	4.2a	4.0 b	3.3a
La Pinta	4.1 b	4.3 b	3.9ab	3.7a	2.7 b	2.0 c	3.9a	3.5 c	3.0 b
Soil									
Harlingen c	4.5a	5.0a	3.9a						
Willacy fsl	3.8 b	3.2 b	2.3 b						

* Means in a column not having the same letter beside them are different at the 0.05 level of significance.

Table 5. Influence of Soil and Date of Sampling on Zinc Concentration in 5 Tomato Varieties.

	Harlingen c *Days After Planting*			*Willacy fsl* *Days After Planting*			*Both Soils* *Days After Planting*		
Variety	*30*	*44* *ppm Zn*	*64*	*30*	*44* *ppm Zn*	*64*	*30*	*44* *ppm Zn*	*64*
Chico	20 b*	22 b	31a	28ab	27 b	28a	24 c	24 c	30a
Chico Grande	32a	38a	38a	28ab	27 b	24a	30ab	32 b	31a
El Monte	26ab	39a	36a	22 b	27 b	22a	24 c	33 b	29a
La Bonita	22 b	44a	34a	30ab	36a	26a	26 bc	40a	30a
La Pinta	33a	42a	33a	33a	41a	26a	33a	41a	30a
Soil									
Harlingen c	27a	37a	35a						
Willacy fsl	28a	32 b	25 b						

* Means in a column not having the same letter beside them are different at the 0.05 level of significance.

Table 6. Influence of Soil and Date of Sampling on Potassium Concentration in 5 Tomato Varieties.

Variety	Harlingen c Days After Planting 30	44 % K	64	Willacy fsl Days After Planting 30	44 % K	64	Both Soils Days After Planting 30	44 % K	64
Chico	5.1a*	4.6ab	4.4 bc	5.4a	4.6 d	3.8 c	5.3 bc	4.6 c	4.1a
Chico Grande	5.2a	5.2a	5.0ab	6.2a	7.3a	5.8a	5.7a	6.2a	5.4 b
El Monte	4.8a	4.5 b	4.0 c	5.6a	5.0 cd	4.8 b	5.2 bc	4.8 c	4.4a
La Bonita	4.6a	4.2 b	4.7 b	5.6a	5.3 c	6.1a	5.1 c	4.8 c	5.4 b
La Pinta	4.6a	4.7ab	5.6a	6.1a	6.3 b	6.0a	5.9a	5.5 b	5.8 b
Soil									
Harlingen c	5.1a	4.6a	4.8a						
Willacy fsl	5.8 b	5.7 b	5.3 b						

* Means in a column not having the same letter beside them are different at the 0.05 level of significance.

SUMMARY

These data indicate that there is a difference in certain cation concentrations in tomato plants due to variety. The differences were generally large for Mg and Zn during the early periods of growth but become smaller with increases in growth time. The varietal differences in concentrations of Mn, Ca, and K, however, were generally small in the seedling stage but differences in concentration of these cations increased with increased growth time. There appears to be an interaction between soil and variety in nutrient uptake but of the cations and varieties studied, the first deficiency expected to occur would be zinc and Chico would be the first variety to show the deficiency. Further research should be initiated to determine if the critical levels of nutrients are the same for all varieties.

LITERATURE CITED

1. Chapman, H. D. and P. F. Pratt. 1961. Methods of analysis for soils, plants and waters. Univ. of Calif. Div. Agri. Sci.
2. Foy, C. D. and S. A. Barber. 1958. Magnesium absorption and utilization by two inbred lines of corn. Soil Sci. Soc. Amer. Proc. 22:57-62.
3. Gorsline, G. W., D. E. Baker and W. I. Thomas. 1965. Accumulation of eleven elements by field corn (Zea Mays L.) Penn. State Univ. Agr. Expt. Sta. Bull. 725.
4. Gorsline, G. W., W. I. Thomas and D. E. Baker. 1964. Inhertance of P, K, Mg, Cu, B, Zn, Mn, Al and Fe concentrations by corn (Zea Mays L.) leaves and grain. Crop Sci. 4:207-210.
5. Hipp, B. W. and C. J. Gerard. 1969. Magnesium-Phosphorus interrelationships in tomatoes. Agron. Jour. 61:403-405.
6. Leeper, P. W. 1966. Chico Grande. Tex. Agr. Expt. Sta. L-693.
7. ——————. 1966. El Monte. Tex. Agr. Expt. Sta. L-692.
8. ——————. 1966. La Pinta. Tex. Agr. Expt. Sta. L-691.
9. ——————. 1964. La Bonita. Tex. Agr. Expt. Sta. L-614.
10. ——————. 1961. Chico. Tex. Agr. Expt. Sta. L-557.

Influence of Rate and Placement of Phosphorus on Growth, Yield and Nutrient Concentration in Carrots

BILLY W. HIPP[1]

Abstract: Studies were conducted to determine the influence of rate and placement of P on yield and chemical composition of carrots grown on a clay soil which contained a relatively high initial P level. Early growth of carrot tops was increased with P placement 3 in. directly below the seed but was not increased if P was placed 3 in. below and 4 in. to the side of the seed. Phosphorus placed directly below the seed slightly reduced the concentration of manganese and increased the concentration of P in the plant tops. Yield of marketable carrots or carrot size was not influenced by the treatments.

INTRODUCTION

Carrots are one of the most important vegetable crops in the Lower Rio Grande Valley of Texas and are grown on a variety of soil types. Little information regarding fertilizer response by carrots is available; however, results of fertilizer studies on a loam soil (1) indicated a response to nitrogen but not phosphorus (P) or potassium. Similarly, data concerning chemical characteristics of carrot plants growing in the Lower Rio Grande Valley have not been reported.

Recent P studies (3) have shown the importance of intricate P placement for maximum production and P uptake by tomatoes grown on soils of the Lower Rio Grande Valley. To determine if the same relationship exists between carrots and P as in tomatoes and P, an experiment was conducted on Harlingen clay soil.

MATERIALS AND METHODS

Soil at the test site was Harlingen clay, a soil with high inherent fertility levels but with a slow rate of water infiltration. The soil contains about 60% clay, shrinks when dry and swells when wet and is fairly uniform in texture to a depth of about 5 ft. Chemical characteristics of the soil are given in table 1.

Phosphorus treatments consisted of 38, 84 and 146 lb. P_2O_5 per acre (as 0-46-0) applied 3 in. directly below the seed and 38 and 84 lb. P_2O_5 per acre applied 3 in. below and 4 in. to the side of the seed. The treatments were replicated three times with a check included in each replication. The P treatments were applied at planting with a fertilizer distributor attached to a Planet Jr. Carrots (var. Long Imperator) were planted two rows per bed on 38 in. centers and watered immediately after planting to obtain a stand. Each plot consisted of 3 rows 30 ft. long. The center row of each plot was harvested for yield data.

Plant samples were taken 50 days after planting for laboratory analysis to determine the influence of rate and placement of P on growth of plant tops and to determine the treatment effect on nutrient concentration in the plant tops. Approximately 60 plants were taken from each plot and the tops separated from the roots. The tops were weighed, rinsed in distilled water, dried at 70°C and ashed according to the method of Chapman and Pratt (2). Cation determinations were made with an atomic absorption spectrophotometer and P was determined by the molybdenum-blue method.

RESULTS AND DISCUSSION

There was a definite influence of rate and placement on early growth of the carrot tops. Figure 1 shows the relationship between rate and location of P placement on the average weight of the individual plants 50 days after planting. There was a linear increase in plant weight from 0.58 to 0.90 gm/plant as P application rate increased from 0 to 146 lb. per acre with the P treatments placed below the seed. However, there were no increases in early growth, if the P treatment was placed 3 in. below the seed and 4 in. to the side.

Concentration of P in the carrot tops was influenced by rate and placement of P fertilizer (table 2). The 38 lb. rate of fertilizer P placed beneath the seed significantly increased the P concentration in the tops from 0.30 to 0.33% but addition of higher rates of P did not increase the plant P concentration above the 38 lb. rate. Placement of P 4 in. to the side and 3 in. below the seed did not influence the P concentration in the plant tops. This would indicate that root growth during the first 50 days was mostly downward. Lateral root growth was less than 4 in. as indicated by the lack of P uptake from the P bands placed 4 in. to the side. The concentration of manganese in the tops showed a tendency to decrease with increased P application rate and was significantly reduced when 146 lb. P_2O_5 per acre was applied. The plant manganese levels were quite high, however, and were probably well above critical levels. Applications of P resulted in slightly higher concentrations of K in the plant tops but the changes were not statistically sig-

Table 1. Chemical characteristics of the Harlingen clay soil used in the study.

pH	*Approximate CEC**	*ppm P by $NaHCO_3$ at pH 8.5*	*ppm P by ammonium acetate at pH 4.2*	*Me/100 g*		*Predominant Clay Mineral*
				K	*Mg*	
8.2	43	28	79	1.5	5.6	Montmorillonite

* Cation exchange capacity

[1] Assistant Professor, Texas A&M University Agricultural Research and Extension Center at Weslaco.

nificant at the 0.05 level. Concentrations of zinc, iron, calcium or magnesium in the plants were not affected by P fertilizer application.

Even though there was an early increase in plant growth due to P

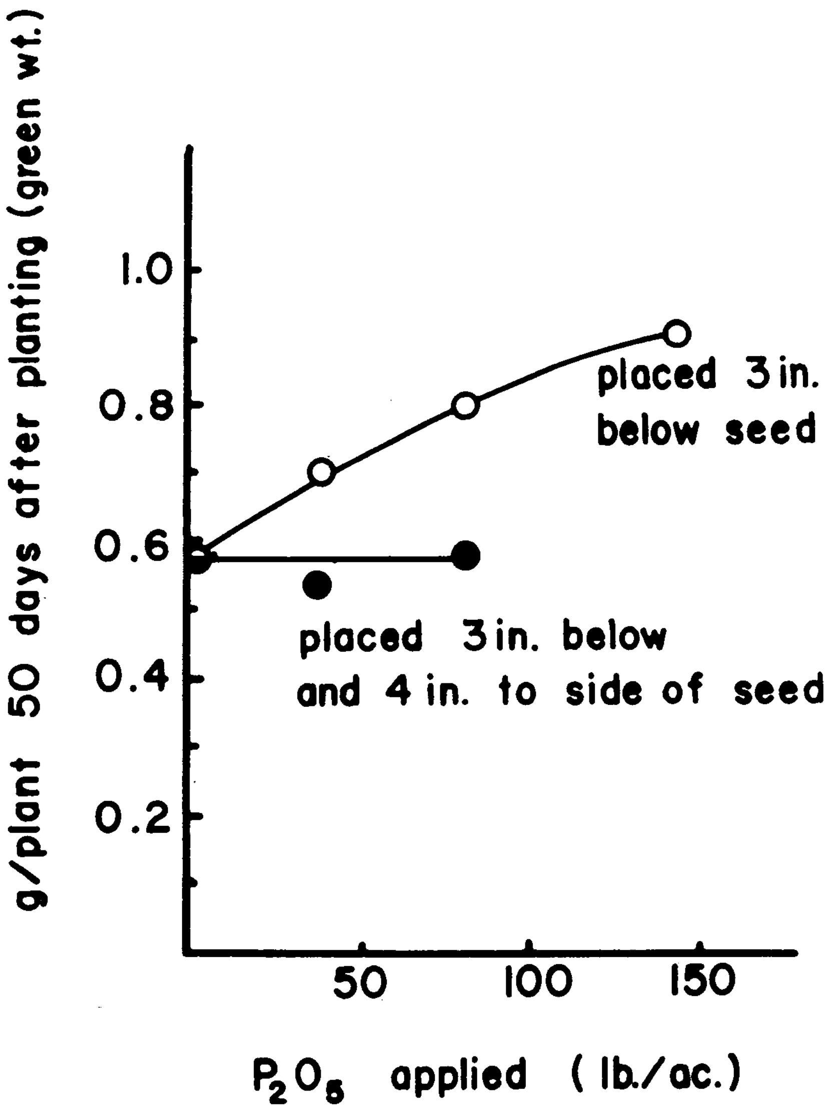


Figure 1. Influence of rate and placement of P on early growth of carrot tops.

Table 2. Influence of rate and placement of P on carrots grown on Harlingen clay soil.

Lbs. P_2O_5/Acre		Yield of carrots T/Ac*	Lb/ carrot	Concentration in tops % P	ppm Mn	ppm Zn	ppm Fe	% Ca	% Mg	% K
0		15.4	0.10	0.30	148	33	489	1.92	0.50	3.14
38	3 in. below seed	15.0	0.10	0.33	137	36	466	1.99	0.54	3.33
84	3 in. below seed	14.4	0.08	0.33	135	34	433	1.78	0.54	3.50
146	3 in. below seed	14.7	0.10	0.34	120	33	469	1.78	0.53	3.76
38	3 in. below and 4 in. to side of seed	14.4	0.09	0.30	151	39	506	1.88	0.52	3.31
84	3 in. below and 4 in. to side of seed	16.0	0.09	0.31	145	38	410	1.86	0.52	3.41
	LSD (.05)	N.S.	N.S.	0.02	21	NS	NS	NS	NS	NS

* Greater than ¾" but less than 1½" in diameter.

application, the applied P did not significantly influence yield of mature carrots as indicated in table 2. Data in table 2 also show that the size of individual carrots was not affected by the P treatments.

Results from this experiment suggest that if clay soils contain more than 28 ppm (129 lb/ac P_2O_5) $NaHCO_3$ extractable P, an early growth response may be obtained from P fertilizer placed 3 in. directly below the seed but final yield of carrots probably will not be increased by the added P.

LITERATURE CITED

1. Burleson, C. A. 1957. The response of carrots to fertilizer application. Jour. Rio Grande Valley Hort. Soc. 11:97-98.

2. Chapman, H. D. and P. F. Pratt. 1961. Methods of analysis for soils, plants and waters. Univ. of Calif. Div. Agr. Sci.

3. Hipp, Billy W. 1968. Placement of phosphorus for tomatoes. Jour. Rio Grande Valley Hort. Soc. 22:49-52.

The Banded-wing Whitefly, *Trialeurodes abutilonea*[1] (Haldeman) a New Pest on Tomatoes in the Rio Grande Valley

J. C. Boling and Michael F. Schuster[2]

Abstract: The data indicates that endosulfan shows promise as a control agent for the banded-wing whitefly. Also, there was little difference in the degree of control obtained between the 0.5 and 1.0 pound per acre rates of this material. The yield response obtained with insecticides indicate that the banded-wing whitefly has become a pest of fall planted tomatoes in the lower Rio Grande Valley.

INTRODUCTION

The banded-wing whitefly, *Trialeurodes abutilonea* (Haldeman), has previously been considered only a minor pest on tomatoes in the Rio Grande Valley of Texas. Tomatoes planted south of Weslaco in the fall of 1965 were observed to be severely damaged by this pest. Egg, nymph and adult stages were found on the underside of leaves. The numbers found on the older leaves indicated that damage can be attributed primarily to the nymphal stages. Whitefly nymphs were found on all stages of plant growth and damage was noted as severe curling of the leaves. In many instances, seedling plants were killed by the large numbers of nymphs feeding on the plants. Adults fed primarily on the younger foliage.

Russell (4) records the banded-wing whitefly on 122 different hosts. We observed whiteflies in large populations on cotton plants during July and August toward the end of the growing season. The majority of the cotton fields had been periodically sprayed with methyl parathion for insect control. Therefore, it would appear that the banded-wing whitefly is not susceptible to control with methyl parathion. Butler (1) reports that *T. abutilonea* is a minor pest on cotton in Arizona and is held in check by parasites and predators. Apparently, periodic applications of methyl parathion may reduce parasite and predator populations, thereby allowing the whitefly to build up on cotton and migrate to tomatoes as cotton is plowed under and tomatoes are planted during August.

Three tests were conducted to determine methods of control of the banded-wing whitefly. The first test was conducted to evaluate the effectiveness of various chemical sprays in reducing whitefly infestations. Two tests were conducted to evaluate various soil applied systemic chemicals and to determine the effect of chemical placement upon the effectiveness of the chemical.

[1] Aleyrodidae: Homoptera

[2] Texas A&M University Agricultural Research and Extension Center at Weslaco.

MATERIALS AND METHODS

Tests with sprays were conducted in an established field of Chico tomatoes. Each plot consisted of a row 25 feet long. Plants in the 6 to 8 leaf stage were treated with candidate materials, using a knap sack sprayer, at a rate of 16 gallons of spray per acre. Each treatment was replicated four times. The number of nymphs and eggs were recorded from five terminal leaflets selected from the 4th limb of the plant apex in each of the plots except on September 8, at which time 4 leaves were selected. On September 22, all insecticidal dosages were doubled due to increasing whitefly populations. The following insecticides were used: dimethoate, endosulfan, parathion, Thiocron (0,0-dimethyl phosphorodithioate 5-ester with 2-mercapto-N-[2-methoxyethyl] acetamide) and phosphamidon.

A second test was conducted in the same field to compare the results of side-dress application of various granular insecticide formulations to tomatoes grown in a fine textured, silty-clay-loam soil. Chemicals are applied about 6 inches from the plants and two inches deep. Soil moisture was abundant at the time of application and the plots were irrigated about two weeks later. Plants, plot size, replications and data recorded was as in the previous described test. Insecticides used were: TD 72 (0,0-diethyl S-N-ethoxycarbonyl-N-methyl carbamoyl) methyl phosphorodithioate, Temik (2-methyl-2-(methylthio) propionaldehyde 0-(methylcarbamoyl) Oxime), Thiocron and DP 1179 (methyl N-(methylcarbamoyl) oxythioacetimidate).

A third test was conducted on the experiment station farm to compare the effectiveness of Temik applied in the furrow and applied 2 inches below the seed at planting. The test was conducted on a coarse-textured, Willacy-fine-sandy-loam soil. The Chico variety of tomatoes was used and each 25 foot plot was replicated three times. The seed were planted in dry soil and irrigated to germinate the seed on September 10.

All data was converted to log $(X + 1)$ and subjected to Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

The results of chemical spray treatments are shown in Tables 1 and 2. On September 8, endosulfan at the 0.5 pound per acre rate appeared to have a greater effect on reducing white-fly nymph population than other treatments. On September 15, significantly greater whitefly nymph control was obtained with endosulfan at the 0.5 pound per acre rate than with both rates of dimethoate, parathion, Thiocron, phosphamidon and the untreated check. Treatments of endosulfan at 0.25 and 0.37 pounds per acre did not differ significantly from any of the other treatments.

An average of the September 8, and September 15, counts indicated that only the 0.5 pound treatment with endosulfan had significantly less nymphs than the control plots. There was no significant difference in number of eggs per leaflet among the treatments.

Data recorded on September 22, 29 and October 14 after the rates had been doubled are shown in Table 2. On September 22, all treatments were significantly better than the untreated check, with endosulfan treatments providing better control than any other treatment. On September 29, endosulfan at 0.5 and 1.0 pounds per acre were significantly better than the check. There was no significant difference between other treatments and the check. On October 14, dimethoate at the 0.5 pound rate and the three rates of endosulfan and phosphamidon were significantly better than the check.

There was no significant difference between treatments in egg counts on September 22. On September 29, the three rates of endosulfan had significantly fewer eggs than the check. There was no significant difference between the check and the other treatments. An average of the egg counts on these three dates revealed that 0.5 and 1.0 pound of endosulfan treated plots had the lowest number of eggs and they were significantly lower than the check and plots treated with 0.25 pound dimethoate and 0.5 pound parathion.

An average of counts on these three dates revealed all treatments reduced the whitefly population significantly when compared to the check. Counts of endosulfan treatments at 0.5 and 1.0 pound per acre were significantly lower than all treatments except endosulfan at 0.75 rate. There was no difference between the endosulfan (0.75 pound per acre rate) and phosphamidon.

Table 1. Control of banded-wing whitefly on tomatoes with insecticidal sprays, Weslaco, Texas 1966.

		Number of nymphs and eggs per leaflet					
		Sept. 8		Sept. 15		Average	
Insecticide	*lbs/acre*	*nymphs*	*eggs*	*nymphs*	*eggs*	*nymphs*	*eggs*
Dimethoate	.125	146.8	83.6	114.5 b	71.0	128.8 c	76.6
Dimethoate	.25	193.2	28.3	117.4 b	81.7	151.6 c	57.9
Endosulfan	.25	135.3	44.1	69.4ab	64.2	98.7abc	55.3
Endosulfan	.37	135.5	36.8	65.7ab	40.0	97.3abc	38.6
Endosulfan	.50	85.0	50.8	27.6a	29.6	53.1a	39.0
Parathion	.25	168.1	72.9	118.7 b	84.7	140.7 c	79.5
Thiocron (R)	.50	149.9	31.3	90.2 b	72.1	116.7 bc	53.9
Phosphamidon	1.00	182.3	89.5	95.7 b	55.9	173.6 c	70.8
Check	—	225.4	115.6	119.4 b	76.2	166.5 c	93.7

1 Means followed by the same letter do not differ significantly at the 5% level according to Duncan's new multiple range test.

Table 2. Control of banded-wing whitefly on tomatoes with insecticidal sprays. Weslaco, Texas. 1966.

		Number of nymphs and eggs per leaflet							
		Sept. 22		Sept. 29		Oct. 14		Average	
Insecticide	*lbs/acre*	*nymphs*	*eggs*	*nymphs*	*eggs*	*nymphs*	*eggs*	*nymphs*	*eggs*
Dimethoate	.25	105.5 cd	16.4	28.9abc	85.3 bcd	27.1 cd	3.7 de	53.8 c	35.1 bc
Dimethoate	.50	97.7 cd	13.4	34.1 bc	33.1abcd	21.7abc	.3a	53.6 c	15.6ab
Endosulfan	.50	40.5a	31.1	14.3a	10.2ab	16.9abc	2.5 bcd	23.9a	14.6ab
Endosulfan	.75	57.3abc	14.9	19.8abc	12.7a	7.8a	.5ab	28.3ab	9.4a
Endosulfan	1.00	47.1ab	6.2	9.5a	15.1ab	7.8ab	1.2abcd	21.4a	7.5a
Parathion	.50	121.7 d	39.4	50.5 c	85.6 d	37.3 cd	2.6 de	69.8 c	42.5 bc
Thiocron (R)	1.00	126.9 d	21.3	45.3abc	46.9abc	63.7 cd	2.3 cde	78.7 c	23.5abc
Phosphamidon	1.00	77.8 bcd	16.3	33.3abc	18.6abc	30.7 bc	2.8 de	47.3 bc	12.5ab
Check	—	262.9 c	25.1	102.7 c	102.9 cd	84.7 d	7.2 c	150.1 d	45.0 c

1 Means followed by the same letter do not differ significantly at the .05 level according to Duncan's new multiple range test.

Yield data (Table 3) indicate that endosulfan treated plots at the lowest and highest rates gave a significantly higher yield than the check and those plots treated with the high rates of dimethoate. The medium rate of endosulfan, and the parathion gave intermediate yields.

Whitefly nymph counts 25 days after side-dress applications revealed that Temik at the 2.0 pound per acre rate provided significantly better control than the untreated check (Table 4). There was no significant difference between other treatments and the check although they had substantially lower infestation of nymphs than did the check.

Tests to evaluate the effectiveness of Temik in relation to its placement showed that lower whitefly infestations were found in plots where Temik was placed below the seed than when applied as in-furrow treatment (Table 5).

Table 3. Yield of ripe tomatoes at first picking following banded-wing whitefly control, Weslaco, Texas. 1966.

Treatments	*lbs/acre*	*Pounds per plot*[1]
Low Endosulfan	.25 and .5	44.10a
High Endosulfan	.37 and .75	40.51a
High Dimethoate	.25 and .5	38.68ab
Medium Endosulfan	.5 and 1.0	37.53ab
Parathion	.25 and .5	34.48ab
Phosphamidon	1.0	32.90 b
Thiocron	.5 and 1.0	32.25 b
Check	—	31.55 b
Low Dimethoate	.125 and .25	30.03 b

1 Means followed by the same letter do not differ significantly at the .05 level according to Duncan's new multiple range test.

Table 4. Banded-wing whitefly control 25 days after side-dress applications of insecticides on tomatoes. Weslaco, Texas. 1966.

Insecticides	*lbs/acre*	*Nymphs/leaflet*
TD 72	2.0	156.4ab[1]
Temik	.5	190.6ab
Temik	1.0	139.5ab
Temik	2.0	148.2a
Thiocron	4.0	142.1ab
DP 1179	2.0	234.3ab
Check	—	366.1 b

1 Means followed by the same letter do not differ significantly at the .05 level according to Duncan's new multiple range test.

Table 5. Control of banded-wing whitefly with Temik applied in-furrow and 2 inches below the seed at planting. Weslaco, Texas. 1966.

		Number per plant 22 days after planting	
Band location	*lbs/acre*	*Nymphs*	*Eggs*
in-furrow	.25	3.17ab[1]	19.3
in-furrow	.50	3.43ab	26.6
in-furrow	1.0	9.13ab	55.1
below seed	.5	.97ab	31.5
below seed	1.0	.50a	6.4
Check	—	17.76 b	83.4

1 Means followed by the same letter do not differ significantly at the .05 level according to Duncan's new multiple range test.

DISCUSSION

Placement of Temik granular insecticide was found to have a marked effect on the degree of insect control obtained with soil applied treatments to tomatoes. It was pointed out by Hipp (3) that seedling tomato roots grow down rather than laterally and respond to phosphorus fertilizer placed below the seed better than that placed to the side.

Seedling tomato tap roots probably grow through in-furrow bands of insecticides and the effect is lost. Butler and Muramoto (2) found that there may be a correlation between increased whitefly population and pubescent cotton leaves. Since tomato leaves are very pubescent, this may open a new avenue for investigation on the control of this pest through plant breeding.

LITERATURE CITED

1. Butler, George D., Jr. 1967. Development of the Banded-wing whitefly at different temperatures. Jour. Econ. Entomol. 60:3:877-78.

2. Butler, G. D., Jr., and H. Muramoto. 1967. Banded-wing whitefly abundance and cotton leaf pubescence in Arizona. Jour. Econ. Entomol. 60:4:1176-77.

3. Hipp, Bill W. 1968. Placement of phosphorus for tomatoes. Jour. Rio Grande Valley Hort. Soc. 22:49-52.

4. Russell, Louise M. 1963. Hosts and distribution of five species of *Trialeurodes* (Homptera: Aleyrodidae). Ann. Entomol. Soc. Am. 56:149-53.

Effect of Reflective Soil Coatings on Soil Temperatures, Soil Moisture and the Establishment of Fall Carrots[1]

C. J. GERARD, G. V. CHAMBERS and R. K. SAUNDERS[2]

Abstract: Reflective coatings when applied to modify the soil surface were effective in suppressing evaporation and in modifying soil temperatures at planting depth for establishing plant stands of carrots. A high inverse relationship was obtained between soil temperatures at planting depth and stand of carrots. Maximum temperatures of 45° to 50°C at planting depth prevented germination of carrots. Certain coatings were effective in suppressing soil temperatures below 40°C at planting depth and in providing a favorable environment for germination of fall carrots. Yields were a function of stand; the carrots which grew under the better reflective coatings produced the highest yields.

INTRODUCTION

High plant populations are especially important in irrigated areas where high yields are needed to offset high production costs. The plant population needed to achieve high yields is dependent upon management practices and type of crop. Research has been conducted in recent years to increase plant population by modifying the environment of planted seed and subsequent young seedlings.

In the late summer and fall in the Lower Rio Grande Valley of Texas, the environment for crop production is modified by frequent irrigations, which supply the moisture needed for germination and evaporative cooling. Unfortunately, a shortage of water with a low salt content frequently makes the practice of applying 3 to 4 light irrigations at 2- to 4-day intervals to establish fall vegetables impractical. In addition, this practice often increases seedling diseases and soil salinity in the seed zone, and so does not insure the desired high plant population.

Emmert (2) reported that aluminum-pigmented plastics were promising for summer plantings of vegetables; Army and Hudspeth (1) altered the micro-climate of the seed zone by using several mulch materials including the use of white and aluminum paints to alter the microclimate of seed zones.

[1] Technical Contribution No. 7459 Texas Agricultural Experiment Station, Lower Rio Grande Valley Research and Extension Center.

[2] Respectively, Associate Professor, Texas Agricultural Experiment Station, Texas A&M University, Lower Rio Grande Valley Research and Extension Center, Weslaco, Research Specialist, Esso Research and Engineering Company, Baytown, Texas, and Research Technologist, Esso Research and Engineering Company, Baytown, Texas, the research affiliate of Humble Oil & Refining Company.

The application of solar heat reflective soil coatings is a possible method of modifying the environment of seed and seedlings. Studies using various soil coatings were initiated in 1964 and continued in 1965. Research with bell peppers has been reported (3). The purpose of this study was to determine the influences of reflective soil coatings on evaporation and soil temperatures and to determine the feasibility of the reflective coating concept for establishing carrots under hot, dry weather conditions.

MATERIALS AND METHODS

Two replicated experiments using reflective coatings were conducted in 1964 and also in 1965 on Willacy loam soil. The seedbeds were prepared by rotovating and leveling. Carrots, Long Imperator, selected as the indicator crop were planted about ¼ inch deep. A number of different experimental reflective soil coatings[3], white to cream colored petroleum resin emulsions, were applied in 6-inch strips over planted seed. Upon application to the soil surface these emulsions formed soil films; each having different characteristics. In 1964 and 1965, some of the treatments consisted of a white topcoat over a black basecoat formed by applying Encap®[4]. In 1964 a treatment using the Encap® alone was part of the research. A bare treatment was also included in the experiment. In 1965 shaded bare and shaded coating treatments were included as part of the experiment. Shading was provided by suspending a white opaque plastic film about 6 inches above the seedbed. Plots were irrigated only once for stand establishment. Photographs showing reflective coatings are shown in Fig. 1. This paper will discuss the influences of soil temperature and moisture and their influences on germination and stand, but it will not discuss the specific influences of treatments on plant establishment.

Germination, stand, soil moisture, soil temperature and yield data were obtained. Soil moisture was determined for 0-1 and 0-2 inch soil depths. Soil moisture was determined by weighing soil samples prior to and after drying at 105°C. Soil temperatures at ¼ and 1 inch in 1964 and 1 inch in 1965 were evaluated with copper-constantan thermocouples and recorded with multiple point recorders. The average temperatures at ¼ and 1-inch were determined from 2 locations on each treatment; the average soil temperatures at 1 inch were determined from 4 locations on each treatment. Relationship between average maximum soil temperatures at ¼ and 1-inch and germination of carrots was determined in 1964; relationship between average maximum soil temperature at 1 inch and germination of carrots was determined in 1965. Maximum soil temperatures at ¼ and 1 inch were averages of maximum temperatures at these depths during the 10 day period following irrigation of plots. Yield data were obtained in 1964 but were not obtained in 1965.

[3] Experimental materials provided by Esso Research and Engineering Company.

[4] Black petroleum mulch. Registered trademark of Humble Oil and Refining Company.

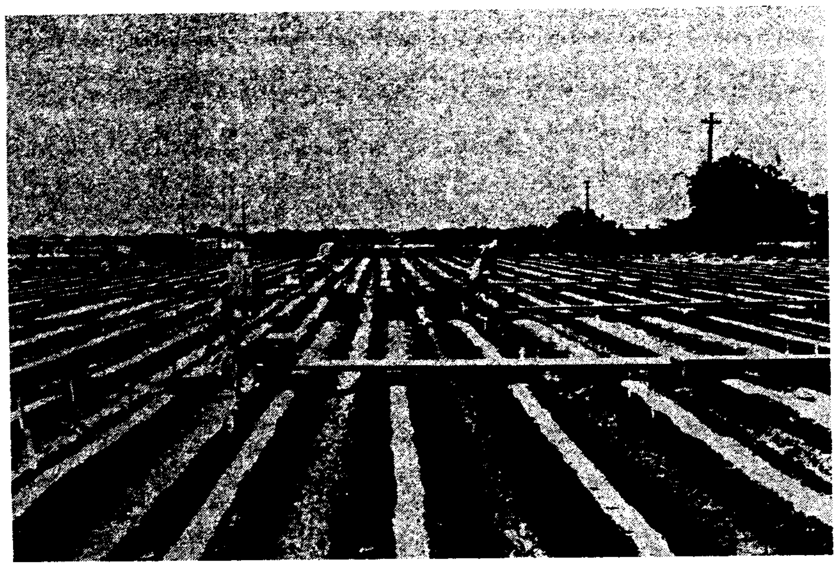


Figure 1. Photograph showing one of reflective coating treatment experiments and multi-point recorders.

RESULTS AND DISCUSSION

Soil temperature, stand and yield data. The relationship between maximum soil temperatures at ¼ and 1 inch in 1964 and maximum soil temperatures at 1 inch in 1965 under reflective coatings and carrots stands are shown in Fig. 2 and 3, respectively. The bare treatments are not included in the relationship because moisture limited germination on the bare treatments. High inverse relationships were obtained between maximum soil temperatures at ¼ and 1 inch and stand of carrots. The relationships between maximum temperatures at ¼ and 1 inch and stand of carrots in 1964 are similar to the relationships obtained with peppers (3). The equation between maximum temperatures at 1 inch and stand in 1965 shows a greater negative slope than equation between maximum temperatures at 1 inch and stand in 1964. The year 1965 was more typical in that rainfall did not occur during the critical germination period, 5 to 7 days, but light rainfall did occur in 1964. However, the maximum air temperatures during the critical germination period in 1964 and 1965 were almost identical ranging from 34 to 36°C. Plant stands of 23 and 16 plants per foot were obtained on shaded bare and shaded coating treatments in 1965, respectively.

The typical influences of different soil coatings including bare treatment on soil temperatures are indicated in Fig. 4. Note the contrast influences of reflective coating and black coating on soil temperatures. The better reflective coatings were effective in modifying the soil temperatures at planting depth, ¼ inch. The differences between maximum soil temperatures at ¼ and 1 inch under the reflective and black coatings were about 1° and 5°C, respectively. The converging lines expressing stands as functions of soil temperatures at ¼ and 1 inch (Fig. 2) also show the effectiveness of the better reflective coatings in modifying the soil temperature.

The better reflective coatings were effective in suppressing soil temperatures at planting depth and increasing plant stands; some coat-

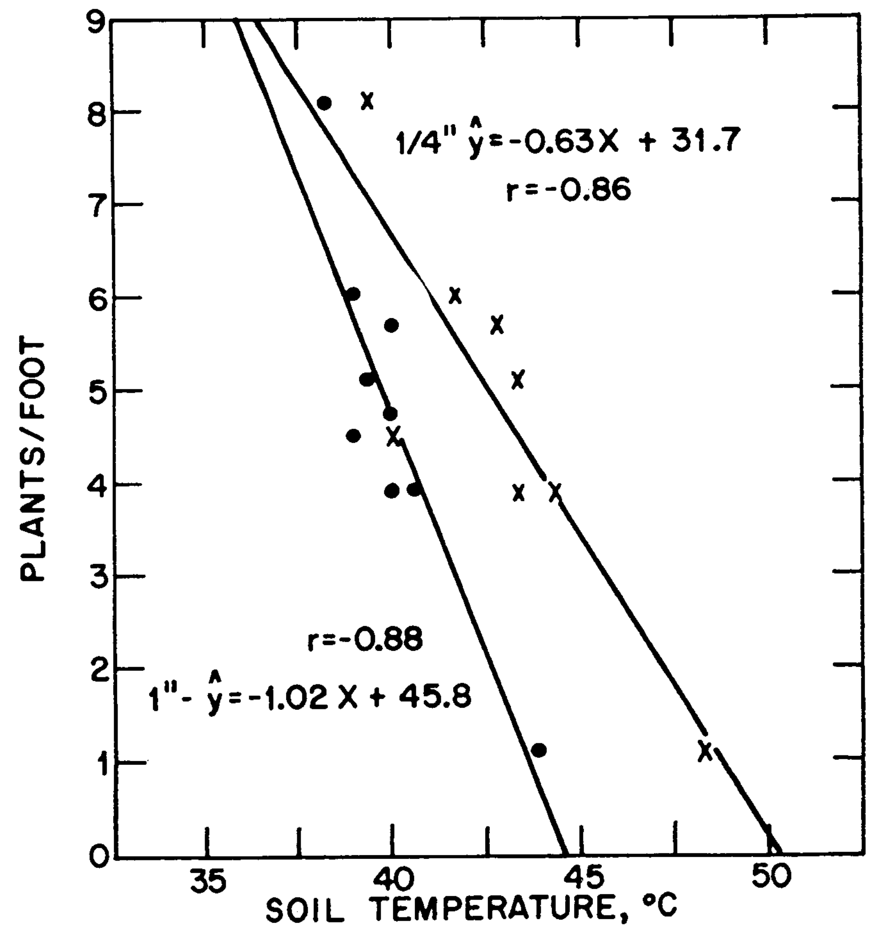


Figure 2. Relationship between maximum soil temperatures at ¼ and 1 inch under reflective coatings and germination of carrots, 1964.

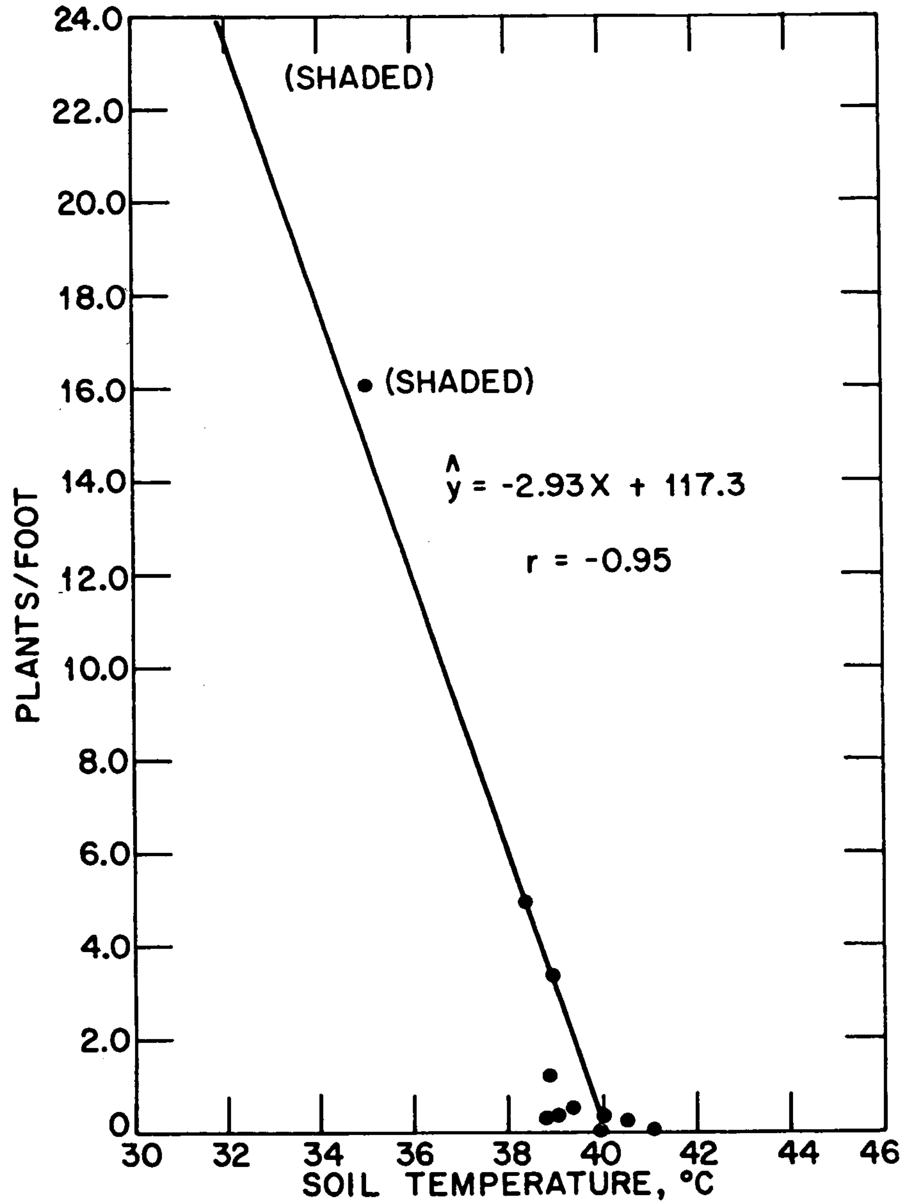


Figure 3. Relationship between maximum soil temperatures at 1 inch under coatings and germination of carrots, 1965.

ings were not effective in suppressing soil temperatures and therefore germination was inhibited. Maximum soil temperatures of 45 to 50°C at planting depth inhibited or induced a seed dormancy reaction. Stands of 5 to 8 plants per foot were established when maximum temperatures at planting depth were 40 to 42°C. Desired plant population is 10 to 12 plants per foot. It is possible that this plant density could be attained with the more effective coatings if double or multiple rows on top of 38-inch beds, a common practice, would have been used rather than a single row which was used in these experiments. Yield was directly correlated with stand in 1964 as indicated in Fig. 5.

Soil moisture and stand data. Certain reflective coatings were extremely effective in suppressing evaporation. Soil moisture on the bare plots was not adequate to promote germination. The typical influence

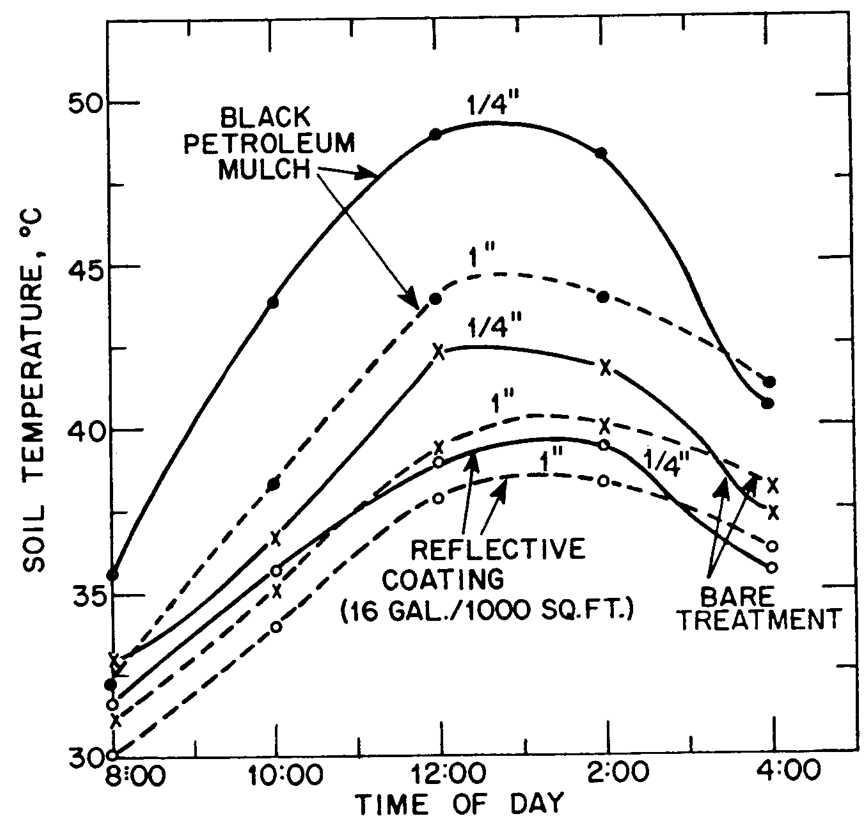


Figure 4. Typical influence of bare, black petroleum mulch and reflective coating treatments on soil temperatures at ¼ and 1 inch depth on Sept. 21, 1964.

of reflective coating and bare treatments on evaporation from the surface inch of soil are indicated in Fig. 6. In one of the experiments in 1965, rains from July 29 through August 5 lowered soil and air temperatures; therefore, soil temperatures were not a factor in the establishment of carrots. However, it was possible to establish a relationship between the amount of reflective coating applied and soil moisture and stand establishment. The decreases in evaporation was a function of rate of application as indicated in Fig. 7. Rates of 10 to 20 gal. per 1000 ft^2 of the applied materials significantly reduced evaporation. The relationships between rates of reflective coating and stand or soil moisture were parabolic as indicated in Fig. 7. The relationship between stands of carrots planted under different rates of typical reflective coating and soil moisture at 0-1 inch was highly significant as shown in Fig. 8. The data suggest that 15 to 20 gal. per 1000 ft^2 of the better reflective coating materials would insure the desired plant populations of carrots if soil temperature at planting depth was not a limiting factor.

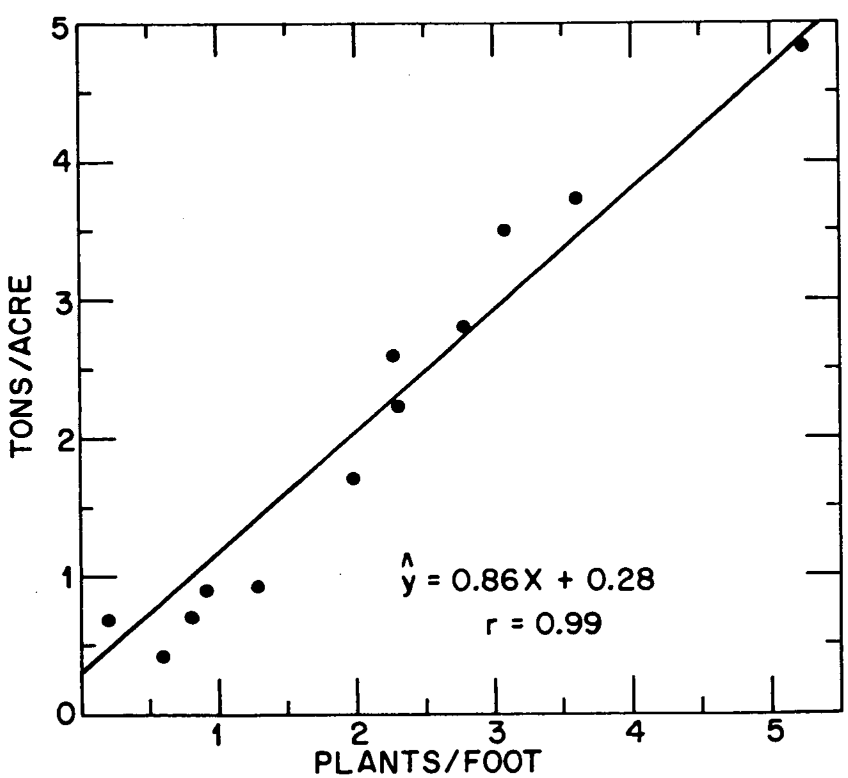


Figure 5. Relationship between yields of carrots and plant population, 1964.

CONCLUSIONS

Reflective coatings when applied to modify the soil surface were effective in modifying soil temperatures at planting depth. A high inverse relationship was obtained between soil temperatures at planting depth and stand establishment of fall carrots. Soil temperatures of 45° to 50°C at planting depth inhibited germination of carrots. Under climatic conditions in the Lower Rio Grande Valley certain reflective coatings were effective in suppressing soil temperatures at planting depth below 40°C. Stands of 5 to 8 plants per foot were attained when maximum temperature at planting depth was 40 to 42°C. The feasibility of using reflective coatings on modified shaped beds or on multiple row plantings on top of 38 to 40-inch beds for increased plant populations and yields needs additional research.

Maximum temperatures at planting depths, ¼ inch, under the better reflective coatings were about 1°C above maximum temperature at 1

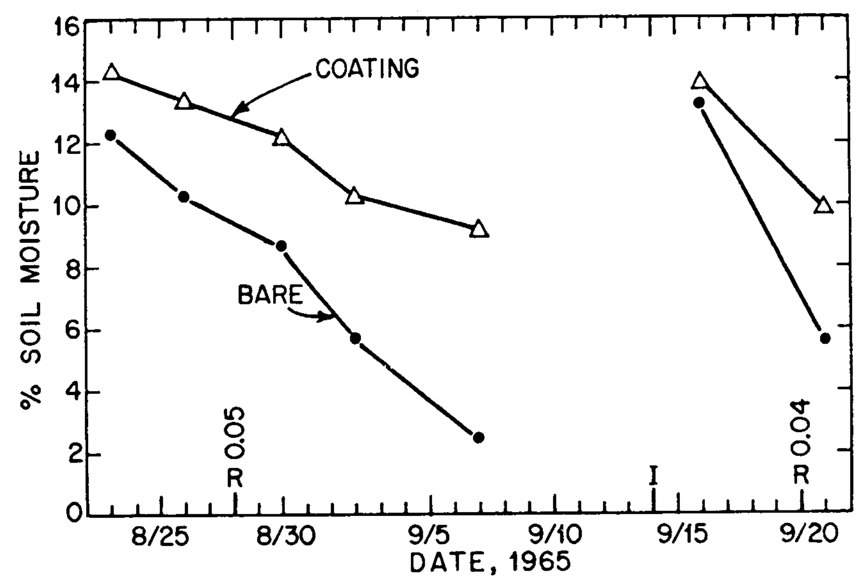


Figure 6. The influence of bare and a reflective coating on soil moisture at 0-1 inch, 1965. R refers to rainfall; I to irrigation.

inch. In contrast maximum temperatures on bare and Encap® treatments at ¼ inch were 2 to 3 and 4 to 5°C higher, respectively, than maximum temperatures at 1 inch depth.

Certain reflective coatings were extremely effective in suppressing evaporation. The decrease in evaporation was a function of applied rate of coating; rates of 15 to 20 gal. per 1000 ft^2 of the better reflective coatings materials which were applied would insure desired plant populations of carrots (10 to 12 plants per foot) if soil temperatures were not a limiting factor.

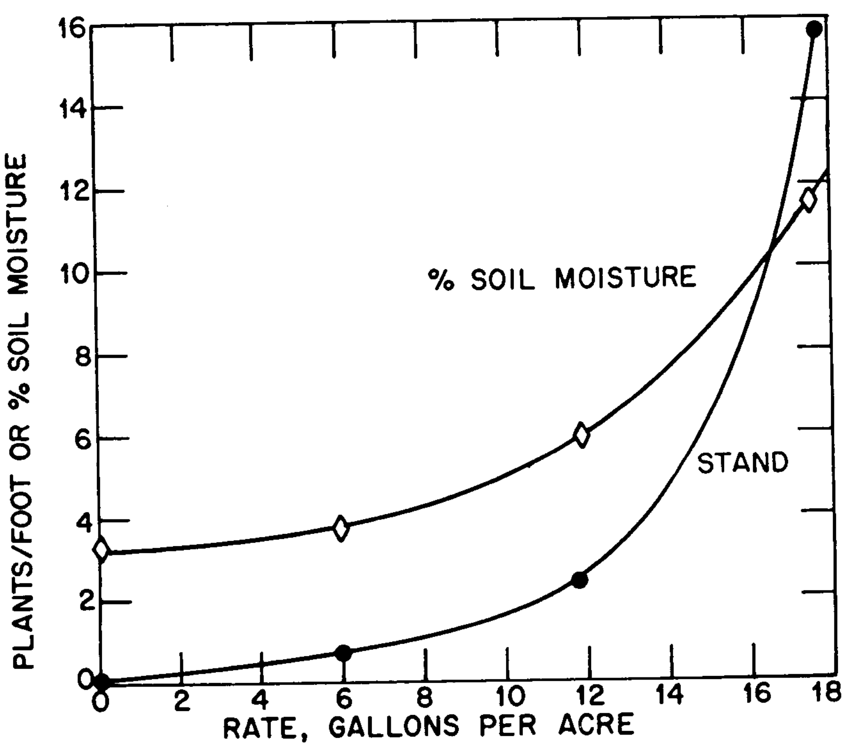


Figure 7. The typical influence of rate of reflective coating on stand of carrots and soil moisture at 0-1 inch, 1965.

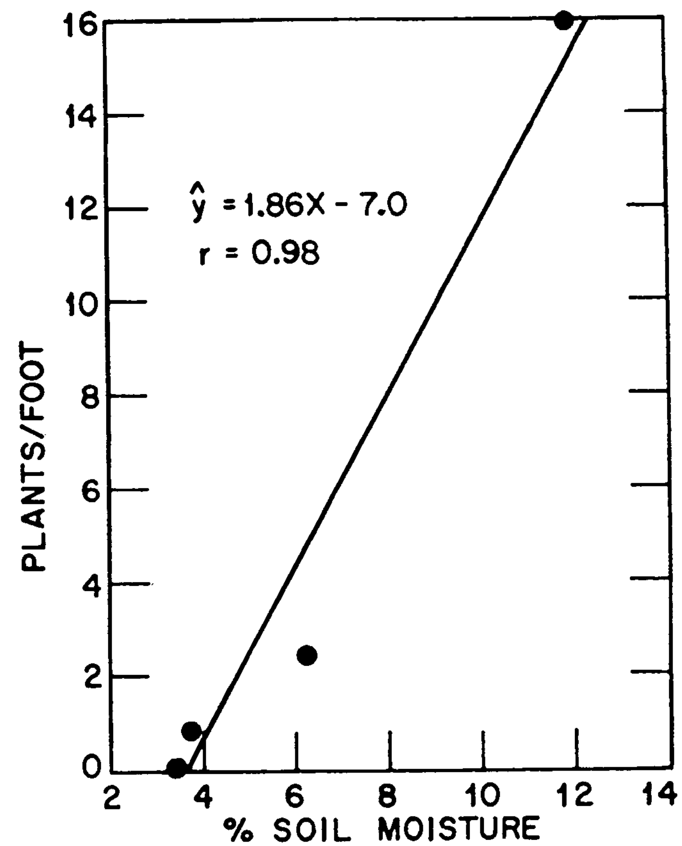


Figure 8. Relationship between stand and soil moisture at 0-1 inch, 1965.

LITERATURE CITED

1. Army, T. J. and E. B. Hudspeth, Jr. 1960. Alternation of the microclimate of the seed zone. Agron. J. 52:17-22.

2. Emmert, E. M. 1957. Black polyethylene for mulching vegetables. Proc. Amer. Soc. Hort. Sci. 69:464-469.

3. Gerard, C. J. and G. Chambers. 1967. Effect of reflective coatings on soil temperatures, soil moisture and the establishment of fall bell peppers. Agron. J. 59:293-296.

The Evaluation of Three Fungicides For Protection and Control of Leaf Mold on Tomatoes

B. L. JONES and P. W. LEEPER[1]

Abstract: Three fungicides were used for the prevention and control of leaf mold of tomatoes. All three were effective both as protectants and controls. Yields were highest when the fungicides were applied as protectants, less when applied as controls, and least in non-treated plots.

INTRODUCTION

Leaf mold of tomatoes (*Lycopersicon esculentum* Mill.) incited by the fungus *Cladosporium fulvum* Cke. occurs on both field and greenhouse tomatoes in the Lower Rio Grande Valley of Texas. The disease is usually a problem only in greenhouse tomato culture in most areas of the United States (2). However, in the Valley, it is a problem on field tomatoes during the spring, summer and fall. Leaf mold severity is least on spring and summer tomatoes, but becomes a limiting factor during the fall for their production. Major damage is confined to the foliage with occasional damage to stems and fruit. During periods of wet weather it causes rapid breakdown of foliage. The severity of the disease is most pronounced on tomatoes with a heavy fruit load.

Resistance to *C. fulvum* would be the most ideal method of control. However, there are at least 10 known races of the pathogen. Tomato varieties resistant to some races have been introduced (1, 3, 4, 5). But varieties with resistance to all races have been difficult to obtain. The commercial varieties grown in South Texas are susceptible to one or more existing race of the fungus.

The use of fungicides for protectants and control of leaf mold has not been intensively investigated in the Valley. This paper reports the results of studies with three fungicides used as protectants and controls of leaf mold of tomatoes during the fall of 1968.

MATERIALS AND METHODS

TAMU Monte Grande tomatoes were transplanted in August 1968 on 80 inch beds in 30 foot plots. The fungicides used were: Manzate D (Manganese ethylenebisdithiocarbamate plus zinc), Benlate (1-(butylcarbamoyl)2-benzimidazole carbomic acid, methyl ester) and Daconil 2787 (tetrachloroisophthalonitrile). A surfactant was used at the rate of 4 ozs per 100 gallons of water with all fungicides. The experiment was a randomized block with 3 replications.

[1] Respectively, Assistant Professor and Associate Professor, Texas A&M University Agricultural Research and Extension Center at Weslaco.

Rates used were:

Manzate D	– 2 lbs 80% WP per 100 gallons of water
Daconil 2787	– 1.5 lbs 75% WP per 100 gallons of water
Benlate	– 2.0 ozs formulation per 100 gallons of water
Benlate	– 3.0 ozs formulation per 100 gallons of water
Benlate	– 4.0 ozs formulation per 100 gallons of water
Check	– No treatment

A protective spray program was begun October 9 at the time of first fruit set and prior to the appearance of any symptoms of infection. Fungicides were applied at 7-day intervals to the foliage with a hand sprayer at 40 psi pressure. This was approximately 100 gallons per acre. A total of 8 applications were made in the protective treatments.

On November 11 leaf mold was first observed on the non-treated plots. A control program was initiated at that time. The same fungicides and rates were used as for the protective program. A total of 3 applications were made at 7-day intervals in the control treatments.

All treatments were terminated December 2, 1968. Tomatoes were harvested November 26 and December 7, 19, 31. The number of fruit, average weight of fruit, and per acre yield were obtained from each plot.

RESULTS

With the exception of Benlate at the 2 oz rate no infection was detected when the three fungicides were applied as protectants. When applied after infection, Daconil 2787, Manzate D and Benlate at all rates checked the advance of the disease but did not eradicate the pathogen. Non-treated check plots were heavily infected. Both Daconil 2787 and

Table 1. The quantity, fruit size and yield of TAMU Monte Grande Tomatoes following treatments with fungicides as Protectants and Controls of leaf mold.

	Number of Fruit/plot		*Fruit size (lbs.)*		*Yield*	
Fungicide	*Protectant*	*Control*	*Protectant*	*Control*	*Protectant*	*Control*
Daconil 2787	739[a]	655	0.26[b]	0.23	25.75[c]	21.05
Manzate D	662	709	0.26	0.25	24.00	23.33
Benlate 2 oz.	717	743	0.25	0.24	23.76	24.20
Benlate 3 oz.	689	671	0.25	0.22	23.20	19.78
Benlate 4 oz.	736	689	0.26	0.23	25.42	20.70
Check	558		0.23		18.34	

[a] Average of 3 replicates
[b] Average size
[c] In tons per acre

Benlate at the 3 and 4 oz rates applied for control were more effective than Manzate D and Benlate at the 2 oz rate.

Yield was increased over 7 tons per acre with Daconil 2787 and Benlate at the 4 oz rate (Table 1). All treatments used as protectants resulted in higher yields than when used as controls with the exception of Benlate at the 2 oz rate.

DISCUSSION

Under the climatic conditions which prevailed during this study, leaf mold was prevented by the application of the three fungicides. When used after initial infection for controls, none of the fungicides completely retarded disease development. That fungicides applied as protectants prevented infection with ample inoculum present, indicates the importance of applying fungicides before infection occurs. Once initial infection has occurred the fungicides applied for control in this study cannot eradicate the pathogen.

LITERATURE CITED

1. Bailey, D. L., and E. A. Kerr. 1964. *Cladosporium fulvum* rate 10 and resistance to it in tomato. Can. J. Bot. 42:1555-1558.
2. Chupp, C., and A. F. Sherf. 1960. Vegetable diseases and their control. The Ronald Press Co. New York. 693.
3. Kerr, E. A., and D. L. Bailey. 1964. Resistance to *Cladosporium fulvum* Cke. obtained from wild species of tomato. Can. J. Bot. 42:1541-1554.
4. Langford, A. N. 1937. The parasitism of *Cladosporium fulvum* Cooke and the genetics of resistance to it. Can. J. Res. 15:108-128.
5. Rich, C. M., and L. Bulter. 1956. Cytogenetics of the tomato. Advan. Genet. 8:267-382.

Implications for Texas of Regional Interdependency in the National Processing Tomato Industry

THOMAS L. SPORLEDER[1]

Abstract: Texas is currently not a major supplier of raw stock processing tomatoes. This article examines several reasons for the position Texas currently holds and presents a model of the national raw stock processing tomato industry. The model helps to explain the nature and extent of regional interdependency among major processing tomato supply areas. Implications of the model are explored as they relate to the potential development of Texas as a major raw stock processing tomato supplier.

Production scientists have recently developed new varieties which hold potential for becoming competitive in terms of yield. However, based upon implications of the national model, if a major submarket for raw stock processing tomatoes evolves in Texas, then Texas aggregate raw stock production would be influenced by production in other areas and by national carryover.

INTRODUCTION

The processing tomato industry is national in scope even though the production of raw stock is geographically concentrated. The demand for processed tomato products is national but the demand for raw stock input is confined to relatively few major supply areas. National or chain processors operate tomato processing plants in each of the major supply areas, purchasing a majority of the total production within any one area. Because of this, and because the demand for processed tomato products is national, the major supply areas compete with one another.

Processing tomatoes are generally grown under contract between grower and processor, and are sold in the form of canned whole, juice, paste, puree, and catsup. This is in contrast with the fresh tomato industry within which tomatoes are rarely grown under contract and are sold to the consumer in fresh, unprocessed form.

Texas is not a major supply state for raw stock processing tomatoes. For example, during 1968, of the 6,967,560 tons of processing tomatoes produced in the United States, 52,200 tons, less than one percent, were produced in Texas (5). During 1967 and 1968, Texas was the eleventh most important raw stock processing tomato supply state, ranked according to production. The purpose of this article is to: 1) examine briefly some basic reasons for the minor position Texas holds as a supplier of raw stock processing tomatoes, 2) present a model of the national

[1] Assistant Professor, Department of Agricultural Economics and Sociology, Texas A&M University, College Station, Texas.

raw stock processing tomato industry which helps explain the nature and extent of the regional interdependency among supply areas and to 3) explore the implications of that model for the development of a larger raw stock processing tomato industry in Texas.

CURRENT POSITION

There exist many reasons for the minor position Texas currently holds as a supplier of processing tomato raw stock. Among the most important are: 1) lack of grower adoption of competitive production technology with respect to processing tomatoes and 2) no national processing plant in Texas processing tomatoes.

A national processor will not be attracted to a new area until competitive production technology exists. Competitive production technology would encompass adoption of modern production techniques such as fertilizing, disease and insect control, lessening uncertainties of hail damage, and mechanical harvesting. Low yield per acre of processing tomatoes is one current production problem in Texas. Recently however, the Chico series of tomato varieties have been developed which yielded 20 tons per acre in test plots[2].

There is some simultaneity between adoption of competitive production technology and no national processing plant in Texas processing tomatoes. A national processor will not allocate capital for plant capacity in an area until technical production efficiency exists, yet technical production efficiency may not develop without expanded demand for raw stock processing tomatoes. For example, grower adoption of mechanical harvesting would likely be encouraged by a new national processing tomato facility in a supply area.

In order to explore the implications for Texas of regional interdependency in the processing tomato industry, a model for the industry is presented in the following section and implications are drawn from it.

THE STATISTICAL MODEL

There exists three major spatially separated submarkets for raw stock input composed of eight states. Current supply areas are more geographically concentrated than in previous years. Pennsylvania, Maryland, New Jersey and New York constitute an Eastern region; Illinois, Indiana, and Ohio constitute a Midwestern region; and California constitutes a Western region. These regions market over 92 percent of the annual United States production. California supplies nearly two-thirds of the total annual production, the Eastern region about 13 percent, and the Midwestern region about 17 percent. (4,5).

2 The L-830 TAMU Chico III is a pear-type disease resistant tomato, designed for machine harvest, which is now in the development stage and will be released in the near future. Information from: Paul Leeper, Horticulturist, Texas Agricultural Experiment Station, Substation 15, Weslaco, Texas.

In previous research by the author, an economic model was constructed which postulates the interconnection among those economic variables deemed important to the derived demand for and supply of raw stock processing tomatoes within any one geographic region (4). This model is briefly described below.

At any point in the marketing channel from the first producer of inputs until the ultimate consumer, there exists a derived demand schedule based upon the consumer demand schedule for the commodity in its final form. For a particular industry, such as the processing tomato industry, specific economic variables are hypothesized to be determinants of the supply of and derived demand for raw stock on the basis of economic theory and a priori knowledge of the industry[3]. Thus, theoretical considerations in addition to a knowledge of the industry provide a basis for a priori isolation of those variables related to processing tomato supply and demand schedules. This same basis is subsequently utilized to formulate hypothesized interconnections among those variables so isolated. The variables hypothesized to be important, and their relationship to each other, form a statistical model of the national processing tomato industry. The model is specified given that the geographic regions previously outlined are three spatially separated submarkets for processing tomatoes.

Specification – There are four basic relations or equations pertinent to each region. These are 1) the derived demand or market price equation, 2) the supply or production equation, 3) the harvested acreage equation and 4) the contract price equation. Even though the specifications of equations that conform to 1 and 2 above are called demand and supply equations, they are not demand and supply equations as generally conceived. The demand equation is specified according to a specific hypothesis concerning price interdependency among the three geographic regions. Since a primary objective is to study the nature of regional interdependency, the demand equation is specified to include two prices for the same product. Although most coefficients of the demand functions specified are theoretically of determinate sign (and some of determinate magnitude over a range), the slope of the functions need not necessarily be negative. A similar statement applies to the supply functions.

There exist no a priori reasons to assume a particular mathematical form for the four equations outlined above. Accordingly, each equation was specified such that each endogenous variable was a linear function of exogenous and other endogenous variables. Linearity is assumed in the absence of evidence in support of some other mathematical form because of computational and interpretive convenience.

3 A general description of the processing tomato industry will not be repeated here since one is given in Shuffet (3).

In general all structural equations in the statistical model are of the form

$$\sum_{k=1}^{G} b_k Y_{kt} + \sum_{k=1}^{K} c_k X_{kt} = u_t$$

where Y denotes endogenous variables, X denotes exogenous variables, u denotes a stochastic disturbance term, and t denotes time period. It was assumed that the u_t are not correlated with any exogenous variables; that E (u) = 0; that $E(u_i^2) = \sigma_i^2$ for all i; and that $E(u_t, u_{t+s}) = 0$ for all t and all $s \neq 0$.

The stochastic structural equations. The endogenous variables are:

Y_{PE}, Y_{PM}, Y_{PW}: Production of processing tomatoes in tons for the Eastern, Midwestern, and Western regions, respectively.

Y_{ME}, Y_{MM}, Y_{MW}: Processing tomato market price in dollars per ton for the Eastern, Midwestern, and Western regions, respectively.

Y_{CE}, Y_{CM}, Y_{CW}: Processing tomato contract price in dollars per ton for the Eastern, Midwestern, and Western regions, respectively.

Y_{AE}, Y_{AM}, Y_{AW}: Processing tomato acreage harvested for the Eastern, Midwestern, and Western regions, respectively.

The exogenous variables are:

X_V : January 1 carryover of processed tomato products on a farm weight basis for the United States.

X_N : Per capita consumption of processed tomato products on a farm weight basis for the United States.

X_D : Personal disposable income in real dollars for the United States.

X_{TE}, X_{TM}, X_{TW}: Average production of processing tomatoes for the previous three years in other areas in tons for the Eastern, Midwestern, and Western regions, respectively.

X_{YE}, X_{YM}, X_{YW}: Average yield in tons per acre of processing tomatoes for the previous five years for the Eastern, Midwestern, and Western regions, respectively.

X_{QE}, X_{QM}, X_{QW}: Yield-quality measure for the Eastern, Midwestern, and Western regions, respectively.

X_S : Price times yield of soybeans for the Midwestern region.

X_R : Price times yield of corn for the Midwestern region.

X_F : Market price of fresh tomatoes in dollars per ton for the Eastern region.

X_U : Price times yield of sugarbeets for the Western region.

X_B : Price times yield of dry edible beans for the Western region.

X_{MW} : California market price of processing tomatoes in dollars per ton used as an exogenous variable.

The specific price interdependency hypothesis concerns the virtual dominance of California (the Western region) over all other states (or regions) in the production of processing tomatoes. The mean average production of processing tomatoes in California for the period 1952 to 1966 was 2,321.5 thousand tons compared to a mean average production of 615.8 thousand tons for the Eastern region and 685.8 thousand tons for the Midwestern region for the same period[4]. The dominance of California to the total market in terms of production suggests the hypothesis that market price in California is determined independent of other producing areas but not vice versa. That is, California market price is included as an exogenous factor in determining the market price of the Eastern and Midwestern regions but is endogenous to the Western region. This price hypothesis was recognized by functionally relating market price in the Eastern and Midwestern regions to local variables and California market price.

The four stochastic structural equations for each region which correspond to the four relations outlined above are[5]:

[4] Part of California's dominance with respect to production may, of course, be attributed to a greater harvested yield per acre than other states or geographic regions. For example, for the period 1952 to 1966, the mean average yield per acre in California was 17.7 while only 11.0 for the Eastern region and 12.4 for the Midwestern region. However, California is also dominant in terms of the number of acres harvested. For the period 1952 to 1966, the mean average number of acres harvested in California was 131,200 while the Eastern region harvested an average of only 56,000 and the Midwestern region only 53,300.

[5] The equation number identifies both the region and relation. The East, Midwest, and West were represented by 1, 2, and 3, respectively, on the left of the decimal. The 1, 2, 3, or 4 on the right of the decimal represents the demand relation, the supply relation, the harvested acreage relation, or the contract price relation, respectively. In addition, the subscripts E, M, or W on each regional variable donates the Eastern, Midwestern, or Western region. A variable without the additional E, M, or W subscript is a national variable or applicable to only one region.

$$(1.1) \quad Y_{ME} = a_{1E} + b_{1PE} Y_{PE} + b_{1CE} Y_{CE} + c_{1MW} X_{MW} + c_{1F} X_F + u_{1E}$$

$$(1.2) \quad Y_{PE} = a_{2E} + b_{2ME} Y_{ME} + b_{2AE} Y_{AE} + c_{2QE} X_{QE} + u_{2E}$$

$$(1.3) \quad Y_{AE} = a_{3E} + c_{3VE} X_V + c_{3NE} X_N + c_{3DE} X_D + c_{3TE} X_{TE} + c_{3YE} X_{YE} + u_{4E}$$

$$(1.4) \quad Y_{CE} = a_{4E} + c_{4VE} X_V + c_{4NE} X_N + c_{4DE} X_D + c_{4TE} X_{TE} + c_{4YE} X_{YE} + u_{4E}$$

$$(2.1) \quad Y_{MM} = a_{1M} + b_{1PM} Y_{PM} + b_{1CM} Y_{CM} + c'_{1MW} X_{MW} + u_{1M}$$

$$(2.2) \quad Y_{PM} = a_{2M} + b_{2MM} Y_{MM} + b_{2AM} Y_{AM} + c_{2QM} X_{QM} + u_{2M}$$

$$(2.3) \quad Y_{AM} = a_{3M} + c_{3VM} X_V + c_{3NM} X_N + c_{3DM} X_D + c_{3TM} X_{TM} + c_{3YM} X_{YM} + u_{3M}$$

$$(2.4) \quad Y_{CM} = a_{4M} + c_{4VM} X_V + c_{4NM} X_N + c_{4DM} X_D + c_{4TM} X_{TM} + c_{4YM} X_{YM} + c_{4R} X_R + c_{4S} X_S + u_{4M}$$

$$(3.1) \quad Y_{MW} = a_{1W} + b_{1PW} Y_{PW} + b_{1CW} Y_{CW} + u_{1W}$$

$$(3.2) \quad Y_{PW} = a_{2W} + b_{2MW} Y_{MW} + b_{2AW} Y_{AW} + c_{2QW} X_{QW} + u_{2W}$$

$$(3.3) \quad Y_{AW} = a_{3W} + c_{3VW} X_V + c_{3NW} X_N + c_{3DW} X_D + c_{3TW} X_{TW} + c_{3YW} X_{YW} + u_{3W}$$

$$(3.4) \quad Y_{CW} = a_{4W} + c_{4VW} X_V + c_{4NW} X_N + c_{3DW} X_D + c_{4TW} X_{TW} + c_{4YW} X_{YW} + c_{4U} X_U + c_{4B} X_B + u_{4W}$$

An implicit equilibrium condition exists in this model. In the demand equations, Y_P may be regarded as quantity demanded; in the supply equations Y_P may be regarded as quantity supplied. However these are necessarily equal.

The imposition of regional equilibrium on the model as opposed to national equilibrium is quite plausible. Raw stock processing tomatoes are rarely transported great distances due to the perishability of the commodity and the high cost of transportation relative to their value per ton.

Time period of analysis. All data utilized for parameter estimation were on an annual basis. The time period of analysis was limited to the years 1952 through 1966. Data for quality were not available before 1952 in some states. Some observations for quality were estimated for some states when this data was not available after 1952.

Identification and estimation. The criterion used for the identifiability of equations (1.1), (1.2), (2.1), (2.2), (3.1), and (3.2) was the order condition. In practice, the order condition may be utilized as if it were sufficient for identification (2). In each equation, the order condition is satisfied with inequality. Accordingly, each equation may be regarded as over-identified. In all cases, the identifying information is due to restrictions that exclude certain variables from certain equations.

Two-stage least squares was utilized to estimate the parameters of the stochastic structural equations since it provides efficient and consistent estimates and yet is computationally rather simple. The detailed computational aspects of two-stage least squares are readily available from several sources (1, 6).

Equations (1.1), (1.2), (1.3), (1.4), (2.1), (2.2), (2.3), (2.4), (3.1), (3.2), (3.3), and (3.4) are presented here as a general hypothesis of the processing tomato industry based upon an economic model. Because of limited space, only selected parameter estimates of the stochastic structural equations will be presented here. For a complete analyses of the estimated equations, refer to the author's previous work (4). Since the value of partial regression coefficients depends upon the extent to which they provide information concerning the relationship between economic variables, the next section presents implications drawn from the estimated stochastic structural equations.

IMPLICATIONS OF THE MODEL FOR TEXAS

Assuming Texas could develop and adopt competitive production technology to attract national tomato processing facilities, what are the implications of regional interdependency for the development of a major raw stock processing tomato supply in Texas?

Price interdependency. One characteristic of the raw stock processing tomato supply, noted earlier, is that the Western region is dominant in production. This dominance in production suggested the regional price interdependency formulation presented in the stochastic structural equations. An estimate of the coefficient of elasticity between California market price (X_{MW}) and regional market price (Y_M) based on the parameter estimate of c_{1MW} and c'_{1MW} is $-$ .05 for the East and +.21 for the Midwest. These coefficients indicate that California market price has more influence on Midwest market price than on market price in the East. However, in neither case could California market price be regarded as a dominant influence in other supply areas.

Generalizing from the rejection of this form of regional price interdependency, the significance for Texas is that the contract price for Texas processing tomato raw stock could be negotiated within limits without direct consideration of market price of raw stock in the dominant production area. This implies that a group bargaining association could benefit Texas growers and would be a logical structural form when an expanded market for processing tomato raw stock evolves in Texas.

Production interdependency. An estimate of the coefficient of elasticity between harvested acreage and production in other areas, based on the partial regression coefficient of X_t in the appropriate region is $-.68$ for the East, $-.25$ for the Midwest, and $-.91$ for the West. These estimated coefficients suggest that the major submarkets for raw stock processing tomatoes are interdependent with respect to production. Note however that the magnitude of the interdependency between any region and the others is less than unity in all cases.

The significance of this finding is that the amount of raw stock demanded in Texas, should Texas become a major supply area, would depend upon supply in other production areas. When considering raw stock processing tomato market expansion, Texas growers need be cognizant that regional production interdependency exists. The significance is clear—the production and marketing of a product for which there is a national demand for the final product cannot take place in a vacuum, devoid of production considerations in competing supply areas.

National carryover. Another aspect of regional interdependency involves the national carryover of processed tomato products (X_V). An estimate of the coefficient of elasticity between harvested acreage and national carryover, based on the partial regression coefficient of X_V for the appropriate region, is $-.63$ for the East, $-.25$ for the Midwest, and $+.25$ for the West. No theoretical rationalization for the positive elasticity coefficient in the West is apparent. The sign and magnitude of these coefficients suggest that, in the aggregate, processors decrease supply purchases (when faced with a large carryover of processed tomato products) in the East more readily than in the West[6].

Note that this generally suggests that processors decrease supply purchases in the smallest producing area proportionally more than in larger producing areas. The implication is that increases in national carryover would likely be associated with decreases in tomato raw stock purchases in Texas of a greater magnitude than in other areas, given that Texas was the smallest production region and there was demand for processing tomato raw stock by a national processor.

CONCLUSIONS

There now exist several barriers to the establishment of a major raw stock processing tomato production area in Texas. Although these barriers are real they are not insurmountable. Recently, production scientists have developed new varieties which hold potential for becoming competitive in terms of yield. Given that competitive varieties could be adopted in conjunction with other production techniques, such as mechanical harvesting, national processors would be interested in locating plants in Texas. Also, if production could be adapted to extend tomato processing plant receiving seasons, this could stimulate the commission of capital for processing tomato plant expansion in Texas. The stimulus would be a processor cost advantage relative to other areas due to an extended season.

However, even if a major submarket for raw stock processing tomatoes evolves in Texas, growers should recognize that their region would be interdependent with other production regions. The statistical model of the processing tomato industry presented here suggests the nature and extent of certain aspects of this interdependency. Texas aggregate raw stock production would be influenced by production in other areas and by national carryover. However, the model suggests that market price received by Texas growers would not be directly influenced by the market price in the dominent Western production area.

In summary, the potential for the development of a major raw stock processing tomato submarket in Texas exists but will not likely evolve in the near future. This is primarily due to the problems involved in producing processing tomatoes in Texas of comparable quality at competitive production costs.

[6] Anv number of explanations for this phenomenon are possible. For example, this tendency could be due to differences in fixed costs of existing processing facilities among regions (or total cost per unit of finished product processed).

LITERATURE CITED

1. Basmann, R. L. The Computation of Generalized Classical Estimates of Coefficients in a Structural Equation. Econometrica XXVII (January, 1959), pp. 72-81.
2. Christ, C. F. Econometric Models and Methods. (New York: John Wiley and Sons, Inc., 1966.)
3. Shuffett, D. M. Demand and Price Structure for Selected Vegetables. Technical Bulletin 1105. U. S. Department of Agriculture, Washington, D. C., 1954.
4. Sporleder, T. L. An Econometric Investigation of Regional Interdependency in the Processing Tomato Industry. Unpublished Ph.D. Dissertation, The Ohio State University, 1968.
5. United States Department of Agriculture. Vegetables for Processing—Revised. Statistical Reporting Service, Crop Reporting Board, Washington, D. C., 1948-1968.
6. Zellner, A. and H. Theil. Three-Stage Least Squares: Simultaneous Estimation of Simultanoeus Equations. Econometrica XXX. (January, 1962), pp. 54-78.

Trends in Cantaloupe Production: Texas and Other Production Areas

Thomas L. Sporleder[1]

Abstract: Texas produces both Spring and Midsummer cantaloupe. Other important supply areas for Spring cantaloupe are Arizona, California, and Mexico. California is the largest production area for Midsummer cantaloupe. This article examines trends in production by supply area for the 20 year period 1949 to 1968 and the 10 year period 1959 to 1968 for both Spring and Midsummer cantaloupe.

Texas was the only major supply area to increase average annual production per capita of Spring cantaloupe from 1959 to 1968. Total Spring production declined during this period. Texas Midsummer annual production was relatively constant during this period.

INTRODUCTION

The objective of this article is to provide basic information concerning production of cantaloupe in Texas and other supply areas and to examine the relative importance of each of these areas. Long-run trends in production are examined for the 20 year period 1949 to 1968 and shorter-run trends are examined for the most recent 10 year period 1959 to 1968. Using this information as a point of departure, the potential future position of Texas in the aggregate market is briefly examined.

Texas is a supplier of both Spring and Midsummer cantaloupe. Consequently, only these two production periods are examined in this article. The Spring production period is defined as April, May, and June while the Midsummer period is defined as August[2].

In Texas, Spring cantaloupe is a more important crop than Midsummer cantaloupe. During the past 20 years (1949-1968) the production of Spring cantaloupe has averaged 732,000 cwt. per year with average annual real price[3] per cwt of \$6.64, for an average annual real total value of \$4,860,480[4]. During the same period, Midsummer cantaloupe annual average production was 278,000 cwt with an average annual real price per cwt of \$4.18, for an average annual real total value of \$1,162,040. Because of the importance of Spring production relative to Midsummer, this article emphasizes the former.

1 Assistant Professor, Department of Agricultural Economics and Sociology, Texas A&M University, College Station, Texas.

2 This is according to the U.S.D.A. definition; however, Texas spring production does not normally start until the first week in June and continues to early July. Midsummer production typically starts in late July and continues through August.

3 Actual price deflated by Consumer Price Index (1957-1959 = 100) (5).

4 Computed from U.S.D.A. Statistics (4).

PRODUCTION WITHIN TEXAS

During the two year period, 1967 and 1968, the annual value of Texas cantaloupe was about 10 million dollars (2, 4). The total value of principal vegetables and melons for fresh market during the same time averaged 92.5 million dollars. In dollar terms then, cantaloupe currently represents about 10 percent of the total value of principal vegetables and melons produced in Texas for fresh market.

Of the eleven major commercial vegetable producing areas within Texas, the Lower Rio Grande Valley is the most important cantaloupe producing area. Since 1961, the Valley has accounted for about one-third of the total acreage harvested (1). The North, Central, and East Texas areas account for another one-fourth of the total acreage harvested with the Winter Garden, Trans-Pecos, and High Plains accounting for the remaining acreage harvested (Table 1).

SPRING PRODUCTION

Relative importance of supply areas. Spring cantaloupe production is geographcially concentrated. There are only 3 major production or supply states: Arizona, California, and Texas. In addition, another major source of supply is from Mexico. The relative importance of these 4 major supply areas during the past 20 years is shown in Table 2.

Note that Arizona is the largest supplier of Spring cantaloupe. For the most recent 10 year period, 1959 to 1968, the 4 largest areas supplied a mean average of 98.2 percent of the total production[5]. During this period, California and Mexico each supplied between 22 and 23 percent of total production, while Texas supplied another 15.4 percent. Also during this period, Arizona's share of the total production declined (about 1.2 percent per year) while the share of total production supplied by Texas increased (about 1.5 percent per year).

Trends in Production. Mean average Spring cantaloupe production in 1,000 cwt for the 4 major supply areas for the 20 year period 1949 to 1968 and the 10 year period 1959 to 1968 is tabulated in Tables 3 and 4 respectively. It is interesting to note comparisons between these periods. During the 1949 to 1968 period, California was the only major supply area to decrease production (about 44,000 cwt per year). However, during the 1959 to 1968 period, both Arizona and California decreased production at a combined annual average rate per year of 94,000 cwt.

Note also that during the most recent 10 year period Texas production increased at an average annual rate of 70,000 cwt. This increase is larger than any other major supply area during this period.

5 Total production is defined as the sum of total United States Spring production and unloads in the United States from Mexico during April, May, and June.

Table 1. Annual cantaloupe acreage harvested by production area within Texas, 1961-67.

Production Area	YEAR[a]							*Mean percentage of total, 1961-67*
	1961	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	
	— — — *1000 Acres* — — —							
Rio Grande Valley	2.0	4.3	5.7	7.5	6.1	5.3	8.0	33.4
Central and East Texas	1.5	2.1	2.0	2.9	3.1	2.6	2.4	14.7
North Texas	1.4	1.9	2.4	2.8	2.2	1.55	2.7	13.4
Laredo	1.1	1.2	1.8	2.9	2.5	1.6	2.2	11.5
Winter Garden	.8	.9	1.6	2.4	3.8	2.25	1.7	11.3
Trans-Pecos	1.6	.8	1.3	1.6	2.0	2.6	1.8	10.5
High Plains	1.9	.4	.3	.4	.3	1.0	.7	5.3
TOTAL	10.03	11.6	15.1	20.5	20.0	16.9	19.5	100.0

a 1968 production statistics are not yet available for production areas within Texas.

Source: Texas Department of Agriculture, *Texas Vegetables, Acres Harvested by Areas,* Texas Crop & Livestock Reporting Service, Austin, Texas, Bulletin 44, January, 1968, p. 6.

Mexico increased unloads into the United States during this period at an annual rate of about 17,000 cwt.

Another interesting comparison between Tables 3 and 4 is that during the 20 year period California mean average annual production was greater than unloads from Mexico, but during the 10 year period the reverse is true. This, of course, is attributable to declining average annual production in California while average annual unloads from Mexico increased.

Total production during the 20 year period increased at an average annual rate of 32,000 cwt, however, the average annual rate during the 10 year period actually decreased by 6,000 cwt. This indicates that total production of Spring cantaloupe has been increasing at a decreasing rate from 1949 to 1968.

Tables 5 and 6 are similar to Tables 3 and 4 except the production time series for each supply area is on a per capita basis[6]. During the 1949 to 1968 period, total production decreased at an average annual rate of about 24 pounds per 1,000 population. The decrease in total production for the 1959 to 1968 period was about 39 pounds per 1,000 population. This comparison indicates that total production (including

6 The population series utilized for the per capita basis was July 1 total population for 48 states (5).

Table 2. Mean average percent of total Spring cantaloupe production° accounted for by 4 major supply areas, with average annual percentage change, 20 year period 1949-1968 and 10 year period 1959-1968.

Supply Area	*20 year period 1949-68*		*10 year period 1959-68*	
	Percent of total production	*Avg. annual change in percent of total production*	*Percent of total production*	*Avg. annual change in percent of total production*
	Percent	Percent	Percent	Percent
Arizona	37.4	0.0	37.8	—1.2
California	27.8	—1.2	22.3	— .6[a]
Mexico	17.7	.7	22.7	.3[a]
Texas	15.4	.5[a]	15.4	1.5
All other states	1.7	b	1.8	b

° Total production is defined as the sum of total United States Spring cantaloupe production and unloads of Spring cantaloupe from Mexico for April, May, and June.

a Not statistically significantly different from zero at the 95% probability level.

b Not computed.

Source: Computed from U.S.D.A. statistics.

unloads from Mexico) of Spring cantaloupe decreased at an increasing rate during the last 20 years. Note that, in absolute terms, total production during the 20 year period increased at a decreasing rate, but per capita production during this period decreased at an increasing rate. Thus aggregate Spring cantaloupe production is not increasing as fast as population.

Texas is the only major supply area that increased per capita production of Spring cantaloupe during the most recent 10 year period (Table 6). In this respect, the trend in Texas was unique from any other supply area.

Table 3. Computed values for simple linear regression time trends* for Spring cantaloupe production for 4 major supply areas and the United States, 20 year period 1949-1968.

Area	M^a	*a*	*b*	$S_{y.x}$	V^b
		— — — *1000 cwt* — — —			
Arizona	1,736	1,608	12	334	.193
California	1,262	1,725	—44	283	.224
Mexico	842	450	37	377	.447
Texas	732	470	25	360	.492
United States[c]	4,652	4,320	32	589	.197

*Model: Y = a + bX + u

[a] M = Computed mean production in 1000 cwt for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

[c] Includes unloads from Mexico for April, May, and June.

Source: Computed from U.S.D.A. statistics.

Table 4. Computed values for simple linear regression time trends* for Spring cantaloupe production for 4 major supply areas and the United States, 10 year period 1959-68.

Area	M^a	*a*	*b*	$S_{y.x}$	V^b
		— — — *1000 cwt* — — —			
Arizona	1,835	2,171	—61	248	.135
California	1,069	1,254	—34	379	.354
Mexico	1,114	1,019	17	367	.329
Texas	757	371	70	244	.322
United States[c]	4,860	4,894	— 6	499	.103

*Model: Y = a + bX + u

[a] M = Computed mean production in 1000 cwt for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

[c] Includes unloads from Mexico for April, May, and June.

Source: Computed from U.S.D.A. statistics.

Relative importance of supply areas. There are normally 7 states that produce Midsummer cantaloupe. Of these 7, California is by far the most important. During 1968, California produced 5,827,000 cwt of the total United States Midsummer cantaloupe production of 6,655,000 cwt. Texas was the second largest producer with 264,000 cwt (4). The other 5 supply states produced a total of 564,000 cwt.

Trends in production. The mean average Midsummer cantaloupe production in 1,000 cwt for California, Texas and the United States for the 20 year period 1949 to 1968 and the 10 year period 1959 to 1968 is

Table 5. Computed values for simple linear regression time trends* for Spring cantaloupe production in cwt. per 1,000 population for 4 major supply areas and the United States, 20 year period 1949-1968.

Area	M^a	*a*	*b*	$S_{y.x}$	V^b
		— — — *cwt per 1000 population* — — —			
Arizona	9.39	10.715	—.074	1.910	.192
California	7.397	11.389	—.380	1.630	.220
Mexico	4.728	3.357	.131	2.160	.457
Texas	4.130	3.246	.084	2.129	.515
United States[c]	26.654	29.165	—.239	3.379	.127

*Model: Y = a + bX + u

[a] M = Computed mean production in cwt. per 1000 population for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

[c] Includes unloads from Mexico for April, May, and June.

Source: Computed from U.S.D.A. statistics.

Table 6. Computed values for simple linear regression time trends* for Spring cantaloupe production in cwt. per 1,000 population for 4 major supply areas and the United States, 10 year period 1959-1968.

Area	M^a	*a*	*b*	$S_{y.x}$	V^b
		— — — *cwt per 1000 population* — — —			
Arizona	9.740	12.203	—.448	1.258	.129
California	5.678	7.201	—.277	2.045	.360
Mexico	5.877	5.740	0.0	1.880	.320
Texas	3.961	2.197	.321	1.257	.317
United States[c]	25.702	27.783	—.378	2.609	.102

*Model: Y = a + bX + u

[a] M = Computed mean production in cwt. per 1000 population for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

[c] Includes unloads from Mexico for April, May, and June.

Source: Computed from U.S.D.A. data.

shown in Tables 7 and 8, respectively. During the 20 year period, California, on the average, accounted for about 77 percent of the total production while Texas accounted for about 4.5 percent. Also during this period, California's production increased at an average annual rate of 168,000 cwt while total production increased only 135,000 cwt. This means that other supply states, on the average, decreased production. Significantly though, this was not true of Texas.

During the most recent 10 year period, California has supplied about 82 percent of the total while Texas has supplied about 4.3 percent (Table 8). California production increased about 44,000 cwt per year during this period while Texas production, on the average, remained constant. Total production decreased about 1,000 cwt per year. Note that comparisons between the 20 year period and the 10 year period reveal that California production increased at a decreasing rate over the 20 year period. Also, Texas production during the 10 year period was at a higher mean average level than during the 20 year period, but neither increased nor decreased on a trend basis.

Table 7. Computed values for simple linear regression time trends* for Midsummer cantaloupe production for California, Texas, and the United States, 20 year period 1949-1968.

State	M[a]	a	b	$S_{y.x}$	V[b]
		--- 1000 cwt ---			
California	4,755	2,995	168	579	.122
Texas	278	234	4	47	.169
United States	6,159	4,744	135	617	.100

*Model: $Y = a + bX + u$

[a] M = Computed mean production in 1000 cwt for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

Source: Computed from U.S.D.A. statistics.

Table 8. Computed values for simple linear regression time trends* for Midsummer cantaloupe production for California, Texas and the United States, 10 year period 1959-1968.

State	M[a]	a	b	$S_{y.x}$	V[b]
		--- 1000 cwt ---			
California	5,644	5,419	41	679	.120
Texas	298	299	0.0	36	.120
United States	6,860	6,915	—10	636	.093

*Model: $Y = a + bX + u$

[a] M = Computed mean production in 1000 cwt for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

Source: Computed from U.S.D.A. statistics.

Production per capita for California, Texas, and the United States is reported in Tables 9 and 10[7]. During the 20 year period 1949 to 1968, average annual total production increased about 24 pounds per 1,000 population. However, during the 10 year period 1959 to 1968, total production decreased at an average annual rate of 56 pounds per 1,000 population. This indicates that Midsummer cantaloupe production per capita increased at a decreasing rate from 1949 to 1968. Note from Tables 7 and 8 that this trend is also true, in absolute terms, of total production.

Per capita production in Texas was relatively constant from 1949 to 1968. Of course, this means that production in absolute terms increased since population increased (Table 7).

[7] As before, the population series utilized for the per capita basis was July 1 total population for 48 states (5).

Table 9. Computed values for simple linear regression time trends* for Midsummer cantaloupe production in cwt. per 1,000 population for California, Texas, and the United States, 20 year period 1949-1968.

State	M[a]	a	b	$S_{y.x}$	V[b]
		--- cwt. per 1,000 population ---			
California	26.821	21.000	.554	3.207	.120
Texas	1.584	1.586	0.0	.271	.171
United States	34.994	32.456	.242	3.403	.097

*Model: $Y = a + bX + u$

[a] M = Computed mean production in cwt. per 1000 population for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

Source: Computed from U.S.D.A. statistics.

Table 10. Computed values for simple linear regression time trends* for Midsummer cantaloupe production in cwt. per 1,000 population for California, Texas, and the United States, 10 year period 1959-1968.

State	M[a]	a	b	$S_{y.x}$	V[b]
		--- cwt. per 1,000 population ---			
California	29.824	30.900	—.196	3.489	.117
Texas	1.573	1.698	—.023	.189	.120
United States	36.286	39.340	—.555	3.302	.091

*Model: $Y = a + bX + u$

[a] M = Computed mean production in cwt. per 1000 population for the trend period.

[b] V = coefficient of variation = $(S_{y.x}) \div (M)$

Source: Computed from U.S.D.A. statistics.

California average annual production per capita decreased during the most recent 10 year period. However, during the 20 year period the trend in per capita production was upward. Thus, California's per capita production increased at a decreasing rate from 1949 to 1968.

FUTURE SUPPLY POSITION OF TEXAS

Spring. Based on the most recent 10 year trend in production (Table 4), the future importance of Texas as a supplier of Spring cantaloupe will increase. Given the trends in Table 4, Texas will supply a larger percentage of Spring production, since the total production is declining[8].

Midsummer. Based on the most recent 10 year trend in production (Table 8), the importance of Texas as a supplier of Midsummer cantaloupe will remain relatively unchanged in the future. However, the percentage of total production from Texas will increase slightly, since total production is declining.

CONCLUSIONS

Texas supplies more Spring cantaloupe than Midsummer. The total annual value of Spring cantaloupe has averaged more than 4 times that of Midsummer cantaloupe. Of the total production of both Spring and Midsummer cantaloupe the Lower Rio Grande Valley is the single most important geographic production area within Texas.

Spring. Arizona is the largest supply area for Spring cantaloupe, but has experienced declining production during the past 10 years. During the 1959 to 1968 period, average annual unloads from Mexico exceeded the production of any major supply state except Arizona.

Texas experienced the largest annual average increase in production from 1959 to 1968 of any leading supply area. In fact, Texas was the only major supply area to increase production per capita. Thus, Texas has been expanding its importance as a supplier of Spring cantaloupe especially during the most recent 10 years.

Both total production (domestic production plus unloads from Mexico) and total production per capita decreased from 1959 to 1968. Total production increased at a decreasing rate from 1949 to 1968.

Midsummer. California is the largest supply area for Midsummer cantaloupe. Production from California increased at a decreasing rate from 1949 to 1968.

Texas annual production was relatively constant during the most recent 10 years and therefore declined on a per capita basis.

[8] In addition to these trends, the new Dulce and Perlita varieties will enable Texas growers to extend the production season in any one area. These new varieties also have greater mildew tolerance and improved sugar content.

Total production decreased during the 1959 to 1968 period, thus, per capita production of Midsummer cantaloupe also decreased for this period.

LITERATURE CITED

1. Texas Department of Agriculture. Texas Vegetables. Texas Crop and Livestock Reporting Service, Austin, Texas, Bulletin 44, January, 1968.
2. Texas Department of Agriculture. Texas Vegetable Statistics. Texas Crop and Livestock Reporting Service, Austin, Texas, Bulletin 43, October, 1967.
3. United States Department of Agriculture. Fresh Fruit and Vegetables Unload Totals. Consumer and Marketing Service, Washington, D. C., 1949-1968.
4. United States Department of Agriculture. Vegetables—Fresh Market—Revised. Statistical Reporting Service, Crop Reporting Board, Washington, D. C., 1949-1968.
5. United States Department of Agriculture. Working Data for Demand Analysis. Economic Research Service, Economic and Statistical Analysis Division, Washington, D. C., October, 1968.

Economic Analysis of Producing, Harvesting, Packaging, and Total Revenue Received for South Texas Onions, 3 Year Period 1966-68

CHAN CONNOLLY[1]

Abstract: Production and F.O.B. costs for seeded South Texas onions varies primarily with yield levels. Based on the 1968 estimated cost structure and yield levels for the three year period 1966-68, average production cost per 50 pounds ranged from $0.64 to $1.11. Average F.O.B. cost ranged from $2.02 to $2.49.

Total revenue received from one acre of onions varies with both yield and price. Break even yields at the F. O. B. level ranged from 89 to 325 50 pound bags per acre. Variations in both year to year and F.O.B. prices caused large variations in total revenue received per acre. Because of the magnitude in the total revenue variations, the South Texas spring onion crop is considered a high risk crop.

INTRODUCTION

The purpose of this study is to develop an economic break even analysis for direct seeded South Texas onions at the production and the F.O.B. levels using F.O.B. annual average prices for each year of the 3 year period 1966-68.

METHODS

As there is no recent research on the cost of growing South Texas spring onions, estimated cost budgets were developed using 1968 price levels under typical management. These budgets were reviewed with firms producing South Texas onions and are considered representative for 1968. Relationships between cost of production and yield were developed at the grower level and relationships between total cost of growing, harvesting, packing, and selling by yield levels were developed at the shipping level. Total cost and total revenue functions at various yield and F.O.B. price levels were derived and used as the structural components in the break even economic graphic model.

Cost of Production:

The 1968 estimated typical production cost budget per acre for South Texas direct seeded spring onions is presented in Table 1. Total cost of producing an acre of onions is divided into two components. One component is *variable costs* per acre which includes all money costs that are incurred in the growing of an acre of South Texas onions. All costs that are borne by the grower regardless of the fact that onions are planted, are referred to as *fixed costs*. Variable costs plus fixed costs equal total cost. This is the traditional method of structuring costs for economic analysis.

The typical production cost budget was developed by omitting opportunity cost for the labor and management services provided by the grower. Profit at the grower level was likewise omitted. With these two costs omitted the typical total cost for producing an acre of South Texas onions in 1968 was estimated at $210.88 (Table 1).

The cost of producing 50 pounds of onions varies inversely with yield. Yield per acre is the major variable determining economic efficiency of onion production. Large variations in yield exist among firms in South Texas due to weather, plant population, and time of planting. For example, yield of late onions is much greater than yield of early onions. The relationship between yield and cost is presented in Table 2 and Figure 1.

Table 1. Estimated typical cost budget per acre for direct seeded South Texas onions, 1968[1].

Variable Costs Per Acre:		
Tractor & Equipment Operating Cost	$0.80/hr for 10 hrs.	$ 8.00
Tractor Labor	1.50/hr for 14 hrs.	21.00
Other Labor – Irrigation, Thinning, etc.	1.00/hr for 22 hrs.	22.00
Seed	2.5 lbs @ 6.50/lb	16.25
Fertilizer 100-100-0	200 lbs @ 11.00 cwt	22.00
Insecticide	2.00/acre–3 applications	6.00
Fungicide	4.00/acre–3 applications	12.00
Herbicide	9 lbs/acre @ 1.17 lb	10.53
Irrigation Water	6 irrigations @ 2.50 ea	15.00
Interest on Operating Capital	132.78 @ 7%–6 mo.	4.65
Total Variable Costs		$137.43
Fixed Costs Per Acre:		
Taxes	$10.00/acre	$10.00
Interest on Land	$450 per acre @ 6.5%	29.25
Machinery Depreciation Per Acre	Varying from $20 to $40/acre	30.00
Interest on Capital Invested in Machinery	$40 to $80/acre @ 7%	4.20
Total Fixed Costs		$ 73.45
Total Production Costs		210.88

[1] Estimates obtained from selected South Texas onion grower-shipper firms in November 1968.

[1] Associate Professor, Texas Agricultural Market Research and Development Center, Department of Agriculture Economics and Sociology, Texas A&M University Agricultural Research and Extension Center at Weslaco.

The average yield per acre for South Texas onions for the 3 year 1966-68 period was as follows[2] (1):

1966	190	50 lb. bags
1967	330	50 lb. bags
1968	230	50 lb. bags

The cost of producing 50 pounds of onions at these yield levels falls between points A and B on the cost curve in Figure 1. The range of costs per 50 pounds of onions at these yield levels is from $0.64 to $1.11.

[2] U. S. Department of Agriculture and Texas Department of Agriculture, Texas Vegetable Statistics, Bulletin 49. Feb. 1969 p 35.

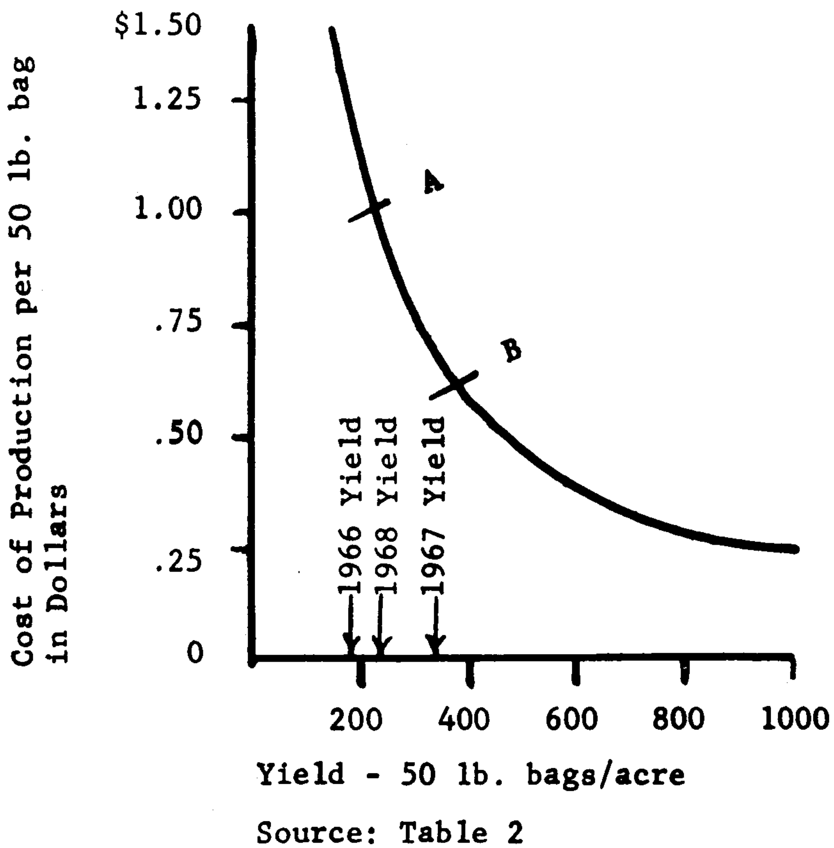


Figure 1. Relationship between cost of production and yield per acre for South Texas Direct Seeded Spring Onions, 1968.

Cost of Harvesting, Packing and Selling:

South Texas spring onions are typically marketed in 50 pound bags. Consequently all harvesting, packing and selling costs in this analysis are based only on 50 pound bag units. Cost of production plus harvesting, packing and selling equal total cost (TC) or F.O.B. cost.

The knowledge concerning the cost of harvesting, packing and selling is less perfect than the production cost. The harvesting, packing and selling services are provided by firms in the private sector and cost records from these firms are not available. The estimated costs of harvesting, packing and selling, Table 3, were reviewed with major firms in the South Texas onion industry and are considered representative for 1968. It is reasonable to assume that cost of management and a profit for the firm is included in the total cost of $1.38 per 50 pound bag.

The estimated F.O.B. costs per 50 pound bag by yield of South Texas onions in 1968 are presented in Table 4 and illustrated in Figure 2. The F.O.B. costs per 50 pound bag ranged from $2.02 to $2.49 for the three year 1966-68 yield levels. This range on the TC curve is represented between points A and B, Figure 2.

Total Revenue:

Total revenue (TR) per acre of seeded South Texas onions is influenced by both yield and price. A TR budget with ten yield and three price levels is presented in Table 5.

Annual average F.O.B. prices for South Texas onions for the three year 1966-68 period are as follows[3]:

1966	$3.75	per 50 lb bag
1967	2.03	per 50 lb bag
1968	3.42	per 50 lb bag

[3] U. S. Department of Agriculture and Texas Department of Agriculture, Texas Vegetable Statistics, Bulletin 49, February 1967, p 35.

Table 2. Relationship between yield and cost of producing 50 pounds South Texas seeded spring onions, 1968.

Yield in 50 lb units	*Cost per 50 lb units*
150	$1.40
200	1.05
300	0.70
400	0.53
500	0.42
600	0.35
700	0.30
800	0.26
900	0.23
1000	0.21

Source: Table 1.

Table 3. Estimated harvesting, packing and selling cost per 50 lb bag South Texas spring onions[1], 1968.

	Cost per 50 lb bag
Harvesting	$0.43
Packing	0.85
Selling	0.10
Total Harvesting, Packing and Selling Costs	$1.38

[1] Estimates obtained from selected South Texas shippers in November, 1968.

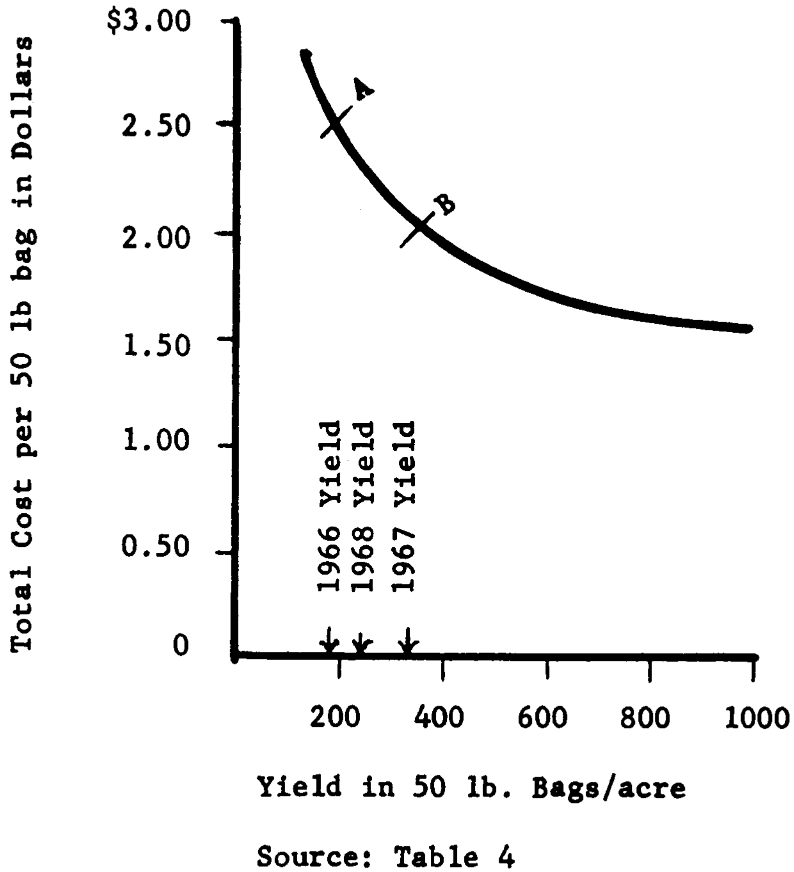


Figure 2. Relationship between cost of producing, harvesting, packing and selling by yield per acre for South Texas direct seeded Spring onions, 1968.

Break-Even Analysis:

The relationship between TC and TR by various yields and prices are graphically illustrated in Figure 3. Three different TR curves are illustrated by using the following hypothetical F.O.B. prices.

$1.50 per 50 lb bag
2.00 per 50 lb bag
3.00 per 50 lb bag

The TC curve is also illustrated. The break even point is where TR and TC intersect. At an F.O.B. price of $2.00, the break even yield

Table 4. Estimated total f.o.b. cost per 50 lb bag and per acre by yield, direct seeded South Texas spring onions, 1968.

Yield 50 lb Bags	Production Costs	Harvesting, Packing Selling Costs	F.O.B. Cost Per 50 lb Bag	Total Cost Per Acre
150	$1.40	$1.38	$2.78	$417.00
200	1.05	1.38	2.43	486.00
300	0.70	1.38	2.08	624.00
400	0.53	1.38	1.91	764.00
500	0.42	1.38	1.80	900.00
600	0.35	1.38	1.73	1038.00
700	0.30	1.38	1.68	1176.00
800	0.26	1.38	1.64	1312.00
900	0.23	1.38	1.61	1449.00
1000	0.21	1.38	1.59	1590.00

Source: Tables 1, 2 and 3.

Table 5. Computed total revenue per acre for South Texas seeded spring onions by yield at various hypothetical price levels.

Yield 50 lb bags	Total Revenue $P = \$1.50$ 50 lb bag	Total Revenue $P = \$2.00$ 50 lb bag	Total Revenue $P = \$3.00$ 50 lb bag
150	$ 225.00	$ 300.00	$ 450.00
200	300.00	400.00	600.00
300	450.00	600.00	900.00
400	600.00	800.00	1200.00
500	750.00	1000.00	1500.00
600	900.00	1200.00	1800.00
700	1050.00	1400.00	2100.00
800	1200.00	1600.00	2400.00
900	1350.00	1800.00	2700.00
1000	1500.00	2000.00	3000.00

is 350 50 lb bags per acre. Likewise, at an F.O.B. price of $3.00 the break even yield is about 150 50 lb bags per acre. Given a total cost curve, the break-even yield point varies with price. For example, Figure 4 indicates that at the 1966 price of $3.75, the break even yield would be about 89 50 lb bags; for the 1967 price of $2.03, break even yield would be about 325 50 lb bags; and for the 1968 price of $3.42, the break even yield will be about 154 50 lb bags. Given the TC and F.O.B. prices for the 3 year 1966-68 period, the range in break even yields of onions in South Texas ranged from 89 to 325 50 pound bag yield per acre.

SUMMARY

Production and F.O.B. costs for seeded South Texas onions varies primarily with yield levels. Based on the 1968 estimated cost structure, and yield levels for the three year 1966-68 period, average production cost per 50 pounds ranged from $0.64 to $1.11. Average F.O.B. cost ranged from $2.02 to $2.49.

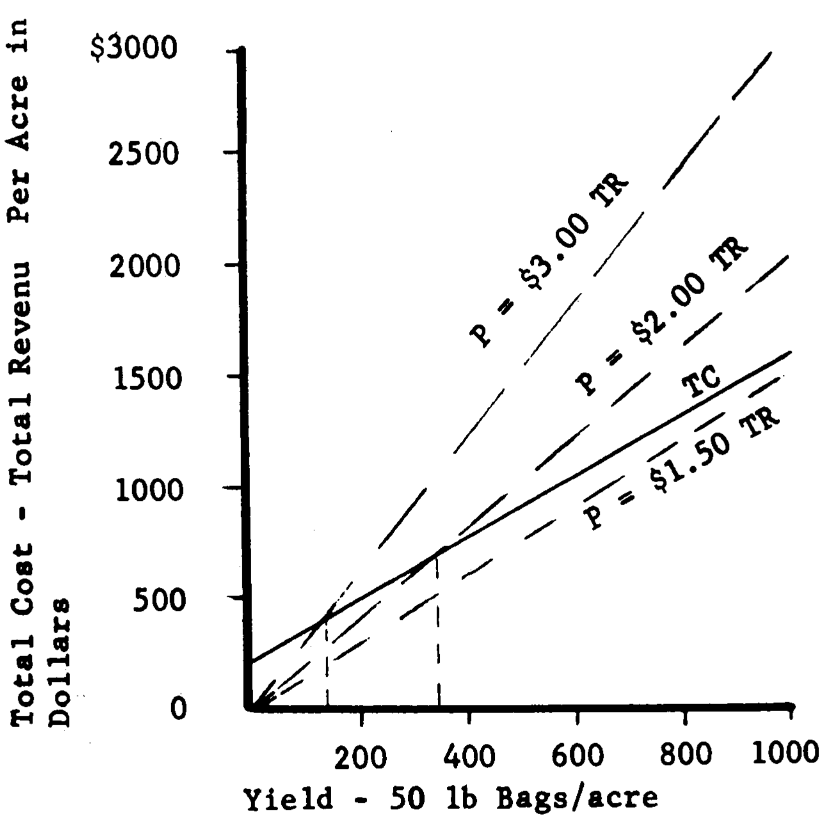


Figure 3. Relationship between total cost and total revenue for direct seeded South Texas onions at various hypothetical price and yield levels, 1968.

TR for an acre of onions varies with both yield and price. Based on the 1968 estimated cost budget, break even yields for the three year 1966-68 period using F.O.B. prices ranged from 89 to 325 50 pound bags per acre.

Variations in year to year yields caused the large variance in F.O.B. costs. Likewise, variations in both year to year yields and F. O. B. prices caused the large variations in TR per acre. Because of these variations,

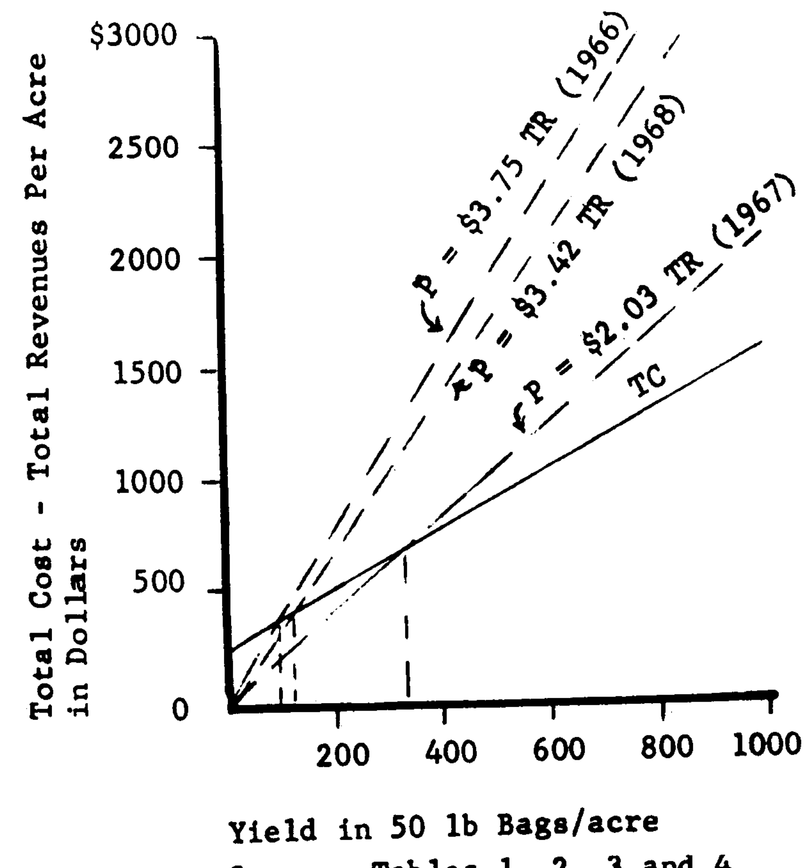


Figure 4. Relationship between total cost and total revenue for direct seeded South Texas onions at 1966, 1967 and 1968 average annual prices.

the South Texas spring onion crop is considered a high risk crop.

LITERATURE CITED

1. U. S. Department of Agriculture and Texas Department of Agriculture, Texas Vegetable Statistics, Bulletin 49, February 1969 p 35.

U. S. Onion Consumption and Buying Behavior Patterns

CHAN CONNOLLY[1]

Abstract: U. S. per capita consumption of onions has remained steady at a level of 11.5 pounds for the 18 year period 1950 to 1967. Consequently the increase in demand has been directly associated with population growth.

In 1965, onions were purchased each week by about 56 percent of all U. S. households. The value of onions purchased at retail by these households averaged about $0.08 per week for each household with an average weight of about 0.6 pound. Consumption varies little between household income groups above an annual disposable income level of $3000.00.

INTRODUCTION

During the three months of March, April and May, Texas supplies a dominant share of onions to the U. S. National Market. For the three year period 1966-68, Texas supplied 25 percent of the National market in March, 84 percent in April and 51 percent in May (2).

Quantity of South Texas onions marketed may be controlled indirectly by the South Texas Onion Committee that administers Marketing Order 959. This committee has the right to regulate not only grade but also packing and shipping hours of all South Texas onion shipping firms. This latter right is an indirect means of controlling the rate of product flow to the market. Properly administered, this right aids orderly marketing of South Texas onions to the National market.

Knowledge relative to onion consumption and buying behavior patterns in the United States provides information not only to the decision making committee administering the South Texas marketing order, but also to the many sub-regional production areas supplying the National market. The purpose of this study is to examine the long-run U. S. onion consumption trend during the 18 year period 1950-67, and to analyze weekly consumption rates by U. S. households.

METHODS

Least squares linear regression is used to fit the long-run trend line

[1] Associate Professor, Texas Agricultural Market Research and Development Center, Department of Agricultural Economics and Sociology, Texas A&M University Agricultural Research and Extension Center at Weslaco.

for the 18 year period 1950-67 by using data tabulated in Table 1. The statistical model is as follows:

$$\text{Statistical Model:} \quad Y = b_0 + b_1X_1 + u$$

where:

Y = Annual per capita consumption of onions in pounds

b_0 = Level of the trend line

b_1 = Slope of the trend line

X_1 = Time in years

u = Stochastic disturbance term

Data from the 1965 Food Consumption Survey made by the U. S. Department of Agriculture was used to estimate weekly consumption characteristics of U. S. households (4).

RESULTS

The annual per capita consumption of onions in the United States has been very stable, as is indicated in Table 1. The long run trend for the 18 year period 1950-67 may be expressed with the following mathematical linear function:

$$Y = 11.5 + .003X_1$$
$$(\text{t value}) \quad (0.207)$$

This function indicates that the level of annual per capita consumption of onions in the United States for this period was about 11.5 pounds, and that per capita consumption increased at the rate of .003 pounds annually. This slight increase, however, is not statistically significant at the .05 level of significance. Consequently the per capita consumption

Table 1. Per capita consumption of onions in U. S., 1950-67.

Year	*Lb/capita*	*Year*	*Lb/capita*
1950	11.8	1959	11.5
1951	11.6	1960	12.3
1952	11.8	1961	11.5
1953	11.7	1962	11.7
1954	11.1	1963	11.9
1955	10.9	1964	11.4
1956	11.4	1965	11.4
1957	11.8	1966	11.5
1958	11.7	1967	11.7

Note: Includes 0.1 pound of shallots each year 1929 through 1958; since 1958 less than 0.05 pound.

Source: U. S. Department of Agriculture, Food Consumption, Prices, Expenditures Agricultural Economics Report No. 138, ERS, Washington, D. C. July 1968. p 77.

was very stable at the 11.5 pound level. The increase in demand during this period is associated with population growth.

The 1965 Food Consumption Survey made by the U. S. Department of Agriculture indicated that the average household consumed about 0.63 of a pound of dry onions per week of which 0.60 of a pound was purchased and 0.03 of a pound was either produced or given to the household as a gift (Table 2). Consumption varies very little between household income groups above an annual income after tax of $3000.00. This is consistent with Shafer's (1) findings. Shafer's price model revealed that annual disposable income deflated by the consumer price index (CPI) did not add any explanatory power to price at the F.O.B. shipping level for South Texas onions. The survey also indicated that the average household spent about $0.08 per week for dry onions with 57.9 percent of all households using dry onions each week. It was further indicated that about 55.5 percent of the households purchased dry onions each week. These data reveal that U. S. households make frequent purchases of dry onions in small lots.

Table 2. U. S. Consumption of all and purchased mature onions per household per week in pounds, dollars and percent of households by income levels, Spring 1965.

Annual Money Income After Taxes, 1964	*Quantity per household per week in pounds*		*Money value per household per week in dollars*		*Percent of households using in a week*	
	All	*Purchased*	*All*	*Purchased*	*All*	*Purchased*
All households	.63	.60	.08	.08	57.9	55.5
$1000	.39	.33	.05	.04	39.6	34.9
1000-1999	.49	.43	.06	.05	47.5	42.9
2000-2999	.56	.51	.07	.06	53.1	49.0
3000-3999	.66	.62	.08	.07	57.2	54.3
4000-4999	.70	.68	.09	.08	63.6	61.0
5000-5999	.63	.61	.08	.08	57.6	55.5
6000-6999	.71	.68	.10	.09	62.3	59.9
7000-7999	.77	.76	.10	.10	65.2	63.6
8000-8999	.66	.65	.08	.08	63.8	62.9
9000-9999	.61	.60	.08	.07	61.3	59.8
10000-14,999	.68	.67	.09	.09	62.1	61.5
$15,000	.67	.66	.10	.09	62.0	60.7

Source: U. S. Department of Agriculture, Food Consumption of Households in the United States, Agricultural Research Service, Washington, D.C.

LITERATURE CITED

1. Shafer, Carl E. A Statistical Analysis of Season's Average Prices for Texas Winter Carrots and Early Spring Onions, 1954-64, Department Technical Research Report No. 66-2, Department of Agricultural Economics and Sociology, Texas A&M University/Texas Agricultural Experiment Station.
2. Stewart, Kenneth L. Statistical Information Concerning the South Texas Early Onion Crop. Texas Agricultural Extension Service, Weslaco, Texas. Mimeograph, December 18, 1968.
3. U. S. Department of Agriculture. Food Consumption, Prices, Expenditures. Agricultural Economic Report No. 138, ERS, Washington, D. C. July 1968 p 77.
4. U. S. Department of Agriculture. Food Consumption of Households in the United States, Spring 1965. Agricultural Research Service, Washington, D. C.

Persistence of Incorporated Herbicides In Furrow-Irrigated Soils[1]

R. M. Menges and J. L. Hubbard[2]

Abstract: The soil persistence of 6 cotton herbicides was studied in a furrow-irrigated, sandy clay loam by recording the growth of vegetables and other indicator plants grown in rotation with herbicidally-treated cotton plantings. Ryegrass, onions, sorghum, and spinach were injured by certain herbicide residues but oats, cabbage, carrots, and lettuce were unaffected. Onions were injured by all 6 herbicides, indicating significant herbicidal residues in soil 7 months after treatment in cotton.

Bensulide was most persistent; diuron, linuron, prometryne, and trifluralin were intermediate; and DCPA was the least persistent herbicide[3].

Table 1. Common, trade, and chemical names of herbicides[4].

Common name	*Trade name*	*Manufacturer*	*Chemical name*
Bensulide	Prefar	Stauffer Chemical Company	*0,0*-diisopropyl phosphorodithioate *S* ester with *N*-(2-mercaptoethyl) benzenesulfonamide
DCPA	Dacthal	Diamond Shamrock Company	dimethyl-tetra-chloroterephthalate
Diuron	Karmex	E. I. DuPont de Nemours & Company	3-(3,4-dichlorophenyl)-1,1-dimethylurea
Linuron	Lorox	E. I. DuPont de Nemours & Company	3(3,4-dichlorophenyl)-1-methoxy-1-methylurea
Prometryne	Caparol	Geigy Agricultural Chemicals	2,4-bis(isopropylamino)-6-(methylthio)-*s*-triazine
Trifluralin	Treflan	Elanco Products Company (Division of Eli Lilly Co.)	*a,a,a*-trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine

[1] The work was a cooperative project of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and the Texas Agricultural Experiment Station, Weslaco, Texas.
[2] Research Horticulturist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Agronomist, Texas Agricultural Experiment Station, Texas A&M University, Weslaco, Texas, respectively.
[3] See Table 1 for chemical names.
[4] Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the USDA, and does not imply its approval to the exclusion of other products that may also be suitable.

INTRODUCTION

It is conceivable that where herbicides are applied in soil, to control weeds over an extended period of time, that rotational crops may be injured by the original herbicide applications. Injury depends on the chemical and physical characteristics of the herbicide in question, methods of herbicide application, soil and weather conditions, and the sensitivity of the rotational crop to the herbicide. Preliminary field studies from 1962 to 1964 showed that preemergence applications of 1½ lb/A of diuron applied in furrow-irrigated, spring-seeded cotton plantings persisted in a Willacy fine sandy loam sufficiently to reduce the yield of fall-seeded lettuce.

The main objective of the experiments reported herein was to study the persistence of herbicides incorporated in furrow-irrigated soils where the herbicides are applied annually in cotton and vegetable plantings grown in rotation.

MATERIALS AND METHODS

A field experiment was initiated in 1965 and continued in 1966 on a furrow-irrigated Hidalgo sandy clay loam in the Lower Rio Grande Valley in Texas[5]. Each year in March, the soil was disked, listed into beds and furrows, and then rotary tilled. Beds were 40 inches wide with 20-inch plateaus. 'Stoneville 7A' cotton was planted 2 inches deep in 1 row per bed.

Herbicides were sprayed 1 day after planting of cotton in 64 gal/acre of water to the surface of plateaus, and were immediately incorporated with the surface inch of soil by a power-take-off- (PTO-) driven rotary tiller with L-shaped cutting teeth. Earlier research with fluorescent tracers qualitatively determined the efficiency of incorporation (1). Postemergence, layby soil surface applications of linuron were not incorporated with soil.

Treatments were replicated 4 times in a randomized block design and were repeated in 1966 on the same field plots. All plots were furrow-irrigated 1 day after treatment and thereafter as needed to maintain optimum growing conditions. Methyl parathion was sprayed several times for insect control and 60 lb/A of nitrogen was injected into beds just after the thinning of cotton. Plots were hand-weeded 3 weeks after planting and periodically thereafter. Furrows were kept weed-free with cultivation.

After cotton was harvested and the stalks were shredded, the experimental area was disked and again listed into beds and furrows. Beds were then floated, rolled, and fertilized 6 inches deep with 60 lb/A of nitrogen as NH_4NO_3 and 80 lb/A of phosphorus as P_2O_5. In October of each year, or approximately 7 months after herbicide treatment, Italian ryegrass, 'Early Hybrid 7' spinach, 'White Granex' onion, 'Globe Y. R.' cabbage, 'Valverde' lettuce, 'Long Imperator' carrot were seeded in 1 or 2 rows per plot. 'Alamo X' oat seeded in 1965 was replaced with 'Pioneer 820' sorghum in 1966.

[5] Hidalgo sandy clay loam contained 65% sand, 22% clay, and 13% silt; 1.5% organic matter, 7.8 pH, 19% water at field capacity, and 21.6 meq./100 g. cation exchange capacity.

Each plot consisted of 10 beds, 35 ft long with 15 ft guard areas between tiers of plots to eliminate herbicide-soil movement from plot to plot by disking. Data were obtained from only the 6 inside beds, to eliminate error from herbicide-soil movement from plot to plot in the semi-annual rebedding operation.

RESULTS AND DISCUSSION

The amount of weed infestation showed that most of the herbicides were active in soil in both 1965 and 1966 applications, but that herbicidal activity was somewhat greater in 1966. Conversely, green weight data on the indicator plants showed a longer persistence of herbicides in soils in 1965 (Table 2). Moldboard plowing after 1965 cotton harvests may have concentrated the herbicidal residues in soil by compaction and thereby increased vegetable injury. Onion was the most sensitive herbicide injury indicator plant in 1965.

DCPA persisted in soil sufficiently to reduce the growth of onion in 1965. The non-selectivity of DCPA in onions was previously reported (1). Diuron injured onions and spinach in 1965. Linuron, a compound related to diuron, and used at layby in cotton plantings, persisted in soil sufficiently to injure onions in 1965 and sorghum in 1966.

Bensulide is known to persist for 1 or 2 years in irrigated soils (2): its persistence in soil was illustrated by injury to sorghum and spinach in 1966. This persistence of initial treatments makes it possible to reduce herbicide rates in plantings of succeeding crops in some cotton-vegetable rotation plans.

The persistence of bensulide, DCPA, linuron, and trifluralin in soils is being intensely studied in irrigated soils. The studies will investigate the effects of climate on the movement and persistence of herbicides in soil and develop new and improved herbicidal application techniques.

LITERATURE CITED

1. Menges, R. M., and J. L. Hubbard. 1968. Influence of climate and soil incorporation on herbicides in onions. Proc. Amer. Soc. Hort. Sci. 92: 498-507.

2. Menges, R. M., and J. L. Hubbard. 1969. Influence of climate and soil incorporation on herbicides in carrots. Weed Sci. (In press).

Table 2. Persistence of cotton herbicides in soils as shown by the yield of indicator plants grown in rotation with cotton.

	Rate	Yield (lb) per plot[a]												
		Oats	Ryegrass		Cabbage		Carrots		Lettuce		Onions		Sorghum	Spinach	
Herbicide	(lb/A)	1965	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966	1966	1965	1966
Bensulide	6			35		88		62		72		44	0.8°		26°
DCPA	6	20	12	35	81	95	44	67	26	75	13°	41	3.0	17	32
Diuron	1½	19	12	34	69	92	41	64	23	84	15°	44	2.8	13	32
Linuron[b]	2	18	12	35	69	108	43	77	25	82	14°	48	2.5°	15	29
Prometryne	3	20	10°	30	74	103	42	82	20	78	12°	47	4.0	18	33
Trifluralin	1	21	11°	30	76	89	41	85	21	80	14°	44	2.9	17	29
Trifluralin + DCPA[c]	1 + 6	20	13	31	75	103	45	88	26	92	14°	48	3.8	15	31
Trifluralin + Prometryne[c]	1 + 3	19	13	32	77	104	46	82	24	93	13°	45	2.8	16	32
None, unweeded check		20	13	32	80	95	44	72	27	88	19	45	3.4	16	30
LSD, 5%			1.6	5.2		14.4	4.0	18.8		16.7	4.0	8.3	0.8	3.6	3.6

a Average of 4 replications.
b Layby soil surface application.
c Trifluralin was applied in 1965, whereas DCPA and prometryne were applied in 1966.
° Significantly different from unweeded check, 5% level.
Treatment data except sorghum rounded off to whole numbers for presentation.

Foam for Frost Protection[1]

J. F. Bartholic, R. J. Rektorik, and M. D. Heilman[2]

Abstract: Using foam for frost protection was evaluated on two plots of bell peppers similarly instrumented with a number of temperature sensors. A fire-fighting type of foam was used to cover the vegetation. Leaf temperatures were 3°F warmer under the foam compared with the nonfoamed plants during the coldest part of the night. The temperature at the one-inch soil depth remained constant after foaming but continued to drop in the nontreated plot. Thus, the area covered with the foam was adequately protected from freezing temperatures. This information helped validate the hypothesis that the soil contains sufficient energy to heat the crop if adequate insulation is provided. A foam with greater stability and a generator with larger capacity may be required for large-scale field operations.

INTRODUCTION

The dollar value of vegetable crops varies from year to year, but generally, the Lower Rio Grande Valley vegetable value is surpassed only by citrus and cotton. However, because of the susceptibility of many vegetables to cold conditions, considerable economic losses frequently result from untimely freezes.

Inclusive dates of high probability of freezes (3) for selected Rio Grande Valley cities are:

Location	*Duration*
Harlingen, Texas	25 December – 30 January
Raymondville, Texas	22 December – 30 January
Mission, Texas	21 December – 30 January

Usually vegetables are planted in the early spring to obtain emergence after the last freeze or they are planted in the late summer so harvesting can be completed before the first fall freeze. Yet, for tender plants emerging near the time of the last average frost, there is still a 50% probability of freeze. In the fall there is a 20% chance of a freeze which could destroy nearly mature vegetable crops as early as 12 days before the date of the first average fall freeze. Freezing temperatures in the mid-Valley can occur from November through March.

Thus, due to the relative uncertainty of freeze conditions and variations in climatic factors that affect harvesting dates and marketing considerations, it is necessary to obtain improved methods for protecting vegetables against untimely freezes.

---

1 Contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, in cooperation with the Texas Agricultural Experiment Station, Texas A&M University.

2 Research Soil Scientist, Agricultural Engineer, and Research Soil Scientist, respectively, USDA, Weslaco, Texas.

Three approaches for protection of vegetables are possible, but they need further evaluation. The first is to physically cover the vegetables with some structural material such as a box. A second approach has been suggested recently by researchers Siminovitch, et al., (5) and Eggert (2), and earlier by Shear and Barrows (4) and Thiegs and Wright (6). It involves the adaptation of various types of foams for frost protection of tender vegetation. However, the procedures involved bubbling air through a foam liquid confined in containers similar to 2.5-gallon fire extinguishers or other small volume devices. These units were not suitable for large volume foam production required for field use. A third approach involves the addition of heat by artificial sources, which includes irrigation – flood or sprinkler, heater blocks, and return stack heaters. The heaters are most efficient in tall crops or orchards (7).

Of the three approaches for frost protection mentioned here, it was felt that the foam-forming materials may hold the greatest potential for protecting large acreages of freeze-sensitive vegetables. A foam with proper insulating properties and stability would have considerable value in the Lower Rio Grande Valley. It is particularly applicable in this area since several warm days usually precede the outbreak of cold conditions. These warm periods provide time for energy to be stored in the soil. This energy then is available for heating the crop during the cold periods. The energy from the soil is normally lost through radiation and turbulent exchange with the atmosphere. With a foam-forming insulating material, however, it might be possible to essentially trap this stored energy within the crop canopy.

MATERIALS AND METHODS

Duplicate plots of bell peppers were planted September 13, 1967. The plots were about 10 ft. wide and 24 ft. long, consisting of 3 beds with 2 rows on each bed. Duplicate instrumentation was used in each plot.

The instrumentation consisted of temperature sensing devices placed in the soil and on plant leaves. The sensors were at 1-, 2-, 4-, and 8-inch soil depths. Leaf temperature was measured at about 8-inch height. Each sensor gave the average of three point measurements. The output from each trithermocouple sensor was recorded on a multipoint recorder with an internal reference junction.

The foam method involved covering one plot and using the second as a check. To provide a large volume of foam, an EP-30 electric-powered foam generator was borrowed from National Foam Systems, Inc.[3] The unit requires 110-volt electric power supply, a 40- to 100-psi water supply, and a foam liquid. The water is forced through a venturi section to induce a 1 to 3% by volume siphon mixing of the foam liquid. The mixture is then discharged through nozzles onto a 3/16-in. nylon mesh. A fan-forced draft through the liquid-coated mesh produced a low-density bubbly foam at rates to 3000 cfm. A detergent base foam-forming material was used.

[3] National Foam Systems, Inc. Trade names and company names are included for the benefit of the reader and do not imply endorsement or preferential treatment of product by U. S. Department of Agriculture.

The foam generator, a 110-volt electric generator, a water pump, and water reservoirs were mounted on a 2-wheel tool carrier for field mobility. Figure 1 shows a static test of the system just after the foam had been generated. The 55-gallon drums are water reservoirs. The foam-forming liquid stored in a 5-gallon container at the front of the trailer is not visible. With the large capacity of the generator, it is possible to move down the rows at speeds of 4 mph and completely cover the canopy with the foam material.

RESULTS

The ability of foam to protect against freezing conditions was tested during the period (noon) Jan. 13 through Jan. 14, 1968. The night was generally ideal for severe radiation frost, with very little wind movement (< 3 mph) and clear skies. Incoming longwave radiation was about 0.3 cal./cm^2/min., which made very rapid radiation cooling possible as solar radiation decreased during the afternoon of Jan. 13.

Figure 2 shows soil and leaf temperatures before, during, and after

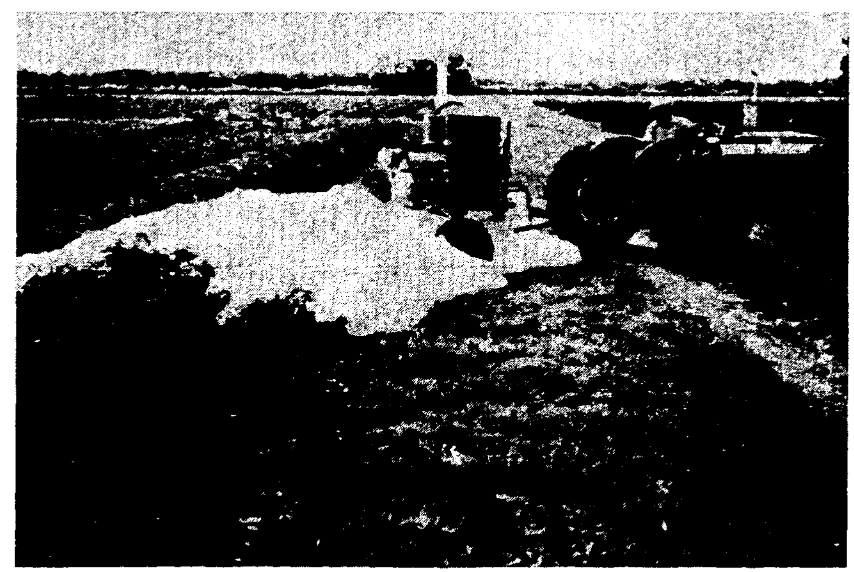


Figure 1. Picture of trailer-mounted foam generator and foam.

foam treatment. Jan. 13 was a warm day but temperature decreased rapidly as solar radiation decreased. Foaming was started at 2050 and a nearly immediate increase in leaf temperature is shown. Leaf temperature in the foam increased to about 46°F and then gradually decreased until 0800 on Jan. 14. The large increase in leaf temperature resulted in part from the warm temperature of the freshly generated foam. Additional foam was generated at 2130, 2230, and 2400. Short-

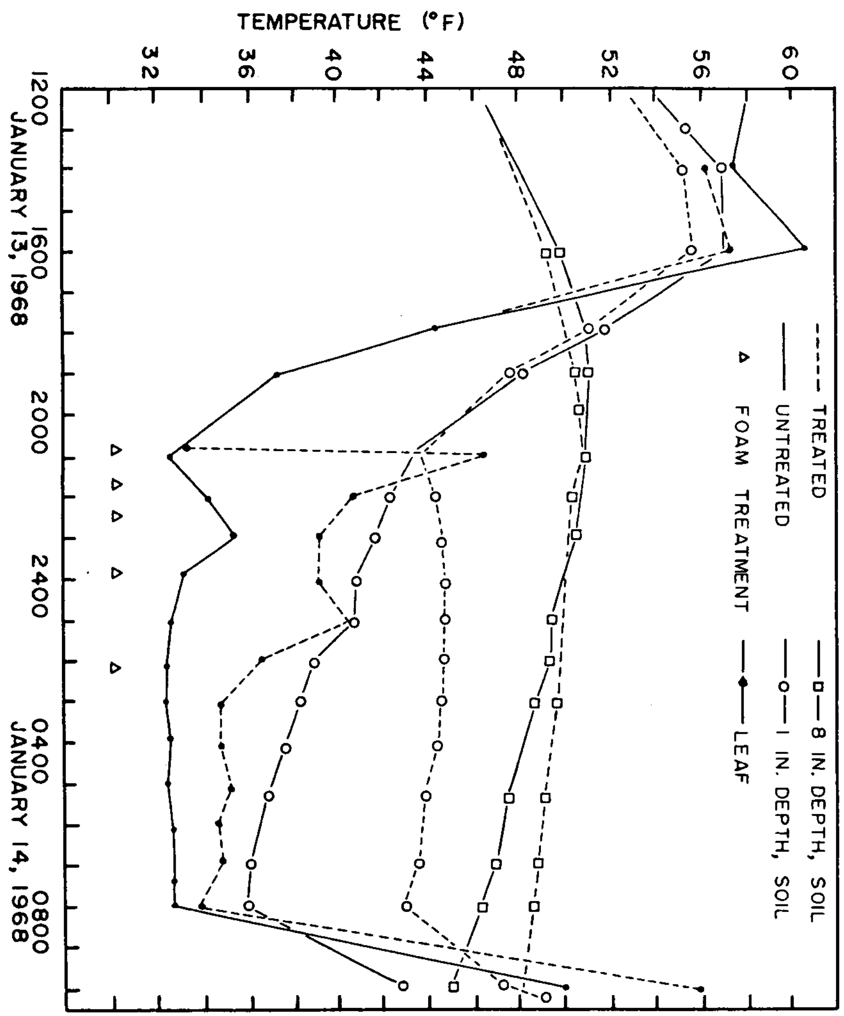


Figure 2. Soil and leaf temperatures before, during, and after foam treatment.

ly after 2400 freezing temperatures appeared to have frozen the surface bubbles which helped considerably in stabilizing the foam.

Another attempt to apply foam at 0200 resulted in a foam generator malfunction that sprayed water over the plot and partially destroyed the existing foam cover. However, sufficient foam remained at 0800 to cover the plants.

The good insulating capability of the foam caused a very abrupt change in the cooling pattern of the soil. The 1-inch depth was most dramatically affected since its rapid temperature decrease was completely stopped. The foam affected the rate of temperature change at all measured depths within 6 hours.

The difference in temperature between the two plots was greatest for leaf and 1-inch soil temperatures, as would be expected. Differences were as large as 7°F for the 1-inch depth and ranged from 14°F immediately after initial foaming to an indicated 1°F at 0800 for the leaf temperatures. Actually, the leaf temperatures in the nontreated plot could have been at least 2°F or more cooler than recorded from 0200-0800 since the recorder has a lower limit of .5°F. Leaf temperatures of citrus in the same general area during this experiment were as low as 28.7°F.

DISCUSSION

Covering plants with foam effectively decreased the rate at which energy was lost from the soil-plant system. The resulting higher leaf temperatures in the foam demonstrated its ability to protect tall vegetables. Difference in temperatures at the 1-inch soil depth showed the good insulating ability of the foam near the soil surface, which would be important in protecting newly emerging vegetation in early spring.

Upon reexamining Fig. 2, it is clear that the soil's ability to provide heat to the soil surface and crop was adequate when the normal rates of heat loss to the atmospheric boundary layer and space were decreased as they were with the foam.

This experiment was adequate to show the potential of this method of frost protection for small vegetables. However, a number of additional materials that might provide a more stable foam are now available, and should be tested. Also, a number of configurations for foam-forming generators are possible and should be evaluated with the ultimate goal of large-scale, rapid field application. Braud and Chesness (1) recently reported on the evaluation of a larger number of materials as possible sources for the foam-forming material and have made specific suggestions relative to the foam-forming material and gelatin-type stabilizers. Also, they have developed a dispenser for foam, which, although it provides relatively small volume, is an important step toward field application.

With the information now available pertaining to new materials and methods of dispensing, as well as preliminary cost estimates, it appears that a second generation foaming material and dispenser that would generate foam at a very reasonable cost is easily within reach.

LITERATURE CITED

1. Braud, H. J., and J. L. Chesness. Physical properties of foam insulation for protecting plants against cold weath. Presented at the Winter Meeting ASAE, 1968.
2. Eggert, D. A. Use of liquid foam to prevent freeze injury to strawberry blossoms. Horticultural Sciences 3(1):11-12, Spring, 1968.
3. Haddock, Donald J. The recurrent threat of cold to crops in the Lower Rio Grande Valley: An interpretation of weather records. J. Rio Grande Valley Hort. Soc. 17:178-184. 1963.
4. Shear, C. B. and H. L. Barrows. Insulating foams for the protection of plants against frost. USDA, CRD, Memo CR 44-63, 1953.
5. Siminovitch, D., W. L. Ball, R. Desjardins, and D. S. Gamble. Use of protein-based foams to protect plants against frost. Canadian J. Plant Sci. 47:11-17. 1967.
6. Thiegs, B. J. and Norman Wright. Foam compositions for protecting plants from frost damage. U. S. Patent No. 2,875,-555, Chem. Abs. 53(10):9527. May 25, 1959.
7. Young, R., N. Maxwell, M. Bailey and W. R. Cowley. Temperature in and around grapefruit trees as affected by underthe tree heat sources. J. Rio Grande Valley Hort. Soc. 18:15-20. 1964.

PEACHES

Temperature Effect on Date of Bud Break in Low Chilling Peach and Nectarine Varieties in South Texas

NORMAN P. MAXWELL and CALVIN G. LYONS, JR.
Texas A&M University Agricultural Research and Extension Center at Weslaco

Abstract: This paper gives 2 year field observations concerning date of bud break for 2 low chilling peach and 1 nectarine variety in South Texas. Also given are thermograph records indicating total number of hours accumulated below 45° and 50°F as well as those above 70°F. By comparing the thermograph records with the date of bud break, it was concluded that for peaches of South China parentage accumulation of hours below 50°F were effective for breaking rest. The data also indicates that accumulated hours above 70°F did not inhibit bud break.

A problem of growing peaches in South Texas is the accumulation of enough cold hours during December and January to break flower and leaf bud rest. In order to determine the average number of cold hours received, records have been kept for many years. This type of record is necessary so that the selection of varieties can be made that will be adaptable to the area.

It has been observed that the common white, freestone and clingstone South China peaches growing in home plantings in the Lower Rio Grande Valley would always break rest about the first week in January. This experiment was initiated to determine whether some varieties or strains of peaches might respond to chilling hours above 45° in South Texas.

MATERIALS AND METHODS

The University of Florida and a private corporation in Florida have released several low chilling peach and nectarine varieties that are currently being tested in South Texas.

Two private growers near La Feria, Texas, in cooperation with the Texas Agricultural Experiment Station planted a test plot of Flordasun (Florida LI-15 (a Southland x Hawaiian F_3 seedling) x Springtime), Sunred nectarine (Panamint x Fla 9-10 (Southland x Hawaiian F_2)) and Early Amber (Plant Patent No. 2458), Okinawa x Palomar (Plant Patent No. 1652)) in the spring of 1965 and 1966. All 3 varieties under test have South China parentage. The Texas Agricultural Experiment Station planted a test plot of the same varieties in February 1967 on the Station near Weslaco, Texas.

The trees were one year old plants budded on Nemaguard rootstock. Observations were made in 1967 and 1968 when flower buds began growth in the springtime.

Under Florida conditions the varieties under test are reported (2) to need the following number of cold hours below 45° before rest is broken. Flordasun requires about 300 hours, Sunred nectarine 300 hours and Early Amber is listed at approximately 350 hours below 45°F.

RESULTS AND DISCUSSION

The number of cold hours below 50°F and above 70°F are given in Table 1 for the period of December and January 1-15. Observations of the test plots in 1967 and 1968 showed that bud break for both Flordasun and Sunred nectarine started about January 15. At this date only 221 hours below 45°F had been accumulated in 1967 and 183 hours in 1968. Either of these is considerably lower than has been suggested as needed for these varieties. However, with the addition of hours of 45-50°F, the requirement of 300 hours was readily met.

Accumulated cold hours of below 50°F and above 70°F for December and January of 1967 and 1968 are given in Table 2. Early Amber trees commenced flower bud growth during the first week of February in 1967 and 1968. Again the hours below 45°F were far less than the

Table 1. Hours of cold below 50°F. and hours above 70°F. recorded at Weslaco, Texas, December and January 1-15 inclusive.

1966-67	*Hours Below 45°*	*Hours 45°-50°*	*Hours Above 70°*
December	109	76	185
January (1-15)	112	38	23
Total	221	114	208
1967-68			
December	88	105	122
January (1-15)	95	100	9
Total	183	205	131

Table 2. Hours of cold below 50°F and hours above 70°F recorded at Weslaco, Texas, in December and January.

1966-67	*Hours Below 45°*	*Hours 45°-50°*	*Hours Above 70°*
December	109	76	185
January	134	100	118
Total	243	176	303
1967-68			
December	88	105	122
January	95	151	80
Total	183	256	202

350 hour requirement but the addition of the hours of 45-50°F exceeded the suggested hours needed to satisfy the chilling factor.

In both tables the total number of hours accumulated above 70°F during the chilling period apparently had no effect on bud break in any of the 3 varieties. As soon as their chilling requirement was completed and several days of warm weather occurred flower buds commenced growth. Flordasun peach and Sunred nectarine require 300 hours of cold to break rest. In 1966-67 December-January 15 cold hour accumulation below 50° was 335 hours. During the same period 208 hours occurred above 70°. In 1967-68 December to January 15 there were 388 hours below 50° and 131 hours above 70°. In both years Flordasun and Sunred nectarine broke rest about January 15. By subtracting accumulated hours above 70° from those below 50° occurring December-January 15 in 1966-67 and 1967-68 the remainder is below the number of hours needed to break rest. This would indicate that hours occurring above 70° did not offset those below 50°.

In table 2, hours below 50° in December and January of 1966-67 were 429 and in 1967-68 were 439. Hours accumulated above 70° in the same period were 303 and 202. Again by subtracting hours above 70° from those below 50° the remainder is 126 hours in 1966-67 and 237 hours in 1967-68 season. Early Amber peach requires 350 hours of chilling to break rest and in both years rest was broken the first week of February. This again indicates that the hours accumulated above 70° did not offset cold hours below 50°.

Work done in Florida (1) in growth chambers also showed that some low chilling peaches would respond to hours below 55°F just as well as below 45°F. It was also shown in Israel (3) that hours accumulated slightly above 45°F were beneficial in satisfying cold requirements of some peach varieties.

The data discussed above (Tables 1 and 2) indicate that hours above 70° did not affect the accumulation of chilling hours. These findings differ somewhat from those in other areas as it has been reported (2, 3) that hours above 70°F would inhibit bud break and subsequent growth.

It was observed that after flower bud growth started in Flordasun and Sunred nectarine, periods of cold weather would slow the growth and opening of the blossoms. This in turn caused the trees to set a few early fruit when buds first broke dormancy and the main crop would set as soon as the temperatures stayed high enough that bud development was not interrupted. No freeze damage occurred to the fruit buds in either test year.

After the first week of February ambient temperatures were generally high enough that peach bud growth was rapid and continued with very little interruption due to low temperatures.

The 3 varieties of peach and nectarines reported on are of South

China parentage. It is possible that peach and nectarine varieties not having South China parentage will give a different response to cold hour accumulation and the effect of high temperatures on breaking of winter dormancy.

CONCLUSIONS

Several conclusions may be made from the data presented. In South Texas many peach varieties with South China parentage will have their cold hour requirement satisfied with temperatures of 50°F or lower. Also temperatures of 70°F or higher occurring during the period of cold hour accumulation do not offset or affect chilling hours. The trees started flower bud break as soon as their chilling hours had been accumulated irregardless of the hours above 70°F.

It can also be concluded from the above data, there is a potential for growing commercially early maturing peaches in the South Texas area, even though most varieties are reported to require more cold hours than are normally received in this area. Before any large scale plantings are undertaken, the desired varieties should be thoroughly tested for their adaptability to South Texas.

LITERATURE CITED

1. Gurdian, R. J. and R. H. Biggs. 1964. Effect of Low Temperatures on Terminating Bud Dormancy of Okinawa, Flordawon, Flordahome and Nemaguard Peaches. Fla. State Hort. Soc. 77:370-379.
2. Sharpe, R. H. 1966. Peaches and Nectarines in Florida. Fla. Agricultural Station Circular 299.
3. Samish, R. M., S. Lavee and A. Erez. 1966. A Concept of Dormancy of Woody Plants with Special Reference to the Peach Proceedings XVII International Horticultural Conference Vol. III:397-408.

SWEET SORGHUMS

Sweet Sorghum in South Texas: Yield Potentials and Cultural Practices

W. R. COWLEY[1]

The potential of sweet sorghum as a sugar source crop is not a consideration of recent origin (5, 11, 15, 16). Sweet sorghum stocks were introduced into the United States more than 100 years ago and were rather intensively investigated during the late 1800's by Wiley, Neal and others of federal and state research agencies. The genetic stocks of high sucrose content, early introduced from Africa, were highly susceptible to diseases, and the technologies of plant breeding were at that time not sufficiently advanced to overcome these limitations. Confronted with deficiencies in processing technologies as well, research activity in the project declined prior to 1900.

As World War II cast its dark shadows of disruption upon the world sugar economy, there was renewed interest in the potential of sugar production from sweet sorghum. There were some pilot plant evaluations made under the stress of the war pending emergency (4). Genetic stocks of sweet sorghum were introduced from Africa, India and other countries during the 1940's (1). These investigations were centered at U.S.D.A. stations at Meridian, Miss., and Beltsville, Maryland. Importations were continued through the years to assemble several thousand lines of genetic stocks with one or more desirable characters of sugar content, purity, vigor and/or disease resistance. Breeding research has since been directed toward the development of commercial type varieties for forage, sirup and high sucrose content (13, 4). Sart, a heavy yielding forage type used to some extent in the Valley, was an outturn of this program as were some sirup varieties grown in the southern states. Stocks used in the Texas research program had their origin from this pool of genetic materials.

Research with sweet sorghum was initiated at the Texas A&M Research and Extension Center in 1961 as a part of a three-phase program to evaluate sorghum, sugar beets and sugar cane as sugar source crops. The interest was motivated by the Cuban Crisis with its resultant possibility of increased domestic allotments and by the need for new crops to support the area economy.

With cooperation of Dr. I. E. Stokes of the Crops Research Division at Beltsville, Maryland, a group of varieties and breeding lines representing a cross section of the materials available from the Federal

[1] Superintendent for Research, Texas A&M University Agricultural Research and Extension Center at Weslaco.

programs was evaluated in 1961 and 1962 (12). A breeding line, designated as Mer 55-1, performed well in both years with projected sugar yields of 3500 and 2800 pounds per acre, respectively. The yield per acre compared favorably with that of Louisiana and Florida sugarcane on a cost per unit basis. The line was subsequently released jointly by the Texas Agricultural Experiment Station, the Mississippi Agricultural Experiment Station and the U. S. Department of Agriculture as the variety, Rio (3). A screening program, cooperative with Federal breeders and which has included several hundred genetic stocks and breeding lines, has been continued through the years (4, 13); lines of higher stalk production in considerable numbers have been developed, but none has consistently produced sucrose of the level and purity of Rio.

A sugar chemist, Mr. B. A. Smith, was assigned at Weslaco in 1964 from the U.S.D.A. Utilization and Research Development Laboratory. In his assignment to characterize the chemical constituents of sorghum juices and to develop processing techniques and procedures, Mr. Smith has been a most valuable contributor in the combined production and utilization project. With voluminous production and chemical data to correlate, a comprehensive technical publication is now in preparation. Mr. Smith, fortunately a companion speaker, will present something of the chemical and processing research.

In presenting the production aspects of the cooperative project, it is assumed that a horticulturally oriented group would have little interest in technical agronomic data. Rather than to present tables and detailed data, it would appear that presentation of conclusions would be of more value and interest.

Major production experience has, of course, been with the Rio variety, although the chemical constituents of genetic stocks are of great interest to the chemist and the breeder.

Rio was developed from a cross of Rex, a disease susceptible variety and a disease resistant stock designated as MW-1048 (3). Rex is an early maturing high sucrose type of unknown origin (probably from the early introduced materials). MN-1048 was introduced from Africa in 1945. Rio is resistant to rust and to leaf anthracnose; the variety has moderate resistance to downy mildew (10) and is not extremely susceptible to damage from cotton insecticides. As the tropical ancestry would indicate, growth and development is affected by day length and temperatures; the cultural requirements are otherwise quite similar to those of other forage and sirup varieties.

The crop can be planted in the Lower Rio Grande Valley from March until August, maturing in 100-115 days to afford a harvest period from July to December. Averages from 4 years of data are shown in Table 1. These data indicate that yields of about 11 tons per acre can be produced in March plantings with a sharply upward increase to 16 and 20 tons from April and May plantings under the conditions of longer day lengths. June planted production is in the intermediate high range

and the break in production comes from the July planting with about 14 tons; August plantings slump to the March production levels and September planted production drops to the 5 ton level. Sucrose and purity do not appear to be strongly correlated with yield levels except possibly in the production from the September planting; these are generally in the 15 per cent sucrose and 70 percent plus purity range, however, comparisons with weather records indicate that variability is introduced by long periods of cloudy weather and excessive rainfall. Since sucrose and purity are but little correlated with yield, the average sugar yield content per ton of cane is fairly constant through the production of August plantings in the range of 200 pounds. Per acre production of sugar, therefore, is more directly correlated with yield in the range of 2,000 to 4,000 pounds.

Row spacing was a matter of particular interest in that in 24 inch spacing of 4 hill dropped plants has been recommended by workers in other areas (13). Results of trials in Texas, however, have shown that 3 inch spacing in drill plantings are higher yielding than 6 inch spacings or the multiple plant, hill dropped arrangement. The advantage, however, was derived from yield increase in that sucrose and purity were not significantly affected.

The irrigation requirements will vary somewhat with the data of planting and the levels of seasonal evaporation losses. Dr. C. J. Gerard (8) concluded from trials conducted with April plantings in 1967 that each irrigation from 1 to 3 applications increased yields about 1.5 tons per acre. Moisture use data reported by Gerard indicates a peak demand during the bloom period. Field experience indicates that moisture stress at the boot stage can also be detrimental to yields. Since Rio produces a heavy seed head, late season irrigation may induce lodging of the tall stalks under conditions of high winds. Disruption and breakage of the root system reportedly results in lowered sucrose and purity (4). Field experience has shown that the problem of late season lodging can be eliminated by special irrigation practice. Irrigation of alternate

Table 1. Production and Juice Qualities of Rio Sweet Sorghum from Monthly Plantings at Weslaco, Texas, 1965-68[1].

	March	*April*	*May*	*June*	*July*	*August*[2]	*Sept.*[2]
Yield (tons/acre)[3]	11.0	15.9	19.2	17.0	14.0	12.0	5.0
Sucrose (%)	15.0	14.6	14.5	15.6	13.0	14.2	12.0
Purity (%)	78.6	76.0	73.8	76.2	72.9	74.4	68.2
Sugar lbs. per ton[4]	208	200	194	213	174	191	133
Sugar lbs per acre	2297	3173	3743	3543	2454	2256	668

[1] Average values of data from the test period.
[1] Two years only.
[3] Stripped cane.
[4] Calculated processed recoveries.

rows at a 3 day interval provides anchorage of the roots to better withstand the effects of high winds.

Data in regard to fertilizer requirements of sweet sorghum produced on Valley soils are not yet definitive in terms of yield responses, or juice quality. Field experience indicates the need for moderate levels of soil nitrogen. Other workers have reported detrimental effects of excess nitrogen (13). Fertilizer trials conducted by Gerard in 1966 (7), however, indicated no correlation of nitrogen level with the sucrose and purity of the juice. Minor element experiments conducted by Matocha in 1964 (10) revealed no consistent response in terms of yields and sucrose content. Plant analyses by Hipp (5) from date of planting trials in 1966 indicated that sorghum plants absorbed manganese and iron at substantial levels; zinc contents found in mid-season growth, however, were fairly low to indicate the possibility of deficiencies. Root system studies made by Gerard in 1967 (8) showed that there was moisture extraction and root activity to a depth of 5 feet; such expanse of the root systems could provide for the absorption of adequate amounts of trace nutrients from a fairly low soil level.

The storage of stocks for milling is an important factor in considering the commercial potential of sorghum. Limited storage experiments indicates a rapid deterioration in quality under conditions of high summer temperatures. The chemical changes involved will be described by the companion speaker and it is suffice to conclude that, in the abscence of controlled storage environments, the cane must be milled in a 24 to 48 hour period from harvest.

Weed control chemicals used on grain sorghum are similarly effective with sweet sorghum along with the associated residue problem.

The major insect pest of sweet sorghum is the sugar cane borer. Both chemical and cultural control practices will be required in commercial scale production. Other types of insects which may damage sweet sorghum plants include mites, aphids and budworms.

Sweet sorghum will have to be harvested mechanically for economical sugar production. It is postulated that mechanical harvesters used in the sugar cane industry might be readily adapted for use with sweet sorghum. The removal of seed heads and leaves will require special modification in the harvesting and processing equipment. Further research is needed to adapt available equipment for harvesting and handling the crop.

Sugar manufactured from sweet sorghum is presently not subject to the provisions of the Sugar Act (6); however, there is no reason to assume that production would not be subject to regulation should the enterprise become commercial. Revision of the Sugar Act by Congress is not scheduled for consideration until 1971 (2); it could be postulated with reasonable accuracy that this sugar source will be considered in any revisions. Incentive for the construction of a mill and development of

an industry is thus reduced by these uncertainties and by the fact that production might not be eligible for subsidy support; no time table projections can be made in view of pending congressional action. Valley agricultural interests are informed of these conditions and such action as possible has been taken toward qualification of the Valley as a sugar production area.

The technologies of production and processing have been materially advanced in recent years with the Lower Rio Grande Valley as significant source of this research effort. Although much research remains yet to be done, it can be concluded that sweet sorghum does have potential as a suger source crop and that the Valley has some capability to share in any economy that might thus be developed.

LITERATURE CITED

1. Brandes, E. W. Progress with Sugar Sorgo, USDA Yearbook, PP 344-352, 1943-47.
2. Blake, Richard W. The Future of the Sugarbeet Industry from a Grower's Standpoint. Jour. Amer. Soc. Sugar Beet Tech. 15-1:5-68 pp. 6-12.
3. Coleman, O. H., W. R. Cowley, D. M. Broadhead, K. C. Freeman and I. E. Stokes. Rio, a New Disease-Resistant Variety of Sweet Sorghum for Southern United States. ARS 34-72, June, 1965.
4. Coleman, O. H., et al. 1965. Cooperative Sweet Sorghum Variety Tests in Southern United States Conducted Cooperatively with State Agencies. CR-17-67, April, 1967.
5. Cook, George H. Results of Field and Laboratory Experiments with Sorghum. New Jersey Agricultural Experiment Station Bulletins 18, 24, 25, 30, 38, 1881-1885.
6. De la Garza, E. Kika, U. S. Congressman, 15th District Texas. Letter. Sept. 22, 1966.
7. Gerard, C. J. Unpublished Data, 1966 Annual Report, Texas Agricultural Experiment Station, Weslaco, Texas.
8. Gerard, C. J. Unpublished Data, 1967 Annual Report, Texas Agricultural Experiment Station, Weslaco, Texas.
9. Hipp, B. W. Unpublished Data, 1967 Annual Report, Texas Agricultural Experiment Station, Weslaco, Texas.
10. Matocha, John. Unpublished Data, 1964 Annual Report, Texas Agricultural Experiment Station, Weslaco, Texas.
11. Neal, Arthur T. The Sorghum Sugar Industry, New Jersey State Agricultural Experiment Station Report, 1887.

12. Stokes, I. E., W. R. Cowley, and J. N. Pratt. Sweet Sorghum in the Lower Rio Grande Valley of Texas, ARS 34-59, September 1963.

13. Stokes, I. E. Review of the Potential Use of Sweet Sorghum for Sugar Production, CE-78-68, Nov. 1968.

14. Ventre, E. K., J. A. Ambler, H. C. Henry, S. Byall and H. S. Paine. U. S. Patent 2,359,537 (Oct. 3, 1944).

15. Wheeler, W. A. *Forage and Pasture Crops,* D. Van Nostrand Company, Inc., Princeton, New Jersey, 1950.

16. Wiley, Harvey W. Record of Experiments with Sorghum in 1892, USDA Bulletin 37, 1893.

Production of Sugar from Sweet Sorghum

B. Ashby Smith[1]

Abstract: The development of new disease-resistant, high-sucrose varieties of sweet sorghums, and the discovery of practical means for eliminating the principal juice constituents which interfere with sucrose crystallization serve to improve the status of this crop as a source of commercial sugar production.

Sugarcane and sugar beets provided essentially all of the 72 million tons of crystalline sucrose produced throughout the world in 1968 (1). Other crops have long been known to contain significant quantities of sugar, but because of crop production problems or processing costs, have not yet been proved sufficiently practical to warrant exploitation. The sweet sorghums, however, now appear to offer exceptional promise of becoming the third commercial sugar crop capable of providing economic returns for grower and processor alike.

The sweet sorghums have been recognized as a potential source of commercial sugar production in the United States for almost 100 years, but efforts to establish a sweet sorghum sugar industry have been hampered by the lack of disease-resistant, high-sucrose varieties and a practical technology for recovering sugar from the crop (9, 7, 4). In 1964 a new disease-resistant, high-sucrose variety named Rio was released by the USDA (2), and since that time several other promising new varieties have been developed and are being evaluated for sugar production. These discoveries have provided an impetus to investigations of practical means for processing the crop and recovering its sugar content.

Two very different sugar production schemes are in common usage today. One of these is employed in producing sugar from sugarcane and the other is specially suited to sugar beets. Unfortunately, neither technology will effectively remove the large quantities of starch and aconitic acid usually encountered in the sweet sorghum juices. Each of these two constituents often occurs at the level of 2 to 3% of the juice solid matter, and their effective removal is an important function of any scheme for the production of crystalline sugar from this crop.

Studies were begun in 1964 at the Food Crops Utilization Research Laboratory in Weslaco with the overall objective of determining if the production of sugar from sweet sorghums would be practical. Simple analyses were made routinely on field samples in order to assist the agronomists with evaluations of new varieties and field management practices. More comprehensive analytical data were also collected on

[1] Research Chemist, Food Crops Utilization Research Laboratory, Southern Utilization Research and Development Division, Agricultural Research Service, United States Department of Agriculture, Weslaco, Texas.

selected field materials to provide information regarding the composition of the plant juices under various conditions of maturity, climate and soil, and with different varieties. On the basis of the data collected from such analyses, a number of procedures were explored for eliminating maximum quantities of starch, together with other undesirable materials such as plant fibers, pigments, minerals and protein from these juices. A technique was found which provided more than 95% elimination of starch, while at the same time effecting the removal of reasonable quantities of other impurities (5). This procedural step was fitted into a sugar production scheme and the entire process was then tested on a large number of sweet sorghum juice samples from various locations and plant sources. Some process improvements were later made to increase the percentage starch elimination (6). Investigations were also made of possible techniques for eliminating aconitic acid, but the procedure patented by Ventre, *et al.*, in 1944, appears to be the most efficient means for removing this material (8).

The sugar production scheme developed in the course of these investigations has been tested extensively in small scale experiments which duplicate reasonably well the conditions attainable in full size pilot plant tests in the sugarcane processing equipment at Louisiana State University in Baton Rouge. Final data from the latter tests are not yet available, but from analysis of the juices, syrups, and molasses, all operations were satisfactory, and the sugars crystallized from the syrups and molasses were of good quality. By steps, the proposed sweet sorghum sugar production process consists of the following operations:

I. Stalk preparation,

II. Extraction of a raw sugar bearing juice,

III. Clarification and removal of starch from raw juice,

IV. Evaporation of clarified juice to semi-syrup,

V. Removal of additional starch from semi-syrup,

VI. Concentration of semi-syrup to heavy syrup,

VII. Removal of insoluble aconitates from heavy syrup,

VIII. Crystallization of raw sugar from heavy syrup by conventional sugar procedures.

Some of the steps mentioned here must be examined more thoroughly, in order to permit the selection of the most suitable processing techniques. In the category of work requiring additional study are Steps I, II, VII and VIII, above. The last two are listed here because no study which included quantitation of products has yet been made. Steps I and II have so far been performed by crushing of hand-harvested, hand-stripped stalks in sugarcane mills. There is no doubt as to the feasibility of crushing the stalks to extract the juice, but this method of extraction should be compared to diffusion of juice from stalk sec-

tions in order to assure selection of the more satisfactory procedure. Labor costs will preclude harvesting and stripping the stalks by hand, but no real difficulty is anticipated in obtaining suitable machines for these operations. Doubtless the plants can be cut with sugarcane harvesters modified to permit severing and collecting of seed heads. Equipment was described in 1887 for removing leaves and leaf sheaths from 190 tons of stalks per day with an efficiency of 90% (3), and offers promise for similar application today.

Only limited examinations have been made of the potential by-products of sugar production from sweet sorghums. The seed, leaves, and leaf sheaths are possible field by-products, and of these the seed seem to have the greatest value, but as yet no market values for any of these have been established. Any use of the leaves and leaf sheaths seems dubious but would warrant examination. In the factory, the scums or sediments from juice clarification, aconitic acid, final molasses, and the bagasse or fiber residue represent the presently identified by-products. As yet only the bagasse has been examined for by-product potential. It has been used in fiber-board as a cane bagasse substitute, and one paper manufacturer indicated that it could be substituted to the extent of about 50% of the cane bagasse or wood pulp in some paper formulations.

It should be noted that the experiments conducted at Weslaco and those at Baton Rouge were made by procedures which can be duplicated in conventional sugarcane processing facilities with a minimum of modification. This preference for sugarcane type processes was based on the equipment available for this work. At a later date, efforts will be made to adapt the essentials of sweet sorghum processing to conventional sugar beet facilities.

A new structure has been completed at the Food Crops Utilization Research Laboratory at Weslaco to provide pilot plant facilities for the study of sugar production from the sweet sorghums and other sugar crops. Specialized equipment will be installed here which will permit the processing of 50 to 300 gallons of sugar-bearing juices and syrups in a manner similar to that employed in large scale commercial sugar production. The various processing units will be arranged so that selected procedures may be evaluated by batch type experiments, or as part of a continuous operation, and can be continued so as to provide crystalline sugars and final molasses. With these facilities reliable estimates can be made of production costs and product quality, and a reasonable value established for sweet sorghum sugar.

LITERATURE CITED

1. Estimated World Beet and Cane Sugar Production for 1968 Crop. Annual Sugar Review of Merrill Lynch, Pierce, Fenner & Smith, Inc.

2. Wiley, H. W. 1888. Experiments in the Manufacture of Sugar from Sorghum. USDA, Division of Chemistry Bulletin No. 20.

3. Ventre, E. K. 1940. Preliminary Report of the Crystallization of Sucrose from Juices of the Sorgo Plant. Sugar J. 3(7): 23-30.

4. Cotton, R. H., L. W. Norman, G. Rorabaugh, and H. F. Haney. 1951. Semipilot Production of Sucrose from Sorghum. Ind. Eng. Chem. 43:628-635.

5. Coleman, O. H., W. R. Cowley, D. M. Broadhead, K. C. Freeman, and I. E. Stokes. 1965. Rio, a New Disease Resistant Variety of Sweet Sorghum for Southern United States. U. S. Agr. Res. Serv., ARS 34-72.

6. Smith, B. A. Filed Nov. 4, 1966. Processes for Removing Starch from Sorghum Juices. U. S. Patent Application, Serial No. 592,685.

7. Smith, B. A. Filed Jan. 22, 1968. Process for Removing Starch from Sweet Sorghum Juices. U. S. Patent Application, Serial No. 699,383. (A continuation-in-part application pertaining to Serial No. 592,685.)

8. Ventre, E. K., J. A. Ambler, S. Byall, and H. C. Henry. (Issue date Oct. 3, 1944.) Process for the Extraction of Aconitic Acid from Plant Juices. U. S. Patent No. 2,359,537.

9. Cook, G. H. 1887. The Extraction of Sugar from Sorghum at Rio Grande, Cape May County, New Jersey. New Jersey Agricultural Experiment Station Bulletin No. 41.