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RIO GRANDE VALLEY HORTICULTURAL SOCIETY

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FRONT COVER: *An attractive landscaped Lower Rio Grande Valley home.*

People who live in the Valley are fortunate in having more ornamental plants available for use than any other locality in the United States. These include both native and exotic plants which thrive in the semi-tropical climate and rich delta soil. When used in formal or informal arrangement they give a touch of subtle beauty and attractiveness to Valley homes the year round.

In addition to enhancing the landscape some plants such as the avocado, mango, papaya and banana provide delicious fruits; the many varieties of citrus add beauty and charm to Valley homes as well as valuable supplement to the daily diet.

A list of ornamentals that grow well in the Valley is too long to include here. Perhaps it is enough to say that "esta es la tierra de las flores."

(Photo by Burt Johnson, Weslaco)

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Table of Contents

CITRUS SECTION

VEGETABLE SECTION

Table of Contents

CITRUS SECTION

Juice Quality of Ruby Red Grapefruit As Affected By Variable Amounts of Petroleum Spray Oil Applied At Postbloom

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ABSTRACT

Little effect on juice quality was found in December and February-March samples from Texas grapefruit trees treated at postbloom with 1.5% or 1.0% oil. The principle effect was a reduction in December of Naringin content of juice samples from certain oil plots. Factors not affected by oil treatment were percent acid, solids/acid and color. The vitamin C and soluble solids contents were affected on only one sampling date.

Petroleum spray oils have been widely used as scalicides and acaricides on Texas citrus during the past 10 to 12 years. Tree responses following oil usage have been reported as follows: increased leaf drop, reduced yields, reduced internal fruit quality, rind spotting, etc. Grapefruit were classed as more tolerant of oils than were oranges (5); so the greatest amount of research time by various investigators was directed to studies with oranges. Grapefruit production in the United States during the 1969-70 season was 27% of that for oranges; however, approximately 66% of the total for grapefruit and oranges from Texas was grapefruit (11). With over 60% of the Texas citrus crop being grapefruit, it was important that the possible effects of oil applied at postbloom on juice quality be investigated during the 1969-72 period.

The composition of petroleum spray oils was quite variable for many years. It was not until the late 40's that selective narrow-cut fractions were made available in very limited quantities for examination by researchers working on control of apple pests (9). These authors showed that spray oils may contain a high portion of hydrocarbons which are inactive insecticidally. A thorough review of work on the development of narrow-range oils (10) was given by Riehl, 1969. Such oils in present day usage are generally more efficient insecticidally and are less likely to result in detrimental tree responses.

A literature review showed only a few investigations had been conducted on the possible effect on juice quality of grapefruit by the narrow-range oils. Narrow-range oils applied to grapefruit trees in Texas during July were followed with a reduction in soluble solids principally with a high molecular weight (362) oil (3). Percentages of soluble solids were reduced in grapefruit (on Oct. 4 and Nov. 2) from plots sprayed on 7/1, 7/15, 8/1 or 9/1 with an oil having a 50% distillation (reduced pressure method) temperature of 475°F (4). The soluble solids of grapefruit (on Nov. 6) from plots treated on 9/16 were significantly smaller than found in samples from plots treated 8/15, 7/11 or 6/14 (4). The solids/acid ratios of samples from 410 and 448 oil plots treated 9/16 failed to meet minimum Texas requirements while samples from 410 oil plots treated 8/15 also failed to have the minimum ratio which could have been the result of larger oil deposits with the 410 oil (4).

The vitamin C content of Florida grapefruit was highest in immature fruit gradually descreasing to the lowest values which were being found in late season (May) (7). Literature was not found to show the possible effects of oil on vitamin C or naringin content of grapefruit. However, vitamin C was slightly decreased by oil sprays in Florida oranges (6) and was lowered in Egyptian oranges following oil, Trithion® and other treatments (1).

Considerable interest had developed in the use of 1.0% oil at postbloom as a rather cheap treatment for the control of certain pests of Texas citrus. Many investigators have experienced detrimental tree reactions as a result of oil applied during periods, such as postbloom, when trees are considered more sensitive to such effects. A 30-acre block of ruby red grapefruit trees was made available north of Monte Alto, Texas for the investigations reported herein. Summer treatment of all plots included 15 gal oil/acre, as used by the grower. However, postbloom treatments included the 10 and 15 gallon rates with a non-oil treatment to determine if postbloom oil might affect certain juice quality factors in December and March samples.

MATERIALS AND METHODS

Grapefruit trees were 13 years old ranging from 8-13 feet in height and planted 15 x 25 feet apart. Each plot was 12 rows wide and 22-27 trees per row for an area of approximately 3⅓ acres in size. Plots were randomized within each 10-acre block and replicated 3 times.

The 3 postbloom treatments consisted of the following amounts of the respective formulations per acre: ½ gal 45.5% chlorobenzilate plus 1 gal 42% EC dicofol (Kelthane); 10 gal 99.65% oil plus 1 gal 46.5% EC ethion; and 15 gal 99.65% oil plus 10 lb 75% WP zineb. All treatments received 15 gal oil in summer treatment with treatments 1 and 3 including 10 lb zineb while treatment 2 included 1 gal ethion. The oil had a 50% distillation point at 10 mm Hg. of 443°F with a 10-90% distillation temperature range of 75°F. Application dates were as follows: 5/6-7 & 8/13-14/69, 4/30-5/1 & 7/31 & 8/3/70; and 5/17-18 & 7/26-27/71.

Two 97,500 ft^3/min air blast sprayers with 2 sets of nozzles on each side were operated at 125 psi to apply the various sprays. Sprayers were pulled at 1 mph and the dilution rate was 2X (500 gal/acre). Some 60% of the liquid was directed into the top half of the trees.

Fruit samples were collected from east and west portions of the trees. One east and one west sample were sampled within each plot. Some 50 fruits were randomly picked (regardless of size) from 3 to 5 feet from the ground in the outer portions of 20 trees. Although fruit varied considerably in size, sufficient juice was present to meet minimum juice requirements for Texas maturity standards (12).

Juice for quality measurements was removed from the fruit by an FMC Model 091B in-line test extractor equipped with 0.027 inch screens. The acid content was determined by titration with standard sodium hydroxide and is reported as anhydrous citric. The soluble solids were determined by direct reading of the Brix scale with an "Abbe 56" refractometer. The vitamin C content was determined by the colorimetric method of Nelson and Samens (8). Color values were measured by calculating the ab ratios obtained from a Gardner Automatic Color Difference Meter using an LB1 standard. Naringin values were obtained by the colorimetric method of Davis (2).

RESULTS AND DISCUSSION

Averages of soluble solids and acid contents of samples taken from oil and non-oil treatment plots on six sampling dates are shown in Table 1. The normal increase in soluble solids and decrease in the acid values of the juice due to seasonal maturity can be observed. A significantly smaller percent soluble solids was found only on 12/15/69 with samples from plots treated at postbloom with 1.0% oil. Differences in acid content or solids to acid ratios were not found in any of the samples.

Averages of milligrams percent vitamin C and percent naringin of juice samples from various treatment plots are listed on given dates in Table 2. Analyses showed a significant reduction in vitamin C only on 3/23/71 with the 1.5% oil treatment. Reductions in naringin were found on each of the 3 December sampling dates as follows: with 1.5% oil on 12/15/69 and with 1.0% oil on 12/15/70 and 12/15/71. A reduction in naringin was also found with 1.0% and 1.5% oil samples on 3/10/70. The smallest amounts of naringin were found 2/28/72 with no difference among treatment samples. However, the naringin content of grapefruit juice at the 0.05% level, or smaller, is generally considered to be satisfactory.

Analyses, using the ab ratios from the Gardner Color Difference Meter, showed no color differences of grapefruit juice among any of the treatment samples on a particular date.

Postbloom oil at 10 and 15 gal/acre followed by 15 gal/acre in summer application caused little or no effect on quality of Texas grapefruit in December and February-March samples. Soluble solids and vitamin C were affected in a single instance while no effect was found on percent acid, solids/acid or color. A reduction in the naringin content was found in the December samples and in 1 of the 3 March samples, but all values were well below the unacceptable level.

Table 1. Juice quality of Ruby Red grapefruit as affected by variable amounts of petroleum oil in postbloom season followed by summer oil at Rio Farms, Inc., 1969-71.

Date	*Soluble Solids, %* *Treatments*[1]			*Acid, %* *Treatments*			*Solids/Acid* *Treatments*		
	1	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
12/15/69	11.2a	10.7b	11.6a	1.50	1.40	1.50	7.5	7.6	7.8
3/10/70	11.4	11.0	11.6	1.31	1.24	1.31	8.7	8.9	8.9
12/15/70	11.2	11.0	11.1	1.39	1.36	1.38	8.0	8.0	8.1
3/23/71	12.1	12.0	12.0	1.16	1.13	1.16	10.4	10.6	10.3
12/15/71	10.4	10.2	10.3	1.47	1.44	1.51	7.1	7.1	6.8
2/28/72	11.1	11.3	11.3	1.19	1.18	1.28	9.4	9.6	8.8

[1] Treatments: *1*-1.5% oil at postbloom, 1.5% oil in August; *2*-1.0% oil at postbloom, 1.5% oil in August; *3*-No oil at postbloom, 1.5% oil in August.

Means followed by the same letter are not significantly different from one another at the 5% level of probability. (Duncan's multiple range test).

Table 2. Juice quality of Ruby Red grapefruit as affected by variable amounts of petroleum oil in postbloom season followed by summer oil at Rio Farms, Inc., 1969-71.

Date	*Vitamin C, milligrams %* *Treatments*[1]			*Naringin, %* *Treatments*		
	1	*2*	*3*	*1*	*2*	*3*
12/15/69	29.2	30.5	28.7	.0178b	.0202ab	.0235a
3/10/70	32.5	31.7	31.2	.0180b	.0172b	.0228a
12/15/70	35.3	33.2	33.2	.0375a	.0317b	.0380a
3/23/71	29.5b	35.7a	36.0a	.0178	.0175	.0200
12/15/71	34.7	34.8	35.7	.0147ab	.0142b	.0163a
2/28/72	31.7	33.0	32.3	.0113	.0114	.0163

[1] Treatments: *1*-1.5% oil at postbloom, 1.5% oil in August; *2*-1.0% oil at postbloom, 1.5% oil in August; *3*-No oil at postbloom, 1.5% oil in August.
Means followed by the same letter are not significantly different from one another at the 5% level of probability (Duncan's multiple range test).

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A Physiological Rind Disorder on Valencia Oranges

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ABSTRACT

In early 1971 a rind disorder occurred in scattered Valencia orange orchards in the Rio Grande Valley. The brown, sunken, scald-like spots resembled rind oil injury. Weather records showed there were several periods when the trees in a high moisture state were subjected to severe moisture stress. Characteristics of the spots suggested that during such periods the rind oil might have been self-expressed by the rapid contraction of the peel against the turgid, unyielding pulp.

INTRODUCTION

During late March and early April, 1971, a rind disorder on mature Valencia oranges was observed in several widely scattered Rio Grande Valley orchards. The disorder was a brown, irregularly-shaped, slightly sunken area with a scalded appearance. The rough texture of the spots caused by the protuberance of oil glands resembled oil stain injury but the affected area was much larger than the usual oil stain, Fig. 1 (3). Like oil stain injury, the spots affected only epidermal cells and did not extend into the albedo. Since the spots were not characteristic of any known insect damage or disease, the disorder was presumed to be physiological. The occurrence of the problem in a Valencia orchard at the Texas A&I Citrus Center allowed study of the malady in some detail.

PROCEDURE

The 10 year-old trees in the A&I orchard were spaced 15 ft. (4.56 m) apart in 25 ft. (7.75 m) spaced rows. The rows ran north and south. On April 22, six affected trees were selected for study. The canopy of each tree was divided into 16 parts: four locations – bottom outside, bottom inside, top outside, top inside; and four quadrants – NW, NE, SE, SW. Total and affected fruit were counted in each part of the tree. On two trees the nature of the rind spot itself was studied in detail. Note was made of the location of the spot on the fruit, the area it covered, its orientation with regard to sun exposure and compass direction and any nearby twigs or leaves that might have brushed against the rind. Ten to 20 fruit from each part of the tree were studied.

The data on the percentage of fruit affected was subjected to analysis of variance considering each tree as a replicate. Where applicable the student's "t" and Duncan's multiple range tests were employed to detect differences between group mean's (5).

RESULTS

The average number and percent affected fruit by location are given in Table 1 and by quadrant in Table 2. The fruit was not evenly distributed within the tree canopy (Table 1). The average yield per tree, 100 fruit, was small and variable, ±20 fruit. The outside locations, the NW quadrant, and the west half of the trees had significantly more fruit than the other parts of the tree. This unequal distribution has been commonly observed in other tests at the Citrus Center. The fruit on the top

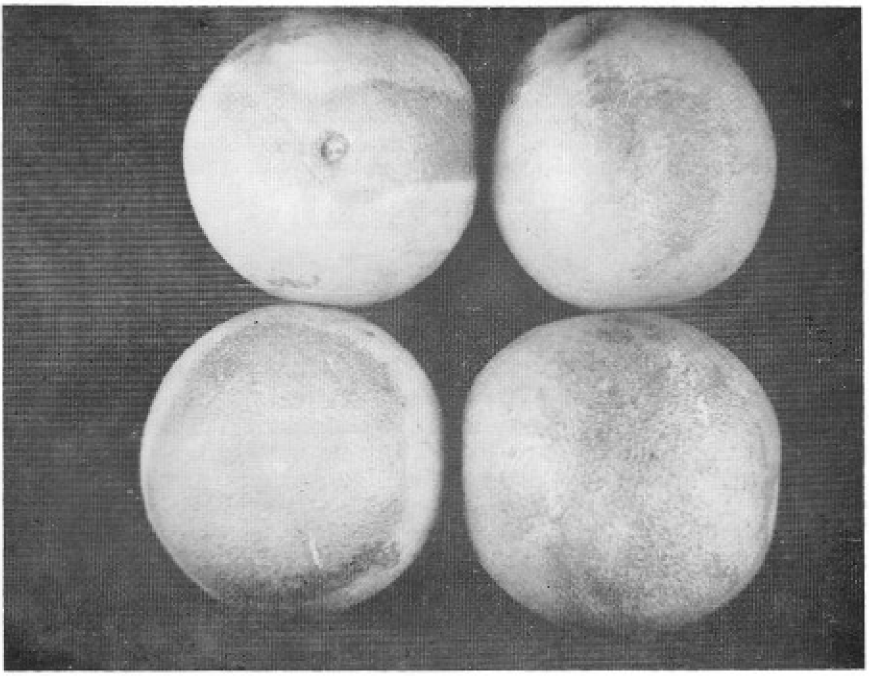

Figure 1. The rind spots are the darker, scalded-looking areas on peel.

Table 1. Total number and percent Valencia oranges affected with rind spot by location in the tree.

Location	*Total Fruit*	*% Affected Fruit*
Bottom Outside	42_{A}	11.7_{ab}
Bottom Inside	15_{B}	6.4_{b}
Top Outside	33_{A}	21.3_{a}
Top Inside	10_{B}	9.2_{ab}

Means in columns with a common *upper* case subscript are NOT significantly different at 1%, those with a common *lower* case subscript are NOT different at 5%.

Table 2. Total number and percent Valencia oranges affected with rind spot by quadrant of the tree.

Quadrant	*Total Fruit*	*% Affected Fruit*
NW	41_A	15.6_a
NE	18_B	18.7_a
SE	11_B	10.4_a
SW	21_C	13.1_a

Means in columns with a common *upper* case subscript are NOT significantly different at 1%, those with a common *lower* case subscript are NOT different at 5%.

outside had a significantly higher percentage of rind spot than the other locations. There were no significant differences between locations within quadrants in either the total number or percent affected fruit. A regression analysis to determine if the percent affected fruit was influenced by the total number of fruit was not significant. Overall 14.4% of the fruit inspected had rind spots.

The detailed study of individual fruit affected with the rind spot revealed the following:

1. In over 96% of the affected fruit the spot was primarily confined to the bottom half (stylar hemisphere) of the fruit.

2. The average spot covered 22% of the fruit surface and ranged from 5 to 75%. The size of the spot varied with the location of the fruit on the tree. The spots on fruit from the top of the tree covered 17% of the fruit surface, those on the bottom, 3%. Spots on fruit from the north quadrants covered 18% of the fruit surface those on the south side covered 7%.

3. In 55% of the affected fruit the spot encircled or partially encircled the stylar button. About half the time these spots touched the stylar button. Otherwise they encircled the button without touching it. In the remainder of these fruit the spots had no apparent association with the stylar button.

4. The spot was on the shaded or unexposed side of the fruit in 70% of the cases. About ⅔'s of the time the spot was directly opposite to the quadrant orientation, e.g. fruit in the NW quadrant usually had the spot on the SE sector of the fruit.

5. Of the affected fruit 35% could have been rubbed by a nearby twig or leaf. However, a similar percentage of unaffected fruit also had twigs or leaves close enough to have rubbed the fruit.

DISCUSSION

The report of a weather-induced rind oil stain on grapefruit (4) together with a study on osmotic pressures in orange fruit (2) provide a tentative explanation for the disorder on Valencias that has been described. While the winter of 1970-71 was unusually warm and dry, five typical cold fronts or "northers" occurred during early 1971. Their dates, maximum and minimum temperatures and relative humidities are given in Table 3. The orchard was irrigated on January 16 and March 5 with in half acre-foot of water each time. On February 26 a ¾ inch (1.9 cm) rain was recorded in a nearby rain guage.

Table 3. Temperatures and relative humidities accompanying cold fronts that occurred in the Rio Grande Valley from January - March, 1971.

Dates	*Temperatures (F)* *Maximum*	*Minimum*	*Relative Humidity (Minimum)*	*Number of Hours Below 30% R. H.*
Jan. 4 - 6	56 (13 C)	33 (1 C)	18%	22
Jan. 30, 31	88 (31 C)	56 (13 C)	8%	7
Feb. 12, 13	74 (23 C)	38 (3 C)	14%	20
Mar. 6, 7	84 (29 C)	46 (8 C)	12%	17

When the "northers" occurred the trees in this orchard were in a good state of moisture. The trees were then subjected to severe moisture stresses from the dry, north winds and warm sunny days. Although soil moisture may have been adequate, severe water deficits in the exposed parts of the tree could have occurred because translocation from the roots could not meet the demands of leaves and fruit. The problem was intensified when the soil temperature was low and the ability of the roots to absorb water was reduced (1). Under such conditions citrus leaves will draw water from nearby fruit (6). Initially most of this water comes from the peel (exocarp) and albedo (mesocarp) while little change in moisture status of the pulp and pericarp occurs (2). Considering these facts, a probable explanation for this type of rind oil spot is suggested.

Prior to the cold front the trees had ample moisture, leaf and fruit tissues were turgid. Within a few hours after the cold front arrived the trees were subjected to severe moisture stresses. The leaves on the north and west sides of the trees lost water rapidly. Since translocation from the roots could not meet the demand, water was removed from nearby fruit. Because of the high proportion of leaves to fruit, a common state in Valencia trees in the Valley, the fruit lost a lot of water very quickly. Most of the loss occurred in the peel while the pulp remained turgid. The effect was like squeezing the peel against a hard ball. The pressure on the contracting peel was sufficient to force oil from the glands onto the surface. Since the stylar end of the fruit has the lowest osmotic pressure or highest water content, the greatest water loss is from this half of the peel yet the underlying pulp remains turgid and unyielding (2). The fact that the peel oil is more concentrated in the stylar half of the fruit lends further credence to the theory of self-expressed oil (7). The fruit in the top, outside and north sections of the tree, being subjected to the greatest and most rapid water losses, would have had more and larger spots.

There could be several explanations for the higher incidence of injury on the unexposed parts of the fruit. It is possible that the exposed portions of the rind may have been toughened by constant exposure to wind and sun. This toughening may have both decreased the amount of oil in the glands and the peel's susceptibility to oil staining. Another possibility is that the injurious constituents of the oil excreted on the exposed areas of the fruit might have been inactiviated or evaporated by wind or sun before causing any perceptible damage. While exposure to only 0.01 ml of lemon oil for 8 seconds can produce a noticeable stain, the conditions under which this occurred were not defined (3). Finally after sunset the winds subside and the relative humidity rises rapidly. Since the exposed part of the fruit may have been warmed by the sun, moisture will tend to condense on the cool, unexposed area. The condensate may then serve to spread the irritant oil over the peel resulting in the large continuous spot seen in Figure 1.

Since irrigating in winter is not a common practice, probably a majority of Valley orchards were dry or under moisture stress during the January - March period. This would explain why only a few orchards were in the right moisture condition to predispose the fruit to injury and were damaged.

A rind stippling of grapefruit attributed to peel oil damage was described in California (4). Circular, dark, sunken blemishes occurred more on exposed surfaces of fruit in the north half of the trees. Rapid drying of the peel caused it to contract against the turgid, incompressible pulp. This pressure expressed oil from the glands and produced the stipple-like stains.

CONCLUSIONS

The failure of the rind spots to fit any known insect, nutritional or disease symptoms of oranges indicates a physiological cause. The distribution and pattern of the injury suggested rind oil staining induced by a rapid moisture loss from turgid fruit. Valencia orchards which were well-watered and had relatively light crops when a dry cold front arrived were predisposed to injury. The fruit on trees already under some moisture stress should have escaped damage. Since all contributing factors must happen in proper sequence the disorder has a low probability of occurring regularly. Maintaining a high humidity within the trees e.g. with sprinklers, would probably reduce injury but the unlikelihood of occurrence argues against taking elaborate measures to prevent this disorder. Maintaining the orchard in a good moisture and nutritional status during the winter is still the best overall practice.

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Nitrate and Chloride Losses in Drainage Effluents from a Citrus Orchard

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ABSTRACT

Nitrate-nitrogen (NO_3-N) and chlorides (Cl) were measured in drainage effluents from a 40-acre citrus orchard on Hidalgo sandy clay loam (Typic Haplustoll). Nitrogen fertilizer (NH_4NO_3) treatments were 0 and 400 lb N/acre. Fifty-one inches of irrigation water in conjunction with 29 inches of precipitation during the study period (July 1968 - May 1970) moved only 16 lb of NO_3-N/acre or 4.0% of the applied N into drainage effluents. Nitrate-N losses ranged from 0.01 to 0.30 lb/acre per day during 200 days of intermittent drain flow. Approximately 1 year was required to move the NO_3-N through an 8-ft soil profile. The concentration wave of NO_3-N became longer and flatter with time, thus reducing the chance of a large quantity of NO_3-N being released into the drain effluents during a short time interval. Approximately 3,000 lb of various salts per acre (1,000 lb of Cl) were removed through drainage effluents. It was concluded that with the application of recommended rates of N fertilizer (125 to 170 lb N/acre) leaching to prevent salt build-up will not result in a significant NO_3-N enrichment of the drainage effluent.

INTRODUCTION

Efficient use of irrigation water and nitrogen fertilizer is a challenge to citrus growers in the Lower Rio Grande Valley. Nutritionally, it is necessary to know the quantity of applied nitrogen remaining in the effective tree root zone after an irrigation sequence or a wet period. If applied nitrogen is leached below the range of the root system, the fate of NO_3-N in drainage waters may become important environmentally.

An estimated 40 acre-inches of water, including effective precipitation, are required to sustain large citrus trees (Coit, 1964). A fraction of this water is required for leaching soluble salts from the soil to control salinity. Heavy producing citrus trees require annual nitrogen fertilizer applications of 125 to 170 lb/acre (Friend and Hancock, 1963; Texas Agricultural Experiment Station, 1968). Minimizing leaching losses of nitrate-nitrogen (NO_3-N) from potentially saline soil profiles is complexed with the tree spacing arrangement. The usual tree spacing (20 x 25 ft) does not appear to permit massive root distribution for avid nitrate absorption.

Stewart (1970) reviewed the literature on NO_3-N accumulation in soils as affected by agricultural practices. Bower and Wilcox (1969) recently reported that nitrogen fertilizers applied to irrigated areas adjacent to the upper Rio Grande had little influence on NO_3-N enrichment of river water in a 30-year salt balance study. Feth's (1966) comprehensive review deals with geochemical sources of N compounds in natural waters and indicates that the contribution of N fertilizer to NO_3-N enrichment of ground water and drainage effluents is not well defined because of widespread agricultural practices and physical environments. The fallacies of some calculated physical parameters used to describe the movement of anions in various soils has been recently illustrated by Kolenbrander (1970). Considerable evidence (Johnson et al., 1965; Meek, Grass, and MacKenzie, 1969) under irrigated conditions indicates that denitrification of applied N may account for low NO_3-N losses in some drainage effluents. Kolenbrander (1969) found little NO_3-N in drain water when grasses were grown on soils containing 35% or more clay.

The purpose of this study was to quantify the loss of NO_3-N in drainage effluents from N-fertilized citrus orchards while leaching to prevent salt accumulations.

MATERIALS AND METHODS

A 40-acre citrus orchard near Edinburg, Texas, established in 1960 on Hidalgo sandy clay loam (Typic Haplustoll), was chosen for the experimental site. Experimental subsurface drains were installed on this site between October 1963 and December 1964. Drain lines were 1,140 ft long, spaced 175 ft apart, and placed at an average depth of 7.25 ft. Five types and sizes of tile and pipe were used (Table 1). Water tables were usually below drain lines except immediately after heavy irrigations or rainfall. Sample access manholes were installed 450 ft apart on 5 lines. The 10 plots used in this experiment were 175 ft wide and 450 ft long. Each drain line bisected 2 plots along the longer axis. Access sampling holes were located on the downstream end of each plot. Seven rows of citrus trees (25 ft apart) were located between drain lines.

Table 1. Description of drainage material used, drain line diameters, and installation date of each experimental line chosen for study.

Drain line	*Drainage material*	*Diameter of drain line*	*Installation date*
		inches	
(2)	Concrete w/o filter	6	1963
(3)	Concrete w/fiberglass filter	6	1963
(4)	Fiber w/fiberglass filter	4	1963
(5)	Plastic w/gravel pack	4	1964
(6)	Plastic w/fiberglass filter	4	1964

The plots were border irrigated and the quantity of water used was measured with a Sparling meter. Soil sampling was along transects perpendicular to drains at locations of 5, 30, and 77 ft on each side of the drain lines. Soil samples were taken to a depth of 8 ft by 1-ft depth intervals during 1968, 1969, and 1970 between peak drain flow periods. Drainage effluent samples were collected daily during peak drain discharge periods and at least weekly during post peak flows. Drain discharge rates permitted calculation of the quantity of NO_3-N and Cl in the drainage water.

Ammonium nitrate was applied to plots during May of 1968 and 1969. Treatments consisted of 100, 200, and 400 lb of N/acre arranged in a completely randomized manner in 1968. The 100- and 200-lb rates were replicated three times and the 400-lb rate, four times. An excessive amount of N fertilizer was used to accentuate the difference between applied and soil N. Randomization was sacrificed in 1969 to use the 5 downstream (drain line) plots for a 400-lb N treatment. The 5 upstream plots were used for control plots. Nitrate-N in drain discharges from control plots was used to estimate the indigenous and previously applied NO_3-N in drain discharges from treated plots. The control and treated areas each contained two of the 400-lb plots used in 1968. Chemical procedures used were those outlined by the U. S. Salinity Laboratory Staff (1954). Excess chlorides were precipitated to employ the phenoldisulfonic acid procedure for NO_3-N measurements.

Table 2. Occurrence and quantity of irrigation water, amounts of NO_3-N and Cl in the precipitation, and irrigation water used.

Date	*Precipitation*	*Irrigation*	NO_3-N	*Cl*	*SAR**	*Electrical conductivity*
	inches	inches	ppm	ppm		millimhos/cm
1968						
7/1 - 7/18		14.0	0.4	184	4.2	1.3
7/18-12/31	6.4					
1969						
1/1 - 6/9	5.7					
6/9 - 6/13		12.0	0.4	119	3.0	0.9
6/13- 8/13	0.7					
8/13- 8/21		5.0	0.7	141	3.5	1.1
8/21-11/8	6.6					
11/8 -11/24		8.0	0.3	171	4.1	1.2
11/24-12/31	1.9					
1970						
1/1 - 4/23	4.9					
4/23- 4/27		12.0	0.3	114	4.6	1.0
4/27- 5/18	2.7					

* SAR = Sodium Adsorption Ratio $(Na^+/\sqrt{Ca^{++} + Mg^{++}/2})$

RESULTS AND DISCUSSION

The necessity of leaching Hidalgo sandy clay loam profiles is evident from the quality of available irrigation water used (Table 2). In addition to 29 inches of rainfall received between July 1, 1968, and May 18, 1970, 51 acre-inches of low sodium-high salinity hazard irrigation water was added to sustain citrus production and leach soluble salts. The irrigation water contributed approximately 8,000 lb of salt per acre to the soil. These salts contained approximately 1,700 lb of Cl and 5 lb of NO_3-N.

Average monthly concentrations of NO_3-N, Cl, and total salts of drain line discharges are shown in Table 3. These data represent 200 days of intermittent drain line flow. Approximately 3,000 lb of salts per acre were removed in these drainage effluents. Only NO_3-N concentrations in drainage discharge are expressed on a plot basis in Table 3. The May 1969 N-fertilizer treatment (400 lb) increased the average NO_3-N concentrations in drainage discharges 10 ppm. The NO_3-N content of the 1968 drainage effluents (average loss of 5.7 lb of NO_3-N/acre) was not related to N-fertilizer additions (100, 200, and 400 lb), probably because of the limited application of water.

Table 3. Monthly discharge of NO_3-N and chloride, sodium-adsorption-ration (SAR), electrical conductivity, and water discharged by drain lines.*

Month	*NO_3-N*		*Cl*	*SAR*	*Electrical conductivity*	*Water discharged*
	Control	*N-treated*				
	ppm	ppm	ppm		mmhos/cm	ft³/acre
1968						
July	—	44	1589	11.5	6.2	2064
1969						
August	45	46	1312	18.6	5.7	382
September	29	41	2113	19.1	9.8	1246
October	37	45	2617	19.6	10.5	138
November	20	40	2117	22.2	7.1	421
December	35	44	2818	21.4	10.3	1945
1970						
January	40	46	2835	22.9	11.1	1104
February	38	44	2810	23.1	11.2	323
April	37	38	1170	16.8	5.7	188
May	34	42	1964	19.8	8.5	725

* NO_3-N concentrations are expressed on plot basis. Other data represent averages per drain line.

Nitrate-N movement in soil profiles induced by N-feritlizer treatment after each leaching period and accompanying daily NO_3-N losses are shown in Fig. 1 and 2, respectively. Figure 1 shows the effect of

100, 200, and 400 lb of N/acre applied in May 1968 on NO_3-N content-depth profiles for November 1968. About 6 inches of precipitation supplemented with 14 inches of irrigation water moved the two largest N applications from the soil surface to the 2-ft depth. Nitrogen applied in May 1968 did not appear in the November 1969 profile soil samples. Small quantities of the N applied in 1968 were detected 15 months later in the August 1969 effluents (Table 3). Some drainage occurred during the winter of 1968-69; however, drain discharge volume was too low to adequately measure. Figure 1 also depicts the effect of two N-fertilizer treatments (0 and 400 lb of N applied in May 1969) on the NO_3-N content-depth profiles in November and December 1969 and May 1970. Extensive leaching by precipitation (16.8 inches) and irrigation water (37 inches) moved the main NO_3-N accumulation to the vicinity of drain lines. Although the main accumulation was moved to the lower part of the soil profile, considerable quantities of applied N remained throughout the profile 1 year later. The NO_3-N difference between the control and 400-lb treatment was approximately 270, 240, and 230 lb/acre (8-ft profile) for November and December 1969 and May 1970, respectively. The concentration wave became longer and flatter in December 1969, reducing the chances of releasing large quantities of NO_3-N to drain effluents during a short time interval. Retention time for quantities of N-fertilizer, much greater than required for citrus production, appears to exceed 1 year in these 8-ft profiles.

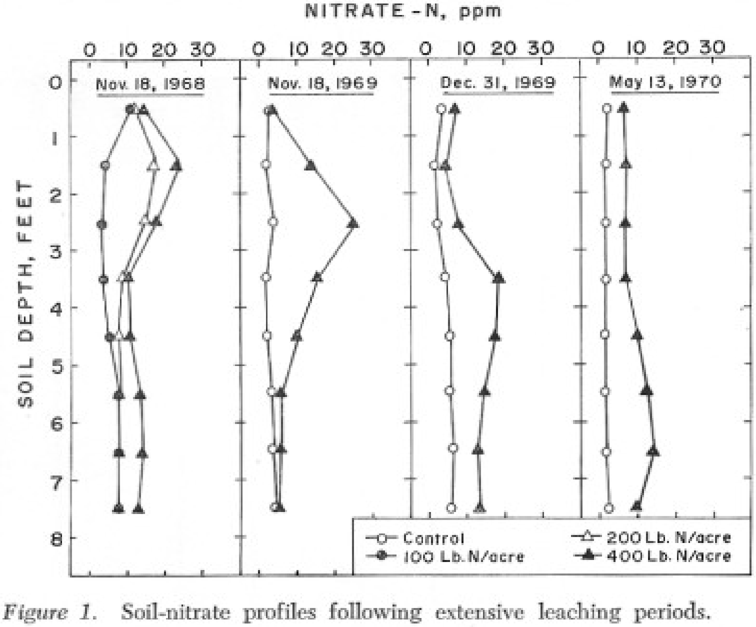

Figure 1. Soil-nitrate profiles following extensive leaching periods.

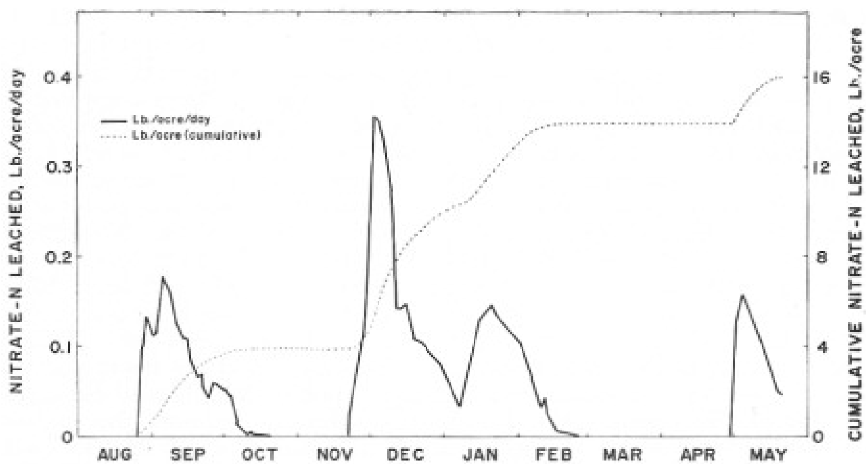

Figure 2. Daily and cumulative nitrate-N losses in 1969-70 drainage effulents from 400 lb/acre N-fertilized plots (2.5 lb of indigenous NO_3-N/acre are not included).

The amount of NO_3-N in the drainage effluent attributed to the 400-lb N-fertilizer treatment is shown in Fig. 2. The NO_3-N losses are weighted average differences between the control and N-treated plots. To calculate these differences, it was assumed that the same quantity of indigenous and residual fertilizer NO_3-N was removed from the control

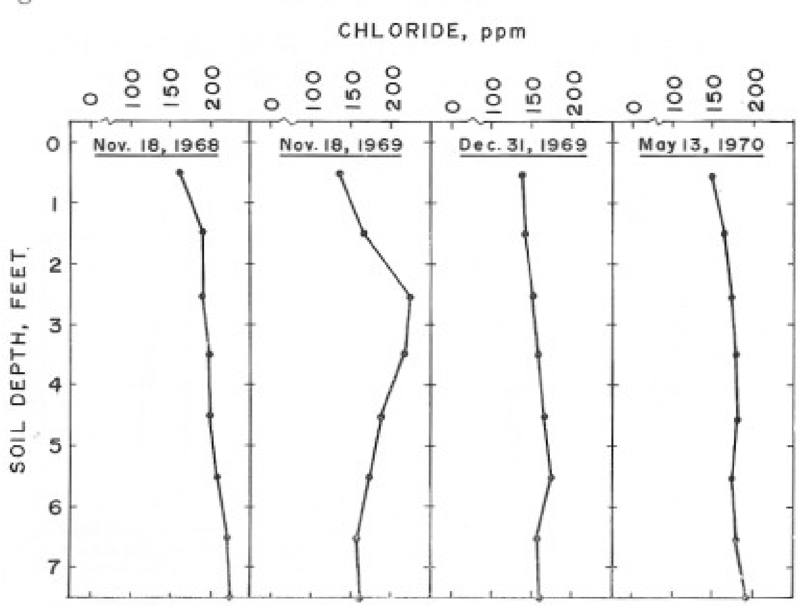

Figure 3. Soil-chloride profiles following extensive leaching periods.

and N-treated plots. Since the upstream control plot effluents also flowed through the downstream sample access sites (N-treated plots), it was necessary to multiply the control losses by 2 and subtract these values from the total quantity of NO_3-N measured in downstream samples. The NO_3-N peaks during 190 days of intermittent drain-line flow (1969-70) are closely associated with the occurrences of irrigation and rainfall shown in Table 2. A cumulative total of 16 lb or 4.0% of the 400 lb applied N entered the drains between August 1969 through May 1970. Most of this N loss occurred during winter months.

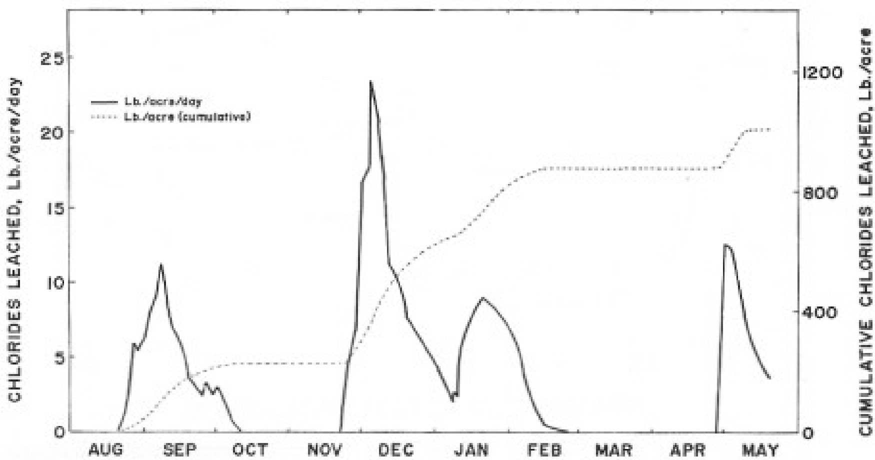

Figure 4. Daily and cumulative chloride losses in 1969-70 drainage effluents from N-fertilizer treated plots.

Choloride movement in soil profiles and losses in drainage effluents are given in Fig. 3 and 4, respectively. Chloride losses from N-fertilized plots (Fig. 4) were estimated by subtracting the quantity of Cl measured at the upstream sample access sites from the total quantity measured at the downstream sample access sites. Peak Cl losses occurred very close to those shown for NO_3-N in Fig. 2. A cumulative total of 1,000 lb of Cl/acre was measured in the drainage effluents between August 1969 and May 1970. Cumulative losses of NO_3-N and Cl shown in Fig. 2 and 4, as well as a regression analysis of the relation between these two anions ($r = 0.90$), indicates that 1.0 lb of NO_3-N accompanied each 62.5 lb of Cl removed in drain effluents. The electrical conductivity of saturated soil extracts (ECe = 1.5 mmhos/cm) measured in 8-ft soil profiles remained nearly constant during the test period, suggesting that most salts added through irrigation water were leached through the soil profile.

Meek et al. (1969) suggest some NO_3-N may be reduced to nitrogen gas before reaching the water table; a considerable loss of nitrogen as N_2 gas occurred in their laboratory studies when the water content of soil was increased to about 90% of the saturation percentage. They also report a 1.5% loss to drainage effluents during the growing season from 250 lb of N/acre applied to cotton. This compared favorable with the 4.0% loss from 400 lb of N/acre during a 10-month period of this study.

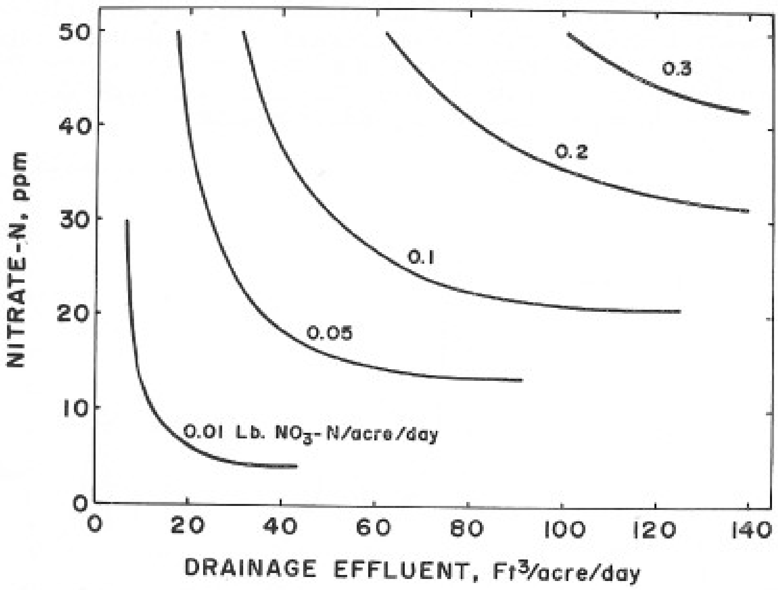

Figure 5. Isoquants relating nitrate losses to varying experimental drainage effluent volumes and nitrate concentrations.

Isoquant curves depicting NO_3-N losses (Fig. 5) were calculated from fluctuating effluent discharge volumes and NO_3-N concentrations. These hyperbolic curves were terminated when slopes equalled zero with respect to a given axis or at the boundary of the experimental data. In many cases both conditions occurred simultaneously. Losses of NO_3-N through drainage effluents following recommended N-fertilizer applications (125 to 170 lb/acre) on these soils are likely to be $\leq$ 0.01 lb/acre per day. For example, if 0.01 lb of NO_3-N/acre per day were lost in 35 cubic feet of drainage discharge, the average NO_3-N concentration in the effluent would be 4 ppm.

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Treatment and Recovery of Footrot Affected Grapefruit Trees

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ABSTRACT

Favorable conditions were created by Beulah, a 1967 hurricane, for the development of a high incidence of *Phytophthora* footrot in two 3-year old red grapefruit groves on sour orange rootstock. A survey in 1968 revealed that of 1,099 trees planted 28 percent had developed footrot lesions. Lesions on 108 trees were treated by excising the infected tissue and painting wounds with a fungicidal wound paint. Four years later, 1972, 90 percent of the treated trees had recovered, were growing well compared to 67 percent for trees that had not been treated.

INTRODUCTION

Footrot of citrus, caused by *Phytophthora* spp. has been known to occur in the Lower Rio Grande Valley (3,5) for many years, and is a serious disease in both California and Florida (1,2). Its occurrence in the Valley has been erratic and losses variable. In most instances where footrot has occurred, only a few trees were affected and the losses comparatively small. Occasionally, as in 1968, a high incidence of footrot developed in certain groves. The primary contributing cause of this outbreak was Hurricane Beulah, which hit the Valley in October 1967 and created conditions favorable for the build-up of a tremendous amount of *Phytophthora* inoculum. Following the hurricane, *Phytophthora* brown rot developed in the large amounts of fruit blown off by high winds. The excessive soil moisture and humid conditions were favorable for brown rot development in citrus fruit in contact with the soil. Also, a considerable amount of fruit on the trees was lost through *Phytophthora* infection.

This report deals with the effectiveness of treating footrot lesions on young grapefruit trees on sour orange rootstock.

PROCEDURE

A survey was made in October 1968 of two Rio Farms 3-year-old grapefruit groves on sour orange rootstock to ascertain the extent of footrot in the groves.

Footrot lesions on 108 trees were treated by cutting out the infected or discolored bark and removing a one-half to one-fourth inch margin of healthy bark beyond the discolored area (1). The wounds were scraped to remove any loose remaining bark tissue. A fungicidal asphalt wound paint (4) was applied to the wounds immediately after removing the infected bark. Observations were made annually for four years on recovery of trees with treated and untreated footrot lesions.

Culture isolations were made from active footrot lesions to determine the causal organism.

RESULTS

In the footrot survey made of two 3-year-old grapefruit groves, it was found that of 1,099 trees planted, thirty-two had died, presumably from rootrot. Of the remaining 1,067 trees, 286, or 27 percent, had footrot lesions low on the trunk. There were 232 trees with active footrot lesions, or gum exuding lesions and 54 trees had inactive or non-gumming lesions. The inactive lesions were covered with dead dry bark tightly adhering to the dead wood underneath; —the causative fungus had either died out or was quiescent.

The fungus *Phytophthora parasitica* was isolated from active footrot lesions in both grapefruit and sour orange bark. It was, also, isolated from lesions on 3-year-old sour orange sedlings, which served as a windbreak.

Table 1. Location of treated footrot lesions in reference to the bud union of grapefruit trees on sour orange rootstock.[a]

	Lesions		*Average length of lesions*
Bud union and location of lesions	*Number*	*Percent*	*Inches*
Lesions entirely above bud union (grapefruit scions)	8	6.9	6.5
Lesions entirely below bud union (sour orange rootstock)	19	16.4	3.4
Lesions extending above and below bud union	89	76.2	7.9
Total and average	116	—	7.1

[a] Data based on excised lesions only.

The footrot lesions ranged in size from very small infected areas to lesions more than 12 inches in length and to some that girdled tree trunks 8 to 10 inches in circumference. The 116 lesions treated averaged 7.1 inches in length and 3.4 inches in width (Table 1). Slightly over 75 percent of the lesions were in the bud union area and extended into both the grapefruit top and the sour orange rootstock. Lesions entirely in the sour orange rootstock were twice as common as lesions above the bud union in the grapefruit top (Table 1). Infected tissue, frequently, extented into the crown roots.

The data in Table 1 and observations made in the initial survey seemingly indicate that sour orange was as susceptible to *Phytophthora* infection as the grapefruit trunks. It is believed, however, that conditions were more conducive for infection below the bud union than above because of moisture conditions and the prevalence of inoculum. Even though sour orange is rated as quite resistant (1), one must consider that infection rate or susceptibility is related to the amount of infective inoculum present. Resistance in the sour orange rootstock may have been an important factor in the recovery of footrot affected trees.

Initial infections, based on observations, occurred low on the tree trunks and more frequently below the bud union than above. The infected areas or lesions were usually above ground line, but in some instances the lesions extended into the crown roots.

Table 2. Recovery of *Phytophthora* infected grapefruit trees four years after treatment.

Treatment of footrot lesions October-November 1968[a]	*Trees Treated*	*Trees recovered from footrot, 1972*[b]	
	Number	*Number*	*Percent*
Trees with treated lesions:			
Active, –exuding gum	85	81	95.3
Inactive, –dry lesions	23	17	73.9
Trees with untreated lesions:			
Active, –exuding gum	147	93	63.2
Inactive, –dry lesions	31	26	83.8
Total trees with footrot	286	214	74.8

[a] Lesions treated by excising the diseased bark, scraping the exposed wood, and painting with an asphalt-fungicidal tree-wound paint.

[b] Tree recovery from *Phytophthora* infection was indicated by callus growth over the footrot lesions, growth response of the trees and healthy foliage.

Tree recovery from footrot lesions four years after treatment was reflected in growth and tree condition. Of 286 trees observed with lesions in 1968, slightly over 74 percent had recovered by August 1972 (Table 2). A total of 104 trees of 1,099 planted, or approximately 10 percent of the original planting were killed by footrot.

Treated trees with active footrot lesions had a higher rate of recovery than untreated trees (Table 2). Approximately 95 percent of the treated trees with active lesions had recovered four years after treatment.

There was no apparent benefit obtained by treating inactive footrot lesions. A slightly larger percentage of trees with untreated inactive lesions recovered than for the treated trees.

The data presented in Table 2 indicate that there was some benefit gained by treating trees with active lesions and none for treating inactive lesions. The recovery of trees with active lesions that had been treated was 50 percent higher than for untreated trees.

Table 3. Size of lesions on treated trees in 1968, in width classes, tree condition four years later, 1972.

Width of lesions	*Treated trees*	*Tree condition 4 yrs. after treatment* Dead	Recovered	
Inches	*Number*	*Number*	*Number*	*percent*
0 — 0.9	2	0	2	100
1 — 1.9	13	2	11	85
2 — 2.9	20	1	19	95
3 — 3.9	25	1	24	96
4 — 4.9	20	3	17	85
5 — 5.9	6	0	6	100
6 — 6.9	8	1	7	87
7 +	14	2	12	86
Total	108	10	98	91

The size of the footrot lesions had little effect on the recovery of treated trees (Table 3). There was a slight increase in recovery of trees with lesions smaller than four inches in width over trees with larger lesions.

Certain conclusions from the data presented may be made with some reservations:

1. Under certain conditions grapefruit trees on sour orange rootstock can develop a high incidence of footrot.
2. Treatment of active or gum exudating footrot lesions will increase the chances of recovery of affected trees.
3. There is little or no advantage in treating trees with inactive lesions.
4. To be most effective, footrot lesions should be treated while small.

ACKNOWLEDGEMENT

The identification of the causal fungus, *Phytophthora parasitica*, Dast. by Dr. Gordon Grimm, Pathologist, U. S. Horticultural Field Station, Orlando, Florida, is gratefully acknowledged.

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Preliminary Tests of Chemical Pruning Agents on Grapefruit Trees

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ABSTRACT

Two formulations of a chemical pruning agent (CPA) were sprayed on new grapefruit shoots in three separate tests. In some tests citrus spray oil, dimethylsulfoxide, ethanol, and a non-ionic surfactant were added to the CPA solutions. In the first two tests the CPA's killed from 10-30% of the terminal shoots. This either stimulated development of sub-terminal buds or increased the growth of the surviving shoots. The effect of the additives was inconsistent. In the last test the CPA's killed few if any shoots. On citrus the effectiveness of CPA's seems dependent on the stage of shoot development and possibly climatic conditions.

INTRODUCTION

In 1966, Cathey reported that spraying plants with solutions of long chain fatty acids (8 to 12 carbon atoms) selectively killed young terminal shoots (2). Subsequently these solutions have been used to promote bushy, compact growth on ornamentals (3,4). While chemicals have been shown to control growth on citrus, the use of fatty acid formulations to chemically prune citrus has not been reported (1). In 1967 and 1969 two of these formulations were tested on grapefruit trees in Texas.

MATERIALS AND METHODS

Initial Test, 1967

In late February two chemical pruning agents (CPA #1 and CPA #2 supplied by Proctor and Gamble Company, Cincinnati, Ohio 45317) were sprayed on one-year-old grapefruit trees in the nursery. Each CPA as a 4% emulsion was applied to two trees. Just enough spray was applied to wet the leaves and shoots without any drip or run-off. The new terminal shoots averaged 1.15 cm long when the sprays were applied.

Second Test, 1967

The following treatments were used in water formulations:

Treatment 1 – 4% CPA #2 + 10% citrus spray oil + 10% dimethylsulfoxide (DMSO)

Treatment 2 – 4% CPA #2 + 10% DMSO

Treatment 3 – 4% CPA #2 + 10% citrus spray oil + 5% non-ionic surfactant (Multifilm Spray Modifier manufactured by Colloidal Products Corporation, Sausalito, California)

Treatment 4 – 5% CPA + 10% citrus spray oil + 2% DMSO + 50% All-Safe (All-Safe is a wax-emulsion type antidessicant manufactured by Certified Laboratories, Fort Worth, Texas)

The number and length of new shoots on each of two branches on three mature grapefruit trees were recorded. One branch on each tree received a CPA treatment on March 6. The second branch on the tree served as a control. Observations on shoot and other growth responses were made on March 10. New shoots were recounted and measured on March 31.

Third Test, 1969

The treatments below were applied to two-year-old grapefruit trees on the dates indicated:

Treatment	*Formulation*	*No. Trees Treated*	*Date Applied*
1	2% CPA #1	2	Jan. 23
2	2% CPA #1 + 5% ethanol	2	Jan. 23
3	2% CPA #1 + 5% DMSO	2	Jan. 23
4	2% CPA #1	2	March 7
5	2% CPA #1 + 5% ethanol	2	March 7
6	2% CPA #1 + 5% DMSO	2	March 7
7	2% CPA #2	3	March 7
8	2% CPA #2 + 5% ethanol	3	March 7
9	2% CPA #2 + 5% DMSO	3	March 7
10	Control	4	—

There were no new shoots on the trees on January 23. The number and length of the new terminal, median, and basal shoots on two branches of each tree were determined on March 7 and on March 27. Approximately 500 ml of CPA solution per tree was enough to just wet the leaves and shoots. On both dates the sprays were applied in late afternoon with clear and sunny skies. Temperatures were 23 and 24.5 C, relative humidity 76 and 60% for January 23 and March 7, respectively.

RESULTS AND DISCUSSION

Initial Test, 1967

Contrary to Dr. Cathey's experience (related by letter) within 4 days after spraying with CPA, 20-30% of the terminal shoots of the trees turned ash grey and abscissed. Some slight cupping of the immature leaves was also observed. Although both sprays were effective, CPA #2 killed shoots more consistently than CPA #1. On the basis of this response further experimentation seemed justified.

Second Test, 1967

By March 10, 10 to 20 percent of the new terminal shoots of trees sprayed with CPA + oil + DMSO (Treatment 1) and the CPA + oil + surfactant (Treatment 3) were dead. Young leaves were severely cupped and the median portion of the leaf margins were killed. The CPA + DMSO spray (Treatment 2) killed few terminal shoots and produced little leaf distortion. The CPA + oil + DMSO + All-Safe (Treatment 4) had no effect at all. For this reason the "after treatment" counts of new shoots on branches receiving Treatment 4 were not made.

Concerning the effects of the additives, one might assume the citrus spray oil could have damaged the young shoots and leaves. However, the effectiveness of the CPA's in the initial test where no oil was used and the lack of response to Treatment 4 which contained oil do not support this assumption. On the other hand the DMSO and All-Safe apparently inhibited the CPA action.

Table 1. The effects of chemical pruning agents on the growth of young grapefruit shoots, 1967. Measurements were taken before treatment (March 6) and after treatment (March 31).

Treatment	*No. of Shoots*		*Shoot Length*		*% Increase in*
	Before	*After*	*Before*	*After*	*Shoot Length*
			cm	*cm*	
1 – CPA #2 + oil + DMSO	16	27	8.5	9.6	13
Control 1	19	14	7.5	11.0	47
2 – CPA #2+ DMSO	11	11	11.4	11.9	4
Control 2	17	13	10.5	11.4	9
3 – CPA #2 + oil + surfactant	34	19	5.0	10.5	110
Control 3	26	22	7.2	11.9	65

Before treatment the length of the new shoots was negatively correlated (significant at 1%) with the number of shoots per branch. After treatment there was no correlation between number and length of shoots. This fact and the data in Table 1 suggest that the CPA + oil + DMSO (Treatment 1) killed the terminal shoots when only a few of a large number of potential shoots had begun growing. This stimulated the subterminal buds to develop. The total number of shoots increased but the average shoot length decreased. With the CPA + oil + surfactant (Treatment 3) almost half of the shoots on the treated branches were killed. Apparently either this treatment was more effective or more of the shoots on this branch were susceptible to CPA action.

Because a greater proportion of total shoots were killed, those surviving the treatment elongated more rapidly.

The differing results of these three treatments indicate either the CPA activity was modified by the additives or the stage of shoot development on the treated branches was different enough to alter susceptibility of the shoots to the CPA. Further testing would be necessary to determine the correct hypothesis.

Third Test, 1969

The January treatments were made to determine the effect of CPA's on vegetative or flower bud development before spring growth. There was no evidence of any consistent effect from these sprays (Table 2). For the treatments applied on March 7, the apparent reduction in the percent increase in shoot length from the CPA #1 spray (Treatment 4) and the CPA + ethanol (Treatments 5 and 8) was not statistically significant. This was true also for increases in shoot length for the CPA #2 (Treatment 7) and the CPA + DMSO (Treatment 6 and 9) sprays. Almost no terminal shoots were killed by any treatment and no leaf cupping or leaf margin burning was observed. These results suggest the susceptibility of new grapefruit shoots to CPA's is dependent on the stage of shoot development and possibly climatic conditions.

Table 2. The effect of chemical pruning agents plus additives on the growth of young grapefruit shoots, 1969. Shoots were measured before treatment (March 7) and after treatment (March 27).

Treatment	*Shoot Position*	*Ave. No. of Shoots Before*	*Ave. No. of Shoots After*	*Shoot Length Before*	*Shoot Length After*	*% Increase in Shoot Length*
				cm	*cm*	
1. CPA #1[1]	Term'l	3	5	1.4	7.6	443
	Median	1	0	.7	—	—
	Basal	0	0	—	—	—
2. CPA #1 + ethanol[1]	Term'l	6	5	8.0	14.6	82
	Median	5	2	3.3	8.8	167
	Basal	1	1	7.0	14.9	113
3. CPA #1 + DMSO[1]	Term'l	5	7	12.1	14.5	20
	Median	5	1	9.7	16.0	65
	Basal	0	0	—	—	—
4. CPA #1	Term'l	3	4	7.5	12.2	63
	Median	2	1	4.2	5.2	23
	Basal	0	0	—	—	—
5. & 8. CPA + ethanol	Term'l	4	4	5.6	10.8	89
	Median	1	1	3.7	4.9	27
	Basal	1	1	1.2	2.6	108
6. & 9. CPA + DMSO	Term'l	4	4	4.4	10.9	148
	Median	1	1	1.1	6.4	482
	Basal	0	0	—	—	—
7. CPA #2	Term'l	5	4	4.4	9.6	118
	Median	1	1	1.6	7.6	375
	Basal	1	0	2.3	—	—
10. Control	Term'l	4	5	5.7	11.8	107
	Median	2	2	4.0	10.4	160
	Basal	0	0	—	—	—

[1] Branches were sprayed Jan. 23, shoot measurements were made Mar. 7 and Mar. 27.

CONCLUSIONS

1) New shoots of grapefruit trees can be killed by chemical pruning agents under certain conditions.

2) Adding citrus spray oil, and a non-ionic surfactant to the spray formulations permitted CPA action but produced different effects. DMSO appeared to inhibit CPA action. Ethanol did not influence CPA activity.

3) While CPA action may be influenced by spray additives, the stage of shoot development seems a more likely cause for the erratic responses of new grapefruit shoots to CPA's. When CPA kills some shoots it may increase the number of sub-terminal buds which develop into shoots, or it may increase growth of the surviving shoots.

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Control of the Citrus Nematode on Valencia Orange in Texas

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ABSTRACT

Application of certain nematicides to established Valencia orange (*Citrus sinensis* (Linn.) Osbeck) trees reduced citrus nematode (*Tylenchulus semipenetrans* Cobb) populations and significantly increased yield for three crops with treatments of DBCP and Bay 68138. Bay 25141 and aldicarb showed initial yield increase, but these increases were not consistent for the three-year period.

INTRODUCTION

The citrus nematode (*Tylenchulus semipenetrans* Cobb) has been reported from most citrus-growing areas of the world. In Texas it has been found in 90% of the orchards sampled in the Lower Rio Grande Valley, which is the major citrus-growing area of Texas (3). Reports from different parts of the world vary as to its economic importance in citrus production.

Since the discovery of the citrus nematode in the Valley in 1950 by Godfrey and Waibel (2), little has been done to determine the effect of the nematode on citrus yield. Sleeth (6) found that orange and grapefruit trees planted in fumigated soil increased growth from 3.2% for Valencia orange to 40.6% for red grapefruit, when compared with trees planted in nematode-infested nonfumigated soil.

The objectives of this experiment were to determine the effect of nematicides on control of the citrus nematode in established orchards under soil and climatic conditions of the Lower Rio Grande Valley and to determine yield differences.

MATERIALS AND METHODS

An 8-year-old Valencia orange (*Citrus sinensis* (Linn.) Osbeck) orchard on sour orange (*C. aurantium* Linn.) rootstock was selected for this experiment. The soil type was a sandy clay loam and the orchard was located at Rio Farms, Monte Alto, Texas. Citrus has been grown on this location for the past 30 years. The design was a randomized block, with seven treatments replicated three times. Each treatment consisted of a row of 20 trees, spaced 12.5 feet apart with 25 feet between rows. Chemicals were applied May 14 and 15, 1968 and were as follows: 1-2 dibromo-3-chloropropane (Nemagon® EC-2, DBCP), *O,O*-diethyl *O,O* (methyl-sulfinyl)=phenyl phosphorothioate (Dasanit®, Bay 25141, ethyl 4-(methylthio)-m-tolyl isopropyl-phosphoromidate (Nemacur®, Bay 68138), and 2-methyl 1-2(methylthio)propionaldehyde-*O*(methyl carbamoyl)oxime (Temik®, aldicarb). All chemicals, with the exception of aldicarb, were liquid. They were applied in the irrigation water with a constant-flow gravity applicator. Aldicarb (10% granular) was broadcast on either side of the tree row with a fertilizer distributor and disked into the soil at a depth of 3 to 4 inches just before irrigation. Soil samples for nematode analysis were taken with a nursery spade. They consisted of 100 gm of soil and 3 gm of roots taken from a composite of four trees per replication. Samples were processed by the Baermann funnel technique. Average yield per 20 trees and average fruit weight and circumference of 20 fruit were recorded yearly from each plot.

RESULTS AND DISCUSSION

Citrus yields (Table 1) were taken in February or March of each year. Yields for 1969 were not taken because the orchard was treated after fruit set; sale of fruit is prohibited when nonregistered pesticides are used. All treatments gave significantly higher yields compared with those from the nontreated plots in 1970. Yields ranged from an increase of 35% with Bay 25141 (20 lb/A) to 70% with Bay 68138 (20 lb/A). Weight and size of fruit after all treatments were higher than those from the nontreated plots; however, these differences were not significant.

In 1971 four of the six materials showed significant increases in yield at the 10% level of probability. Yield after Bay 68138 (20 lb/A) was highest, with an 80% increase over yield of the nontreated citrus. Yields after Bay 25141 (10 lb/A), DBCP (5 gal/A), and aldicarb (20 lb/A) followed in that order. Size and weight of fruit were increased, but these increases were not significant. Bay 68138 (20 lb/A) and DBCP (5 gal/A) were the only treatments that showed significant (10% level of probability) increases in yield over that from the nontreated plots in 1972. These increases were much smaller (25 and 17%, respectively) than increases of the previous year, indicating that the treatment effectiveness was decreasing.

O'Bannon and Reynolds (4) have shown in Arizona that control of the citrus nematode with DBCP significantly increased yield for the next three crops. Baines et al. (1) in California demonstrated that the same chemical was effective in controlling the citrus nematode and increasing yields of both lemon and Valencia orange.

Nematode counts before and after treatment (Table 2) show the degree of control from the various chemicals. Bay 68138 (20 lb/A) and DBCP gave the most consistent control, lasting 2 years. Other treatment effects were much shorter. In other areas (4, 5) a greater initial nematode kill has been obtained with DBCP than was obtained in these studies in the Lower Valley.

Table 1. Influence of nematicides on yield, size and weight of Valencia oranges.

		1970			1971			1972		
Nematicide	*Rate*	*Plot Yield*[a]	*Size*[b]	*Weight*[c]	*Plot Yield*	*Size*	*Weight*	*Plot Yield*	*Size*	*Weight*
			cm	*g*		*cm*	*g*		*cm*	*g*
DBCP	5 gal/A	49.7*	22.4	183.4	45.8*	22.7	199.6	43.3*	24.3	198.6
Bay 25141	10 lb/A	45.0*	22.0	175.0	47.9*	21.7	178.5	39.6	24.6	202.5
Bay 25141	20 lb/A	42.6*	21.9	171.8	35.0	21.5	181.6	37.9	24.2	196.5
Bay 68138	20 lb/A	53.8*	22.1	172.5	52.1*	21.7	177.0	46.0*	24.4	200.5
Aldicarb	10 lb/A	44.0*	22.1	176.3	40.6*	21.4	167.4	41.5	24.8	210.0
Aldicarb	20 lb/A	46.6*	22.2	177.2	43.3*	21.7	181.8	40.4	23.8	186.0
Check		31.6	21.7	169.4	28.8	21.4	171.9	36.7	24.5	199.7
Level of significance†		0.05	N.S.	N.S.	0.10	N.S.	N.S.	0.10	N.S.	N.S.
Least significant difference		10.97			14.03			4.9		

[a] Avg. yield in boxes per treatment

[b] Avg. circumference of 20 fruit per treatment.

[c] Avg. weight of 20 fruit per treatment.

* Significant at the indicated level.

† N.S. = Not significant.

Table 2. Effect of nematicides on citrus nematode populations.

Nematicide	*Rate*	*Average number of nematodes/100 g soil + 3 root (3 reps.)*					
		7-16-68	*1-13-69*	*4-1-69*	*8-7-69*	*6-8-70*	*1-4-71*
Bay 68138	20 lb/A	833	1,013	4,012	867	2,721	21,467
Bay 25141	10 lb/A	7,566	2,300	10,160	1,567	1,254	4,967
Bay 25141	20 lb/A	2,333	6,616	9,643	2,683	2,065	10,733
DBCP	5 gal/A	1,033	766	2,200	233	901	5,513
Aldicarb	10 lb/A	4,800	4,033	5,860	4,212	2,753	6,600
Aldicarb	20 lb/A	1,466	3,100	5,068	2,167	1,164	16,533
Check		8,033	16,843	13,879	2,450	1,476	12,540

An explanation for the failure of these materials to give better control may be the relatively high clay content (19.7%) of the soil. Van Gundy et al. (7) found that a soil high in both clay and silt (17 and 40%, respectively) may absorb DBCP and thus reduce nematode control.

This test showed that an increase in Valencia orange yield can be obtained for up to three years with DBCP (a fumigant registered for use in citrus) and Bay 68138. The latter experimental chemical is not yet registered for use on citrus.

ACKNOWLEDGEMENT

Rio Farms' contribution to the field test by providing the necessary orange orchard, orchard care, and harvesting the fruit is gratefully acknowledged.

NOTES

Experimental quantities of Nemagon EC-2 (DBCP), Dasanit (Bay 25141), Nemacur (Bay 68138), and Temik (aldicarb) were supplied by Shell Chemical Co., Chemargro Corp., and Union Carbide Corp., respectively. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

This is a report on the current status of research involving use of certain chemicals that require registration under the Federal Insecticide, Fungicide, and Rodenticide Act. It does not contain recommendations for the use of such chemicals, nor does it imply that the uses discussed have been registered. All uses of these chemicals must be registered by the appropriate State and Federal agencies before they can be recommended.

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Management of Soil-Borne Diseases of Citrus in the Lower Rio Grande Valley

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ABSTRACT

The most important soil-borne disease of citrus in the Valley are foot rot and brown rot caused by *Phytophthora parasitica;* citrus nematode, *Tylenchulus semipenetrans,* and damping-off of seedlings, caused by *Rhizoctonia, Pythium,* and *Phytophthora spp.* The symptoms, casual organisms, means of spread and the effects of environment on these diseases are discussed. Changes in cultural practices, fumigation of seedbeds and nurseries, and sanitary measures are recommended as a means of controlling foot rot and damping-off. Foliar application of fungicides is recommended for brown rot control. Citrus nematode can be controlled by preplant or postplant application of nematicides.

Soil-borne diseases of citrus have been recognized in this area for a number of years. Foot rot has been known almost since the introduction of citrus into the Valley (9). Citrus nematode was first found in 1950 (7). In spite of the fact that most Valley soils are infested with citrus nematode (8, 18) and with foot rot fungus, control measures are seldom used. Citrus nematode affects the growth rate of young trees (19, 21) and the yield of mature trees (8). Losses and damage to nursery and orchard trees due to foot rot is at times severe.

This article is intended to review the situation with regard to soil-borne diseases of citrus in the Valley. The symptoms of these diseases and the organisms which cause the diseases are described. The measures which can be taken to eliminate or alleviate these problems and the benefits which can be expected from each type of control measure are discussed.

DAMPING-OFF

Damping-off of young citrus seedlings is caused by several different soil-borne fungi. *Rhizoctonia* is the most common, but *Pythium* and *Phytophthora* also cause damping-off (13). These fungi attack and rot the seeds, the roots emerging from the seed, and the stem at the soil line. The base of the stem becomes watery, turns dark brown, and the seedling collapses and dies. Where soil is heavily infested, losses of 80-90% of the seedlings may occur. As seedlings mature they become resistant to damping-off caused by *Rhizoctonia* and *Pythium* and are not generally affected after reaching the 4-5 leaf stage. *Phytophthora,* however, may cause tip blight and bark damage on older seedlings.

Damping-off fungi thrive under moist conditions. Overwatering, poor drainage, high humidity and dense planting tend to increase the

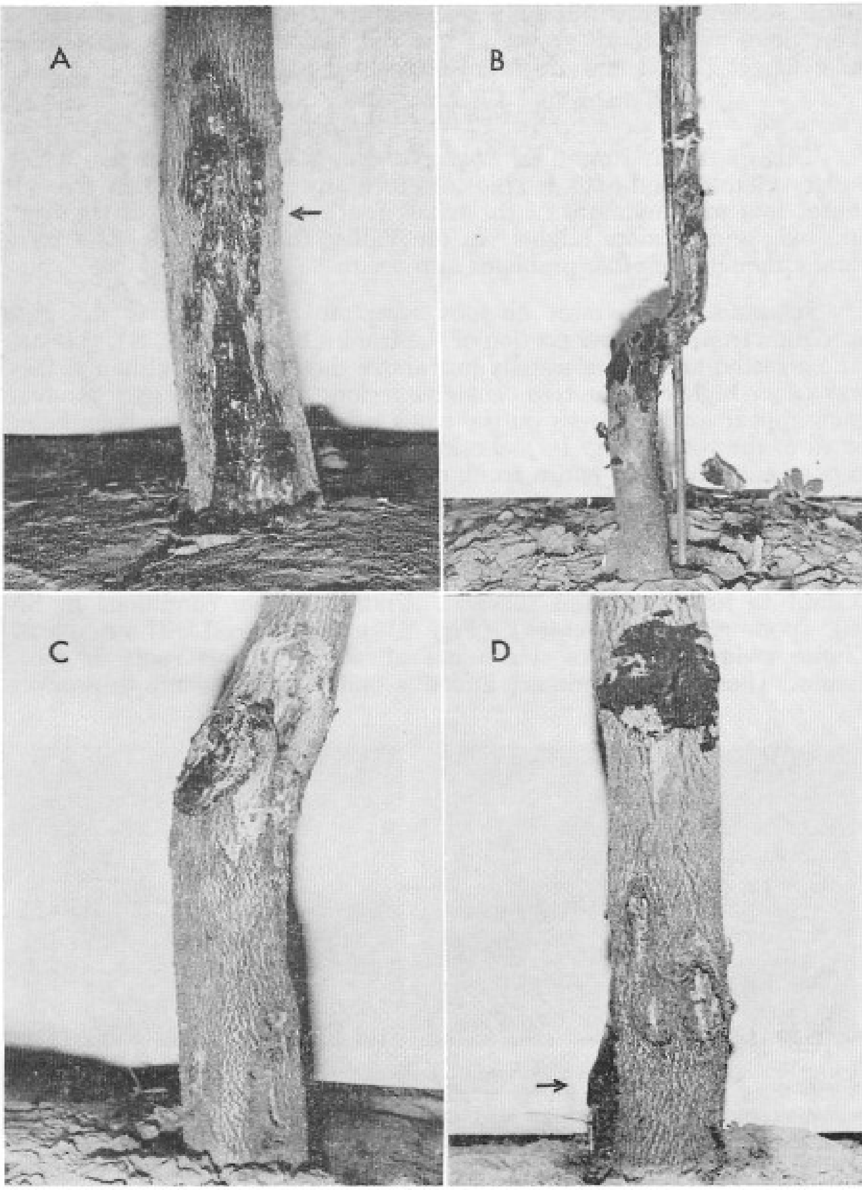

Figure 1. Foot rot symptoms. A) Gummosis of grapefruit, gum originates from above bud-union (arrow) B) Severe gumming above bud-union on young grapefruit tree C) Inactive foot rot lesion above the bud-union D) Foot rot lesions on sour orange rootstock; one active lesion at left (arrow); three healed lesions in center.

severity of the problem. Damping-off is more severe on alkaline soils. Citrus seedlings grown at high temperature are susceptible for only a short time, while those grown at low soil temperatures are susceptible for a longer period and are more severely damaged (13).

FOOT ROT

This disease is caused by *Phytophthora*, a soil-borne fungus, which under suitable conditions is able to attack any part of a citrus tree. It causes foot rot, gummosis of the trunk, root rot, brown rot of the fruit, and twig and blossom blights. In the Valley, foot rot is the most common, although the other problems also occur.

Symptoms. The most obvious symptom of foot rot is the gum exudation from the lower portion of the trunk (10) (Fig. 1A, B). Lesions (the affected areas) are usually just above the bud-union although they may occur higher in the tree. Inactive lesions, which no longer produce gum, appear as dead areas on the trunk where the bark has been killed down to the wood (Fig. 1C). Lesions may vary in size from small spots to ones encircling the entire trunk of the tree.

The fungus. Phytophthora is a member of the group of fungi known as water molds. It is a strict parasite which lives primarily on living plant tissues. This fungus produces several types of spores which are important to its spread and survival. Under suitable conditions in the soil, sporangia (spore cases) (Fig. 2) are produced. These release minute swimming spores which are attracted to host roots or other tissues. These are the primary infective units and germinate to produce

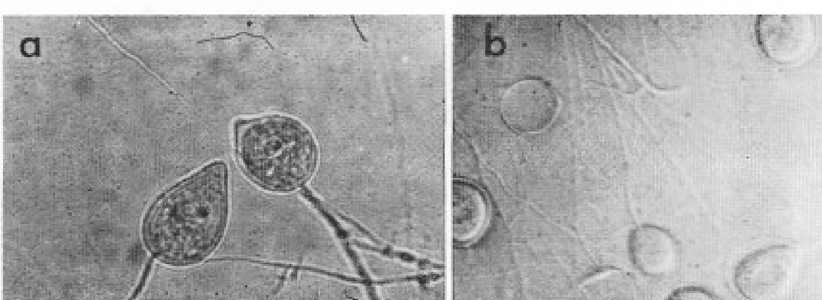

Figure 2. Sporangia of *Phytophthora.* a) Sporangia and mycelium (filaments) of *Phytophthora parasitica* b) Empty sporangium (upper left) after release of 30-40 swimming spores. Full sporangia and mycelium also apparent. Actual sporangial length about 1/625 inch.

the filamentous threads of the fungus (Fig. 2B), which penetrate and kill the host tissue as they grow. Other types of spores are produced under conditions less favorable for growth. These enable the fungus to survive periods in the absence of a host plant or during droughts. Of the several species of this fungus which attack citrus, *P. parasitica* apparently is the only one present in the Valley. In California and Florida, *P. citrophthora* is also present and causes more problems on the aerial parts of the tree, e.g. brown rot and twig blight (10, 25). *P. parasitica* is more strictly confined to the soil and lower parts of the tree. Efforts to prevent introduction of *P. citrophthora* into the Valley seem justified.

Spread. Phytophthora is probably present in most citrus soils in the Valley. The most common means of spread is on nursery stock grown in infested soil and then transplated to uninfested land. The fungus can be spread in almost any way in which soil is moved, i.e., on tractors, cultivators, and other farm implements; on shovels, hoes, and hand tools; on the feet of workmen or animals passing through a field and by run-off water from an infested field.

The effect of environment. Phytophthora is a water mold and must have free water to infect the host. Infection of the trunk can occur in as little as 5 hr (10). The longer the time of contact between free water, the fungus and the plant, the greater the chance of infection. Infection occurs most readily on recently wounded plants. The fungus may also enter through "natural wounds" or growth cracks in the bark (26, 27). The optimal temperature for growth of the fungus is 85-90 F (10). Heavy rains and warm temperatures which often occur in the early fall constitute optimal conditions for infection and disease development. Outbreaks of foot rot are common in the Valley at that time of year.

After infection, the fungus grows in the bark and kills tissue as it advances. Environmental conditions after infection while of less importance, do influence the rate of lesion expansion. Excessively warm or cold temperatures slow the rate of expansion. The fungus spreads more rapidly if moisture on the outside of the trunk is maintained either by the continued presence of water, or by a soil bank or tree wrap (26, 27).

Resistance. A citrus tree resists invasion of *Phytophthora* into healthy tissue by producing barriers to continued spread of the fungus. Most citrus species and relatives are infected by *Phytophthora*. However, different species vary considerably in their ability to rapidly establish barriers to restrict further spread of the fungus (10). Sour orange, which is resistant to foot rot, may become infected and produce some gum (Fig. 1D) but quickly and effectively walls off the infection and only a small lesion is produced (Fig. 3). Unless there are multiple infections on one tree, the growth of sour orange is not greatly affected and trees are seldom killed. Grapefruit, tangerines, and tangelos apparently have some resistance to *Phytophthora* and are able to slow the rate of expansion of lesions. Trees of these varieties, especially young ones, can be killed by foot rot. Fig. 3 illustrates the difference in the resistance of sour orange and grapefruit. Sweet oranges, lemons, and limes are highly susceptible to foot rot and while lesions will sometimes heal, trees of these varieties are commonly severely damaged or killed by foot rot.

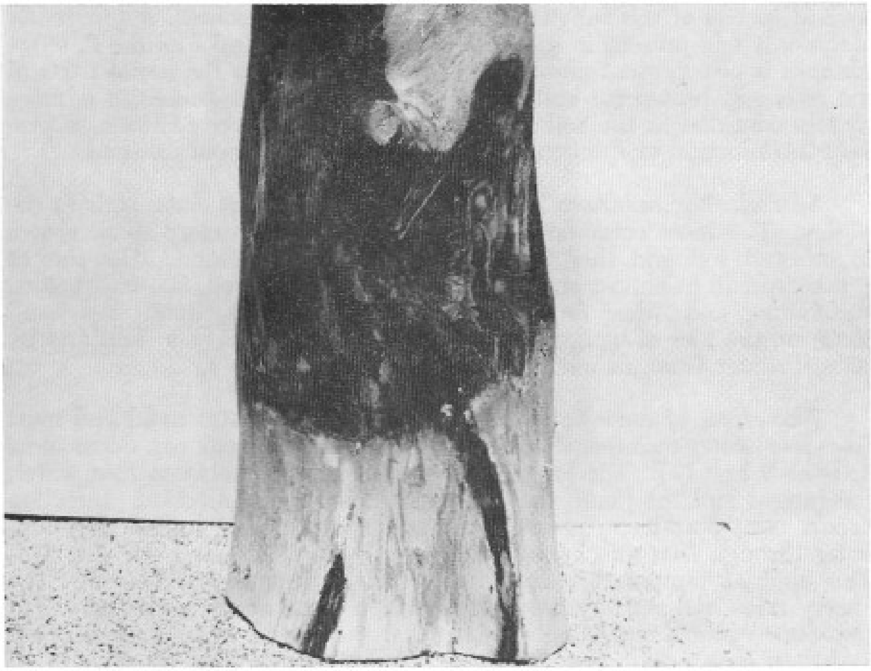

Figure 3. Trunk of a grapefruit tree on sour orange rootstock which was killed by foot rot. Removal of the bark revealed that the affected (dark) area was primarily above the bud-union. This illustrates the difference in resistance between the grapefruit scion and the sour orange rootstock.

CONTROL OF FOOT ROT

Water management. Since free water is essential for infection by *Phytophthora*, avoiding excess moisture is one means of controlling foot rot. Flood irrigation, which brings water into direct contact with the trunks, aggravates the foot rot problem. Water should not be allowed to stand above the bud-union for more than 6 hr. Any means which can be taken to reduce the time that water stands in an orchard will reduce the incidence of foot rot. Poorly drained areas should have tile drainage installed. Standing water after excessively heavy rains should be drained or pumped off as soon as possible. Whatever its other advantages or disadvantages, the use of drip irrigation, where water is applied slowly over long periods and where no borders confine rainfall, should reduce foot rot incidence.

Resistant varieties and cultural practices. Sour orange, almost the only rootstock used at present in the Valley, is quite resistant to *Phytophthora*. This resistance, however, is not used to proper advantage. In the nursery, trees are often budded 2-3 inches above the soil line. When transplanted to the orchard bud-unions are sometimes buried or placed close to ground level. The susceptible plant (grapefruit or orange) is then dangerously close to the source of infection (the soil). Sour seedlings in the nursery should be budded 6-8 inches above the soil line. When transplanted into the orchard, trees should be set so that the top of the ball protrudes slightly above the soil line.

Scaffold branches of nursery trees should be formed in such a way that the crotch of the tree does not hold water. If the main branches form a cup, infested soil, which is splashed into this area or carried there by ants, will remain moist and infection may follow.

Since wounds provide an important entry site for *Phytophthora* (26), it is important to avoid injury to the trees immediately before an irrigation. Hoeing and other operations which may cause injury to the tree are better carried out between irrigations. The use of chemical weed control may reduce foot rot incidence. Firstly, implement injury to trees is avoided. Secondly, cultivation often results in an accumulation of soil around trunks and bud-unions may eventually be buried. Thirdly, rank weed growth, which tends to maintain high humidity around the trees thus increasing chances of infection, is more easily avoided under chemical weed control.

Young trees are commonly banked or wrapped to protect them against freeze damage. Soil banks may place the fungus in contact with the susceptible plant and maintain moisture around the trunks. Soil banks should be avoided. Polyurethane tree wraps are better in that they do not place the fungus in contact with the tree. If the fungus is carried beneath the wrap by water or by ants, the wrapped tree provides an excellent environment for growth of *Phytophthora*. Trunks to be wrapped should first be painted or sprayed with a "banking compound" containing a copper fungicide and an insecticide to control ants. Trees should be wrapped under dry conditions. Any tree showing active gumming from foot rot infection should be left unwrapped. Young orchards should be checked periodically for foot rot damage. If damage has occurred the wraps should be removed during the summer and affected trees treated (see section on surgical treatment) or replaced.

Selection of nursery trees. Ideally, nursery stock to be planted should be completely free from *Phytophthora*. Unfortunately, such trees are not generally available in the Valley and often the presence of the fungus is not apparent. High quality nursery stock should have no evidence of foot rot attack on either the rootstock or the scion. In some years much of the nursery stock available may have some damage from foot rot. If the damage is confined to the sour rootstock (Fig. 1D), the lesions will usually heal and the tree should make normal growth. Trees with lesions above the bud-union (Fig. 1C) may recover from foot rot, but damage is often so severe as to reduce growth or make a weak tree. Trees with lesions above the bud-union should be rejected (Fig. 1B, C).

Surgical treatment. Established foot rot lesions can be treated surgically (10). The bark is first scraped lightly to outline the affceted area.

The bark in the dead area and in an area of live tissue ½ inch around the lesion is removed completely. The exposed lesion is then painted with a copper fungicide mixed with water to the consistency of paint. After 3-4 weeks callus should form around the edge of the treated area and the wood should be dry. The exposed wood is then covered with an asphalt pruning compound to prevent entry of wood-rotting fungi. Copper fungicides may temporarily increase gumming at the cut edges of the bark, but the lesion should heal with no further death of tissue. If lesions continue to expand, either all of the affected area was not removed or the area has been reinfected. Re-treat affected areas as previously.

Surgical treatment is time-consuming and expensive, but may be economical in certain situations. Since small lesions are more easily and effectively treated than large lesions, orchards should be inspected often for early detection of symptoms especially following rainy periods. Where ½ or more of the circumference of the trunk is affected, it is usually better to replace the tree, especially if it is young.

For other methods of control, see the section on soil fumigation.

BROWN ROT

Brown rot of the fruit is also caused by *Phytophthora*. Infection occurs when spores from the soil are splashed onto the fruit and the fruit remains wet for a sufficient period. The decay begins as a small, light brown area which spreads over the entire fruit. Affected fruit remain leathery and pliable and do not become mushy as with some other fruit rots. In humid weather, fruit become covered with the white fluffy mycelium of the fungus.

Brown rot usually occurs on highly susceptible varieties, e.g. oranges. Losses of grapefruit to brown rot are usually limited to an occasional fruit which is in direct contact with the soil. Even with oranges, serious losses are confined to orchards in which water stands for some time and in which a considerable portion of the fruit is borne near the ground.

CHEMICAL CONTROL OF BROWN ROT

Where brown rot of oranges has been a problem, it can be prevented by application of a fungicide just prior to fall rains. It need be applied only to the lower 4 ft of the tree skirts. The following fungicides effectively control brown rot: Tri Basic Copper Sulfate (1 lb/100 gal); Kocide 101 (½ lb/100 gal); COCS (1 lb/100 gal); Dithane M-45 (2 lb/100 gal); Captan 50W (2 lb/100 gal); and Zinc Coposil (2.8 lb/100 gal) (11). Other copper fungicides are probably effective for brown rot control and should be used at the manufacturer's recommended rate. All these fungicides may be applied as effectively with low volume spray equipment at rates equivalent to those used for dilute sprays (11).

CITRUS NEMATODE

Life cycle. Citrus nematode (*Tylenchulus semipenetrans*) is a small roundworm, about 1/60 inch long, which parasitizes the roots of citrus trees. Female larvae of the nematode partially penetrate feeder roots and derive their nourishment from them. After feeding for 3-5 weeks and going through several molts, the females reach adulthood. They appear, under proper magnification, as small, tear-shaped bodies attached

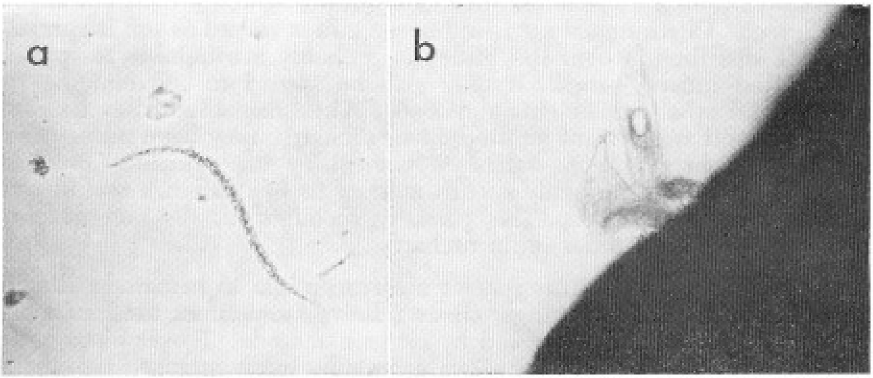

Figure 4. Citrus nematode. a) Second-stage larva. These larvae swim free in the soil. b) Two immature females feeding on a citrus root (dark area). They have penetrated the root but have not developed sufficiently to begin egg production. Actual size of larva and females about 1/60 - 1/80 inch.

to the roots (Fig. 4b). Adult females lay from 75-100 eggs which are extruded from the body in a gelatinous mass. Eggs hatch in about 2 weeks and the larvae emerge and seek out new roots (Fig. 4a). Males are produced but serve only for fertilization and do not parasitize roots. Eggs do not have to be fertilized to hatch.

Citrus nematode is an obligate parasite and cannot multiply in the absence of a host. Host plants include citrus, grapes, olives, persimmons and a few others (15). No known host plant, other than citrus, is commonly grown in the Valley. However, nematode eggs and larvae can survive for several years in soil in the absence of a host plant (15, 22).

Symptoms. Trees supporting high populations of citrus nematode have diminished vigor; small leaves; many dead twigs; small, erratic growth flushes; reduced fruit yields; and an unthrifty appearance. These symptoms are not diagnostic for citrus nematode and may be caused by other types of problems. High populations of citrus nematode reduce the efficiency of water uptake and the uptake of some nutrients, especially copper and zinc (24). Affected trees wilt more quickly than healthy trees and may show micronutrient deficiency symptoms. Heavily infested trees have "dirty" roots. Soil particles cling to the gelatinous egg masses and roots cannot be easily washed free of soil (15).

The effect of environment. The optimal temperature for reproduction of citrus nematode is 77-88 F. Reproduction is severely inhibited above 92 F (22). Soil temperatures in the Valley are in or near the optimal range much of the year. Nematode populations decline somewhat during the winter when temperatures are low. In the summer soil temperatures near the surface may become sufficiently high to inhibit reproduction, especially between the rows and in young plantings. Free water is essential for hatching of nematode eggs and movement of larvae.

Spread. Citrus nematode is soil-borne and is spread as soil is spread. Its wide distribution over the Valley is probably attributable to spread on infested nursery stock. It may also be spread in soil clinging to tractors and other implements and tools. While nematodes may be carried in run-off water from infested citrus orchards, they have never been recovered from irrigation water. Movement by the nematode itself is slight. A nematode probably spends most of its life within a few inches of where it was hatched. This partially accounts for the non-uniform distribution of nematodes in an orchard.

Resistance. Most citrus species are susceptible to nematode attack. Severinia and trifoliate orange, citrus relatives sometimes used as rootstocks, are only slightly attacked by citrus nematode. Troyer citrange is also resistant to some races of citrus nematode, but is attacked by others (15). In the Valley, sour orange and, to a minor extent, Cleopatra mandarin, are used as rootstocks. Both support high populations of citrus nematode although possibly not as high as some other rootstocks, e.g. sweet orange and sweet lime (6).

CONTROL OF CITRUS NEMATODE

Economic infestations in established orchards. Although nematodes are present in almost all Valley orchards, control measures are not always warranted. Tree condition, yield, nematode populations and soil texture must be considered in deciding whether or not to treat for nematodes. Orchards receiving proper irrigation, fertilization and insect control, but having only moderate yields, will probably benefit most from nematode control. Orchards which are declining because of trunk diseases or improper care will probably not benefit greatly by nematode control.

Soil samples should be taken to determine nematode populations. Texas A&M University at College Station makes nematode counts for a minimal charge, and several commercial firms make them free of charge. Take soil samples several inches deep, under the drip-line of the tree and at a time when the soil is reasonably moist. Include some feeder roots in each sample. Put soil from three or more sites in a plastic bag and keep soil moist and cool until it can be examined. Take samples from several locations within an orchard. For comparative purposes choose areas where trees are doing poorly and areas where trees are doing well.

Nematode populations vary tremendously with location and time. Accurate assessment of nematode populations requires many samples, preferably taken at different times of the year. Taking a large number of samples in an orchard is not usually feasible. However, nematode populations in treated and untreated orchards should be checked periodically. It is difficult to determine at what nematode count control measures should be instituted. The number of nematode larvae per 100 g of soil (about ½ cup) may vary from near 0 to 50,000. Orchards with severe root damage due to extensive nematode feeding in the past often support low populations. Healthy-looking orchards which have not yet had extensive root damage may support high nematode populations (16). In untreated, mature orchards at the Texas A&I Citrus Center, counts of nematode larvae/100 g of soil usually range from 5,000 to 15,000. Soil from orchards less than 3 years old usually have less than 2,000 larvae per 100 g of soil. Counts are often highest in orchards which have recently come into production. Nematode numbers per inch of root can also be used as a guide to the degree of infestation: less than 3 females/inch = trace; 3-6 = slight; 6-15 = moderate; more than 15 = severe (5).

Postplant fumigation. The only product registered for control of citrus nematodes in established orchards is DBCP (1,2-dibromo-3-chloropropane). It is usually applied by metering it into the irrigation water. Two-5 gal of actual DBCP (35-85 lb) are applied per acre, depending on the soil type. Most commercial formulations contain about 12 lb of DBCP/gal, although some contain less. Trade names for DBCP include Nemagon, Fumazone, Oxy BBC and others. DBCP is phytotoxic at rates only slightly higher than those recommended. Where water distribution is uneven, high rates may be applied in some areas resulting in phytotoxicity while in other areas rates may be too low to control the nematodes. Consequently, when applying DBCP in irrigation water, the time required to water each pan should be predetermined so that the chemical can be accurately metered into the water. On extremely unlevel land, DBCP may be chisel-injected 2-3 inches deep and watered in immediately rather than metering it into the irrigation water. When chisel-injected, the rate of DBCP should be calculated on the basis of the area actually treated.

Although DBCP may be applied any time of year, periods of moderate temperatures and winds are best. Extremely warm, windy days result in considerable loss of the material to the air. Low soil temperatures result in poor diffusion of the chemical in the soil and poor depth of penetration. DBCP can be applied only once every 3 years; the time of application should be carefully chosen.

The dosage of DBCP depends on soil type. Rates of less than 40 lb/acre, while adequate for sandy soils, are probably inadequate for most Valley soils. Most Valley sandy loam soils probably require 40-60 lb/acre. The higher the percentage of clay in the soil, the more DBCP is needed. In California, DBCP treatment of soils containing more than 20% clay is not recommended (4, 15). Penetration of DBCP in soils with 20-26% clay is poor and control of nematodes is usually unsatisfactory (17,23). High organic matter content in soils also interferes with nematode control by DBCP (17). While sandy soil can be treated more effectively, treatment of some heavier soils of good tilth and low organic matter content may give adequate control. Nematode control on clay or clay loam soils, however, is likely to be poor with little or no benefit derived. Experimental nematicides being tested may prove to be more effective than DBCP for control of nematodes on heavier soils.

Experience in treating mature orchards with nematicides in the Valley is limited. Heald (8) found that treatment increased yields of Valencia oranges from 35-70% above untreated controls. In California, yield increases of 10-93% have been obtained, depending on the severity of the infestation (15). In general, yield increases of 15-25% have been common after nematicide treatment. No effect on yield should be expected until the harvest after the year of treatment. Yield increases are the result of increased fruit size and increased fruit set. Generally, the yield increase is moderate the first season after treatment, greatest the second season after, and moderate again in the third season as the population begins to build up. Most orchards need to be re-treated every 3-4 years.

Preplant fumigation. The materials, rates and methods of application of several preplant nematicides are listed in Table 1. Preplant fumigation will markedly reduce nematode populations and can be used before an old citrus orchard is replanted. In California, preplant fumigation

Table 1. Fumigants, application methods, and rates used for preplant nematode control. (For other soil fumigants, see Table 2) (4).

Fumigant	*Rate (gal/acre)* *Sandy loam*	*Heavier soils*	*Months before planting*	*Method of application*
D-D, Vidden D	70	120	4-8	Chisel-injected 12-14 inches
Telone	56	96	3-4	Chisel-injected 12-14 inches
EDB	5	8	4-8	Chisel-injected 12-14 inches

increased yields by 40% over untreated controls for the first 8 years after planting (15). These tests were conducted using nursery stock which was free of citrus nematode. If nursery stock is already infested with citrus nematode, as much of the nursery stock in the Valley is, it is doubtful whether any benefit would be gained by fumigation prior to planting.

A PROGRAM OF SOIL FUMIGATION AND SANITATION FOR CONTROL OF DAMPING-OFF, FOOT ROT, AND CITRUS NEMATODE IN SEEDBEDS AND NURSERIES

Treatment of seed and seedlings. The first step in growing disease-free nursery stock is to begin with seed free of *Phytophthora.* The seed will be free of the fungus if it comes from fruit borne well above ground level and kept free of soil at all times. For assurance of freedom from *Phytophthora*, seed can be treated in water at 125 F for 10 min, then immersed in cold clean water. Roots of seedlings infected with *Phytophthora citrophthora* can be treated with hot water (110 F, 10 min) to eliminate the fungus. However, it is uncertain whether *P. parasitica* can be eliminated from seedlings in this manner since it produces thick-walled, resistant spores (10). For citrus nematode control, 118 F for 10 min is necessary. This treatment is not recommended since it is close to the temperature at which seedlings may be damaged (10).

Fumigants. Seedbeds and nurseries planted on old citrus soil should be fumigated prior to planting. Fumigation will eliminate damping-off fungi, kill weeds, and provide seedlings free of nematodes and *Phytophthora.* Soils should be fumigated unless they have not been planted to citrus in several years and are well separated from existing orchards.

Fumigants, the methods and rates of application, and times prior to planting are listed in Table 2. Of these materials, methyl bromide has probably been used most widely with the most consistant success. Methyl bromide penetrates clumps of soil and plant debris better than most other fumigants. It is highly effective against weed seeds and disappears rapidly from soil (14). However, it must be tarped immediately after application thus increasing application costs. It is extremely toxic to mammals. Stunting of seedlings grown in methyl bromide-fumigated soils has occurred in some cases in the Valley (20). Before using methyl bromide on large areas, it should be tested on small plots to be sure that stunting does not occur on the soil to be planted. D-D, Vidden D, and Telone are excellent nematicides but high rates are needed to control *Phytophthora.* Long waiting periods before planting are required with these materials. Vapam applied in 6 or more inches of water gives excellent control of both *Phytophthora* and citrus nematode (3). It requires the least amount of equipment for application and disappears from the soil in a short time. Vapam is a water-soluble liquid and penetrates soils as deeply as the water in which it is applied. All of these materials give

Table 2. Preplant fumigants for control of *Phytophthora*, citrus nematodes, damping-off and weeds with application methods and rates, and time prior to planting (12).

Fumigant	*Rate/acre* Sandy loam	*Rate/acre* Heavier soils	*Method of application*	*Months before planting*
Methyl bromide	200 lb	400 lb	Inject 7-8 inches Tarp immediately	1
D-D, Vidden D	150 gal	260 gal	Inject 12-14 inches	6-12
Telone	120 gal	210 gal	Inject 12-14 inches	6-12
Vapam	100 gal	100 gal	In irrigation water	1-1½

fair to excellent weed control, but have no residual action to keep weeds from reinfesting the area after planting. Soils to be fumigated should have a high moisture content, be well tilled, and relatively free of plant debris or large clumps of soil. Fumigation is best carried out when soil and air temperatures and winds are moderate.

Sanitation. In order to maintain nurseries free of diseases, soils, whether fumigated or virgin, must be protected against infestation (1). Large tilage equipment can be disinfested by thorough steam cleaning. Hand tools, stakes, etc. can be disinfested by dipping in a 1:10 dilution of household bleach in water and then rinsing with water. Ties, wraps, and other materials used in the nursery areas should be clean and free of soil. Preferably, the nursery area should be fenced to prevent unauthorized personnel and animals from carrying in infested soil on their feet. Footware should be changed or at least be free of soil when entering the nursery. As an added precaution pans of copper fungicide powder may be placed at the entrance. All personnel entering the nursery should step in the pans to help prevent introduction of *Phytophthora*. The number of people working in the nursery should be limited and all should be thoroughly informed of the proper precautions.

Fumigation of orchard soils. Fumigation of the entire area to be planted is not feasible because of the high cost. If disease-free trees are available, 8-ft diameter sites where the trees are to be planted may be fumigated. This may be done for new orchards planted on old orchard sites, for replacements, or for intersets. To fumigate, construct an 8-ft diameter ring, add 1 pint of Vapam per 200 gal of water in a tank truck, and apply 200 gal of the solution to each ring. When balled and burlaped trees are moved from the nursery, the burlap should be dusted with a copper fugicide to prevent contamination during transport and planting.

Benefits. Fumigation of seedbed and nursery soils and the accompanying sanitary measures are costly. Fumigant alone varies from $250 to $500 an acre depending on the material selected, soil type, etc. The benefits of treatment are many and should outweigh the costs. The first and most easily observed advantage is weed control. Most herbicides are not recommended for seedbeds and nurseries, and all control must be done manually. Fumigation thus gives some immediate return in reduced labor costs. Secondly, citrus nematode populations are reduced which should increase the growth rate and vigor of the seedlings. Thirdly, losses to foot rot are eliminated. Losses presently are sporadic, but when heavy rainfall occurs, they can be severe. Lastly, the nurseryman provides to his customer high quality nursery stock. This is especially important to a grower planting on new soil, one who fumigates planting sites, or one applying a preplant nematicide. Overall this program should not increase the cost of production more than 10 cents per nursery tree. In California, Arizona, and Florida, nursery trees grown under this type of program are certified and specially marked and bring a higher price on the market (2). Such a program in Texas would assure the nurseryman producing trees free of these pests recognition for the superior quality of his trees and provide the grower a source of pest-free trees.

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VEGETABLE SECTION

Enzymatic Solubilization of Nitrogenous Material From Carrot Roots and Tops

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ABSTRACT

Extracts from leafy material show potential to help solve world shortages of protein. By utilizing enzymatic processing techniques, nitrogenous material from carrot roots and tops was increased approximately 20% above values obtained using a conventional non-enzymatic process. Enzymatic processing shows potential as a means to help convert vast quantities of crop residues into nutritious protein food.

INTRODUCTION

Over a third of the world population is underfed (6). With a projected two-fold increase in world population in the next 30 years, scientists must expand food sources to meet the needs of humanity (4). One future source of food that has excellent potential to avert world famine is plant protein (7). Protein from leafy material is high in nutritional value, simple to extract in bulk, and can be obtained from crop residues or native plants (2, 7). Extensive work with composition of leafy material has been conducted at the U.S.D.A. Laboratories at Albany, California (5).

Conventional extraction of leaf protein entails the grinding of fresh leaves so as to liberate most of the protein from the cells and obtain liquid and fibrous fractions. The liquid portion which contains the proteins in the soluble form is separated from the fibrous material by filtration. Then the liquid fraction is heated to around 80°C to induce precipitation of the protein. After precipitation has taken place, the liquid is drained off, leaving a precipitate containing from 50-60% protein plus fats and starch.

Leaf protein produced in this manner contains a mixture of many individual proteins. Thus, the amino acid composition of the bulk prepration appears to be very well balanced. Studies by Duckworth and Woodham (3) have shown leaf protein concentrates from vegetables to have the same biological value for chicks as barley or rye. Using rats, the same workers reported protein efficiency ratio (PER) values of 2.61 as compared to 2.70 for skim milk. Pirie (8) found some leaf protein to be nutritionally better than seed proteins and as good as animal proteins with the exception of egg and milk proteins.

Experimental

Considering the above process, this study was conducted to evaluate the capability of enzymes to improve the recovery of nitrogenous material above the level obtainable using a non-enzymatic process.

MATERIALS AND METHODS

The top and root portions of carrots (*Daucus carota* L., var. Imperator 58) were selected as raw material for this study. A.O.A.C. (1) procedures were utilized. A-12-C, an enzyme derived from *Trametes sanguina*; and ficin, an enzyme obtained from fig latex (*Ficus carica*), were investigated for capability of improving the recovery of nitrogenous compounds from raw material. A-12-C enzyme was obtained from Miles Laboratories, Inc.

Enzyme concentration, pH, incubation time, and incubation temperatures were investigated to determine the influence of each upon the amount of nitrogenous material solubilized.

The carrot material was prepared by placing one hundred grams of fresh carrot roots or tops in a Waring blender. It was blended at high speed using a 3:1 ratio (W/V) of substrate to distilled water. To inactivate native enzymes, the slurry was heated from 85 to 95°C. and maintained for 20 minutes. The slurry was al'owed to cool and adjustment of pH was accomplished by addition of 1.0 N HC1. The desired concentration of enzyme was added to the mixture and thoroughly mixed by mild agitation. At this point, the mixture was placed in a water bath and incubated at various temperatures. After incubation, each sample was vacuum filtered through Whatman #1 filter paper. The residue was washed twice using 150 cc portions of distilled water. The residue was dried overnight in a forced draft oven at 80°C. Total nitrogen determinations were colculated on 200-300 mg aliquots of residue. The constant 6.25 was employed to calculate the percent protein. Nitrogen determinations were also run on the residues of the hydrolyzed material. Nitrogen content of the residue was subtracted from the nitrogen content of the original sample to obtain the amount of nitrogen solubilized by the enzymes. This procedure obviated the necessity of subtracting the nitrogen content of the enzyme from the filtrate.

RESULTS AND DISCUSSION

The results pertaining to the influence of enzyme, enzyme concentration, pH, incubation time, and incubation temperature on the amount of nitrogen solubilized are presented graphically in figures 1-8. The amount of nitrogen solubilized was directly related to amount of enzyme added for carrot roots; while little or no increase was observed for carrot tops past the 0.1% level. Enzyme source and type of protein can cause variations in the effect of pH upon enzyme activity (9). In this case pH 3.5 was optimum with carrot tops and pH 4.5 with carrot roots. In determining the effect of incubation time on the amount of nitrogen solubilized, progressive increases were observed over a 20 hour period. The optimum temperature for enzymatic solubilization of nitrogenous constituents of carrots was found to be 55°C. for carrot roots and 45°C for carrot tops.

In summary, it was demonstrated that enzymes can improve the solubilization of nitrogenous constituents of roots or leaves of carrots.

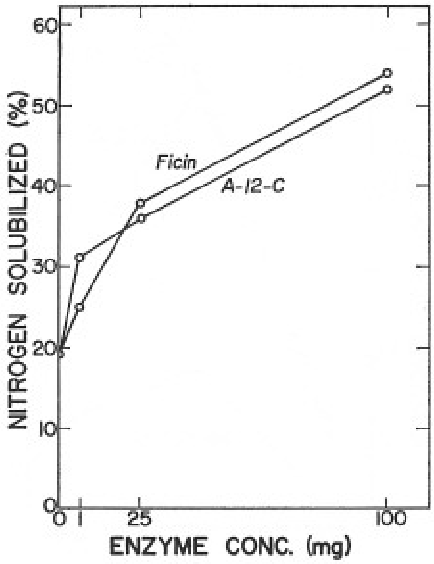

Figure 1. Effect of enzyme concentration upon nitrogen solubilized in carrot roots (10g dry weight). Conditions of assay: pH = 3.5, incubation time = 20 hr, incubation temperature = 45°C.

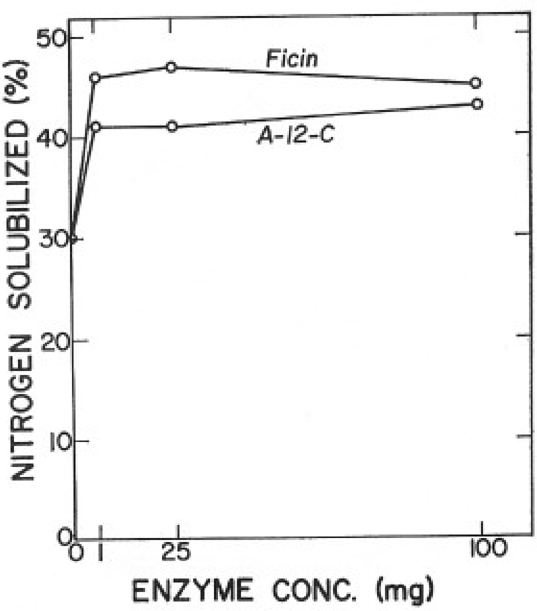

Figure 2. Effect of enzyme concentration upon nitrogen solubilized in carrot tops (10g dry weight). Conditions of assay: pH = 3.5, incubation time = 20 hr, incubation temperature = 45°C.

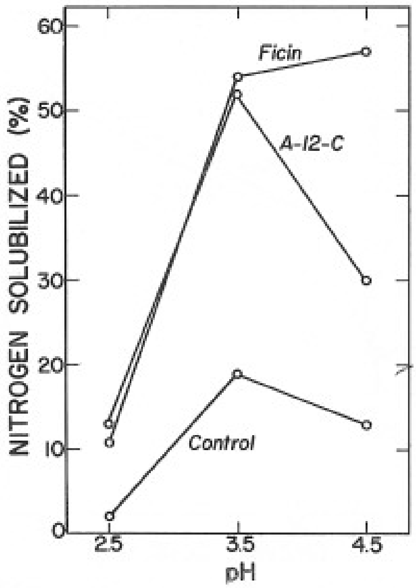

Figure 3. Effect of pH upon nitrogen solubilized in carrot roots (10g dry weight). Conditions of assay: enzyme concentration = 1.0%, incubation time = 20 hr, incubation temperature = 45°C.

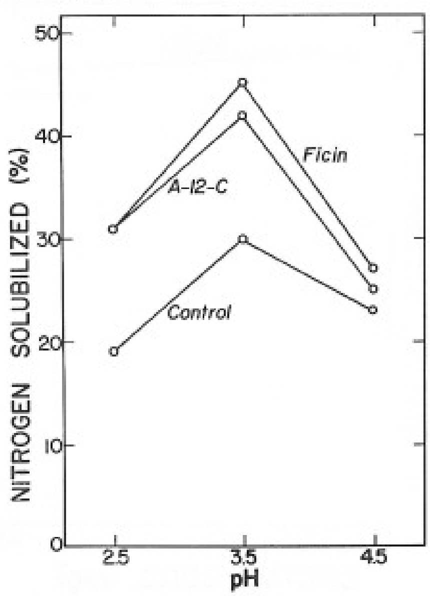

Figure 4. Effect of pH upon nitrogen solubilized in carrot tops (10g dry weight). Conditions of assay: enzyme concentration = 1.0%, incubation time = 20 hr, incubation temperature = 45°C.

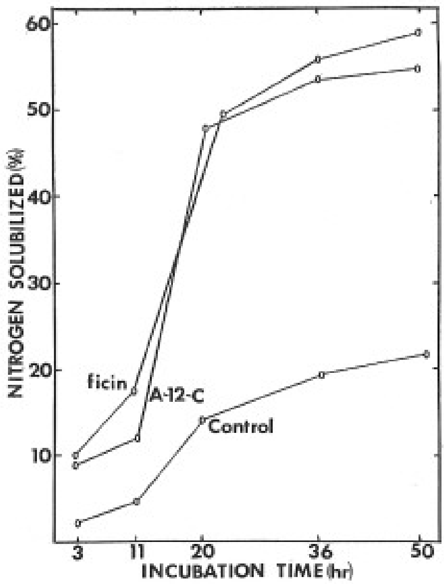

Figure 5. Effect of incubation time upon nitrogen solubilized on carrot roots (10g dry weight). Conditions of assay: enzyme concentration = 1.0%, pH = 3.5, incubation temperature = 45°C.

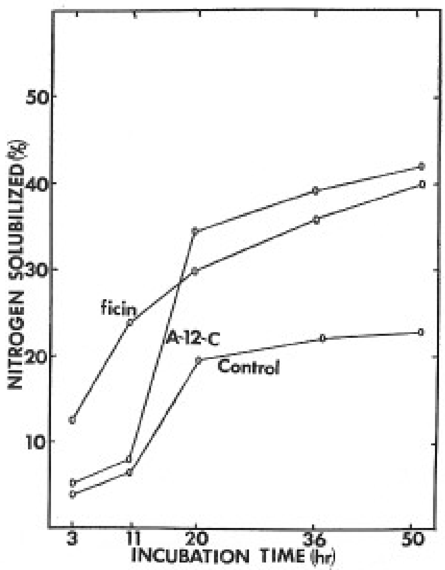

Figure 6. Effect of incubation time upon nitrogen solubilized in carrot tops (10g dry weight). Conditions of assay: enzyme concentration = 1.0%, pH = 3.5, incubation temperature = 45°C.

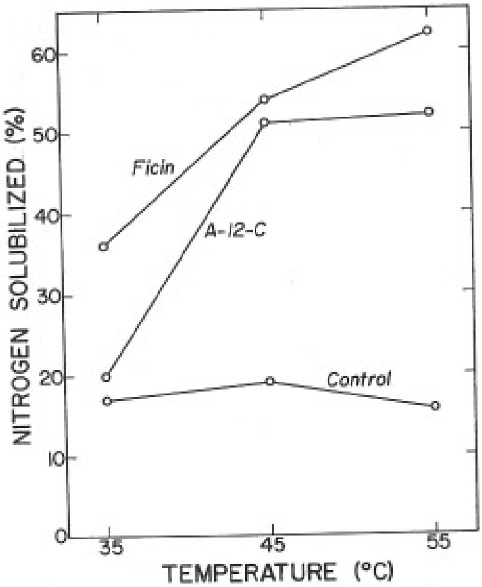

Figure 7. Effect of incubation temperature upon nitrogen solubilized in carrot roots (10g dry weight). Conditions of assay: enzyme concentration = 1.0%, pH = 3.5, incubation time = 20 hr.

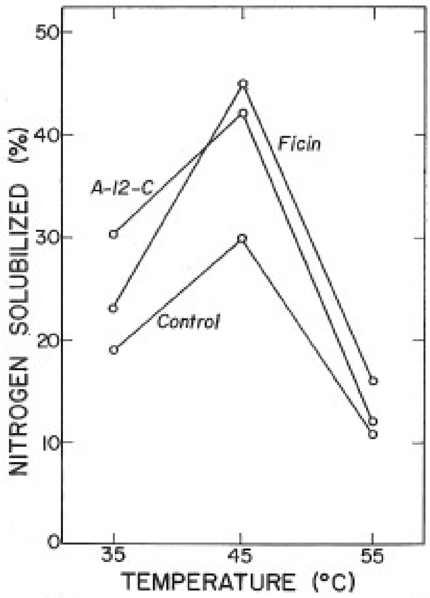

Figure 8. Effect of incubation temperature upon nitrogen solubilized in carrot tops (10g dry weight). Conditions of assay: enzyme concentration = 1.0%, pH = 3.5, incubation time = 20 hr.

CONCLUSION

Protein deficiency is the most serious aspect of the world food problem. New sources of protein need to be investigated and utilized. Protein from leafy crops has potential as a human and animal food source in terms of quality and quantity. Enzymatic processing could be utilized in conjunction with present extraction methods to improve the yield of protein from leafy material.

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Influence of Nitrogen and Phosphorus on Yield and Chemical Composition of Broccoli

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ABSTRACT

Experiments were conducted during a two year period to determine the influence of nitrogen and phosphorus fertilizers on yield and chemical composition of broccoli grown on sandy loam soils. There was a linear response to N up to 150 lbs per acre during both years of the experiment. Broccoli yield was slightly increased with P application when high N rates were applied during one year of the experiment. Nitrogen and P concentrations in the plants were increased with N and P applications but concentrations of Ca, Mg, K, Zn, Mn and Fe were generally unaffected by P and N application.

INTRODUCTION

Broccoli is grown for fresh market and processing in the Rio Grande Valley of Texas. Broccoli acreage has remained relatively constant for the past 10 years, varying from a low of 1300 acres to a high of 3100 acres (2). Per acre yields have also remained relatively constant since 1961.

Broccoli is known to require large amounts of certain plant nutrients, particularly nitrogen. Few experiments concerning nutritional requirements of broccoli have been conducted in the Lower Rio Grande Valley of Texas and information concerning fertilizer requirements of the crop must be obtained from other locations.

Field experiments were conducted in 1970 and 1971 at the Texas A&M University Agricultural Research and Extension Center at Weslaco to obtain information concerning the nitrogen and phosphorus requirements of broccoli grown on sandy loam soils typical of the Lower Rio Grande Valley of Texas.

MATERIALS AND METHODS

The experiments were conducted in 1970 and 1971 on Willacy fine sandy loam soil. The area used in 1970 was previously in citrus and the area used in 1971 was previously in cotton. Additional description of the sites is given in Table 1.

Table. 1. Some properties of the soils used. (Willacy fine sandy loam).

Year	*Lbs NO_3-N in 0-4 ft. soil profile*	*P*[1]	*N*[2]	*pH*
1970	98	17	0.04	7.3
1971	86	13	0.07	7.4

[1] Parts per million P extracted with $NaHCO_3$ at pH 8.5 (0-8 in. depth).

[2] % total nitrogen in the 0-8 inch depth.

Nitrogen treatments (as indicated in Tables 2 and 3) were broadcast over the 6 row x 45 ft long plots then immediately mixed in the soil with a rolling cultivator. Phosphorus was applied at planting to 3 rows of each plot as a band 2 inches below the seed. Phosphorus rates were 0 and 70 lbs P per acre in 1970 and 0 and 44 lbs P per acre in 1971. Broccoli was planted 2 rows per 40 inch bed with the P split equally under each row. The varieties used were Topper 43 in 1970 and Waltham 29 in 1971. Plant populations were approximately 45,000 plants per acre in 1970 and 55,000 plants per acre in 1971. The plots were irrigated 4 times in 1970 and 3 times in 1971. Three insecticide applications were made in 1970 and 2 applications were made in 1971.

Plant samples were taken for laboratory analyses 28 days after emergence in 1970 and 55 days after emergence in 1971. Whole plants were sampled in 1970 but the plant samples in 1971 consisted of the 4th leaf from the growing terminal. Approximately 20 plants were sampled from each plot. The plant samples were rinsed in distilled water, dried at 70°C and dry ashed as described by Chapman and Pratt (1). Cations were determined by atomic absorption, P by the molybdenum blue method and N by Coleman nitrogen analyzer. (Trade names do not imply endorsement by Texas A&M University.)

Harvest was initiated when the first plots were ready then all plots were harvested every 6 days for 6 harvests in 1970 and 5 harvests in 1971.

RESULTS AND DISCUSSION

A nitrogen response was evident about 15 days after emergence in both years as indicated by pale and stunted plants in the check plots and dark green, vigorous plants in the N treated plots. A visual N response remained obvious throughout the remainder of both seasons.

Table 2. Influence of N and P on composition of whole broccoli plants (28 days after emergence) 1970.

Lbs N/ac Applied	*Lbs P/ac Applied*	%[1] *N*	% *P*	% *Ca*	% *Mg*	% *K*	*PPM Zn*	*PPM Mn*	*PPM Fe*
0	0	4.86	0.47	3.95	0.49	2.78	33	63	237
0	70	3.95	0.50	3.96	0.50	2.88	32	64	217
50	0	4.91	0.40	3.65	0.47	3.30	36	53	192
50	70	4.69	0.49	3.68	0.48	3.18	28	63	197
100	0	5.47	0.42	3.64	0.47	3.37	34	69	258
100	70	5.78	0.50	3.61	0.46	2.85	31	84	225
150	0	6.18	0.42	3.63	0.46	3.15	28	74	227
150	70	5.29	0.52	3.34	0.47	3.60	28	72	168
50 + 50[2]	0	5.81	0.39	3.90	0.47	2.87	34	62	217
50 + 50	70	5.32	0.49	3.62	0.47	3.33	31	62	273

[1] Based on 70C drying weight

[2] 50 preplant + 50 sidedress

There was an increase in concentration of N in whole plants that received N in 1970 (Table 2). The magnitude of N concentrations in small plants is an indication of the high N requirement of broccoli. Although the exact critical N concentration could not be determined from this experiment, it is evident that one month old broccoli plants must contain about 6% N for good growth and yield. Phosphorus concentration in the whole plant in 1970 was slightly increased by P application but yields were not increased by P application. This would indicate that P concentrations of about 0.45% in the whole plant were adequate for the yield levels obtained in 1970. Application of N or P did not consistently influence the concentration of calcium, magnesium, potassium, zinc, manganese or iron in the plants.

Table 3. Influence of N and P on composition of broccoli leaves. (4th leaf from terminal) 1971.

Lbs N/ac Applied	*Lbs P/ac Applied*	*% N*	*% P*	*% Ca*	*% Mg*	*% K*	*PPM Zn*	*PPM Mn*	*PPM Fe*
0	0	5.10	0.54	2.95	0.33	2.70	38	84	128
0	44	5.28	0.60	2.84	0.33	2.75	33	72	115
50	0	6.05	0.57	2.79	0.34	2.61	38	82	131
50	44	6.06	0.61	2.75	0.33	2.66	35	86	121
100	0	6.58	0.61	2.33	0.30	2.80	44	69	119
100	44	6.36	0.64	2.33	0.31	2.71	38	68	122
150	0	6.61	0.55	2.68	0.31	2.66	39	77	120
150	44	6.53	0.65	2.24	0.30	2.84	36	74	111
200	0	6.74	0.61	2.25	0.30	2.80	44	74	121
200	44	6.87	0.63	2.69	0.32	2.79	37	86	119
100[1]	0	6.47	0.59	2.39	0.30	2.74	42	74	134
100[1]	44	6.30	0.63	2.66	0.32	2.75	36	78	131

[1] Applied as urea (all other N treatments were ammonium nitrate)

Plant analysis data from the 1971 experiment (Table 3) indicated that N concentrations in leaves (4th from terminal) were increased with N fertilizer applications. Leaf nitrogen concentrations above 6.5% at the stage of growth sampled appeared to be consistent with high yields. Application of P slightly increased P concentrations in the leaves and it appears that P concentrations in the leaves sampled must be above 0.6% for high yields. Zinc and iron concentrations in the leaves were slightly reduced with P application but other elements included in the analysis were not consistently affected by treatment. Concentrations of elements in the plant cannot be compared directly since different parts of the plants at different stages of growth were sampled each year.

Table 4. Influence of nitrogen and phosphorus on yield of broccoli. 1970..

N applied per acre	Pounds of broccoli per acre	
	No P	*With P*[1]
0	1256	965
50	2713	3457
100	4327	3909
150	5483	5475
50 + 50[2]	4202	4237
L.S.D. (5%)	564	862

[1] P applied at rate of 70 lbs P per acre.

[2] 50 lbs applied preplant and 50 lbs applied 35 days after emergence

There was an increase in yield with each N increment applied in 1970 (Table 4) consequently, highest yields were obtained with the 150 lb per acre N rate. It is not evident from these data whether the 150 lb rate was adequate since a substantial yield increase was obtained over the 100 lb rate. The 50 lbs preplant plus 50 lbs sidedress N treatment resulted in approximately the same yield as the 100 lb. application preplant. A response to applied P was not obtained in 1970. The level of soil P was apparently high enough to support the yields obtained.

Table 5. Influence of nitrogen and phosphorus on yield of broccoli. 1971.

N applied per acre	Pounds of broccoli per acre	
	No P	*With P*[1]
0	6207	6062
50	7792	8028
100	8515	8513
150	9755	9919
200	9986	10316
100 as urea	8327	8746
L.S.D. (5%)	773	1298

[1] P applied at rate of 44 lbs P per acre.

Yields in 1971 (Table 5) were much higher than those in 1970 regardless of treatment, however, there was a significant response to applied N with rates up to 150 lbs per acre. The 200 lb rate did not significantly increase yields over the 150 lb N rate. Application of urea as a source of N resulted in yields equivalent to those of ammonium nitrate. It should be noted, however, that the urea was mixed with soil immediately after application. Significant volatile losses of N would be expected from urea if it had been allowed to remain on the soil surface without mixing. Volatile losses of N from ammonium nitrate are generally quite low (3).

In 1971 a slight response to P application was obtained at all N rates except one. This would suggest that the P level of this soil was not quite high enough for the yields attained with the N treatments applied.

Results from these experiments indicate that broccoli has a very high nitrogen requirement and yield response up to rates of 150 lbs per acre should be expected on sandy loam soils containing less than 100 lbs NO_3-N in the 0 to 4 ft profile. Response to P may be obtained on sandy loam soil if soil P levels are below 13 PPM and high N rates are applied.

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Photographic Previsual Detection of Watermelon Mosaic Virus in Cucumber

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ABSTRACT

Watermelon mosaic virus-2 (WMV-2) was previsually detected on cucumber leaves (*Cucumis sativis* L.) 5 days after cotyledonary swabbing by taking daily photographs with Kodak Aerochrome Infrared 2443 film—symptoms were photographically detected 2 days earlier than visual detection on leaves whose cotyledons were swabbed with abrasive and WMV-2 inoculum. Photographic transparencies revealed that virus-infected leaves had areas of darker red color saturation than uninfected leaves. Previsual detection of WMV-2 should be tested in the field for early diagnosis to prevent extensive crop loss, and for roguing of diseased plants in breeding and seed increase programs.

INTRODUCTION

This paper presents results of research that was conducted to ascertain if watermelon mosaic virus-1 (WMV-1) and watermelon mosaic virus-2 (WMV-2) could be previsually detected by photographing cucumber plants with Kodak Aerochrome Infrared 2443 (AIR) film. (Use of a company or product name by the Department does not imply approval or recommendation of the product to the exclusion of others that may also be suitable.) However, previsual detection of plant diseases has had variable success. Manzer and Cooper (4) found that late blight of potatoes could be detected by aerial infrared photography 1 to 3 days before visual symptoms became apparent. A 1971 oral communique with Dr. G. R. Cooper indicated that previsual detection has been increased to 5 days. However, tobacco ringspot virus could be detected only about 1 day before visual symptoms were evident (1). In contrast, Heller (3) found that beetle damage could not be predetected, and Meyer (5) reported that variability interfered with previsual detection of tree diseases.

Cellular discoloration affects reflectance of light over the 700- to 1350-nanometer (nm) wavelength interval. This response is useful in detecting nonvisual symptoms of plant leaf stress (2).

MATERIALS AND METHODS

Cucumber plants (cultivar National Pickling) were grown in the greenhouse in sandy clay loam soil contained in 4.6-liter clay crocks. A 10-20-5 fertilizer was added to the soil at a rate of 27.3 kg/ha of nitrogen. All plants were watered daily with 200 ml of rainwater. Plants were thinned to eight per crock 3 days after their emergence.

A randomized complete block experimental design was used with five replications (crocks) of three treatments: (1) control—cotyledons swabbed with abrasive and sterile distilled water, (2) cotyledons swabbed with abrasive and WMV-1 inoculum, and (3) cotyledons swabbed with abrasive and WMV-2 inoculum. This paper considers results obtained with WMV-2 because a complete photographic sequence was not obtained for plants inoculated with WMV-1. Each cotyledon was inoculated 5 days after emergence, 2 days after the first true leaf was macroscopically visible. Plants were very uniform—their first true leaves appeared and unfolded at the same time.

A series of photographs of all plants were taken beginning 2 days after inoculation and continuing at 24-hr intervals for 7 days until visual symptoms of WMV-2 appeared on leaves of inoculated plants. Photographs were taken with artificial light (Honeywell Electronic, Auto/Strobonar flash) with a Hasselblad camera, 80-mm lens, Tiffen yellow filter and 70-mm AIR film.

Spectral measurements were conducted with a Beckman Model DK-2A spectroreflectometer from the top (adaxial) leaf surfaces of control and WMV-2 inoculated cucumber leaves over the 500- to 2500-nm wavelength interval.

RESULTS AND DISCUSSION

Five days after inoculation of cotyledons and 2 days prior to the appearance of visual symptoms, WMV-2 symptoms were detected on the first true leaves in AIR photographs—healthy leaves produce a darker red image on positive transparencies and prints than affected leaves because of higher infrared light reflectance. Previsual WMV-2 symptoms pro-

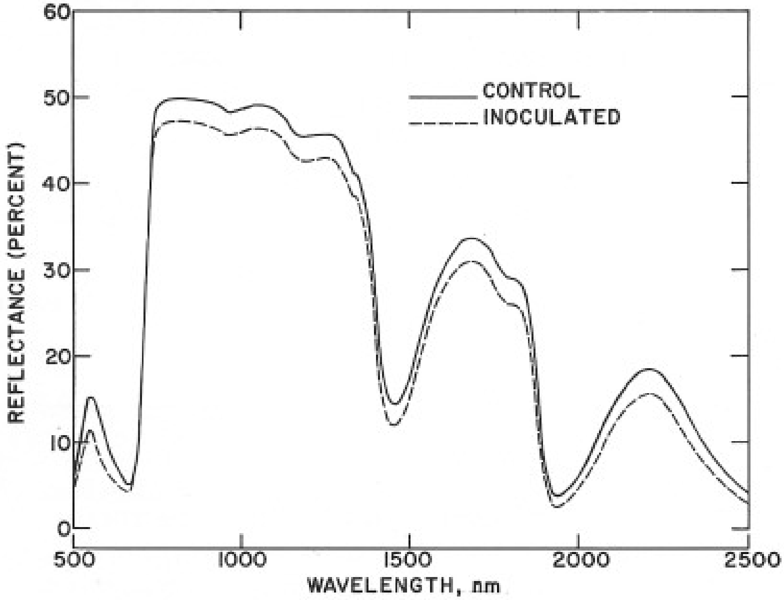

Figure 1. Spectrophotometric reflectance measurements over the 500- to 2500-nm wavelength interval of control and inoculated cucumber leaves.

tion of leaves from control plants. Two days atfer the previsual detection of WMV-2 photographically, the virus showed visually with a characteristic yellow and green mottling pattern and leaf curling.
duced a darker red saturation of leaf areas on AIR film positive prints and transparencies compared with the lighter and uniform red satura-

Figure 1 depicts the light reflectance over the 500- to 2500-nm wavelength interval from the top (adaxial) leaf surfaces of control and WMV-2 inoculated cucumber leaves. Even though the eye could not discern visual differences between control and inoculated leaves, the spectra in Figure 1 show that control leaves had a higher reflectance than inoculated leaves over the entire 500- to 2500-nm wavelength interval. Therefore, it seemed feasible that differences between control and inoculated leaves might be detected photographically.

Previsual detection of virus diseases of plants photographically should be tested in the field for early diagnosis and for roguing of diseased plants in breeding and seed increase programs. Early treatment of plant diseases could help prevent extensive crop loss. For example, AIR photographs could be taken of a crop and the film processed and evaluated within 4 hours. Previsual detection of virus diseases may be also useful for crop estimates.

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OTHER AREAS

The Impact of Exports and Imports on Texas Agriculture

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Talk given at the Annual Horticulture Institute, Jan. 25, 1972

I would like to give an overall picture of exports and imports for the United States and Texas, which includes an idea of the impact agricultural exports and imports have on the Texas economy.
Let me give a few statistics:

1.) Texas has the third largest fruit and vegetable harvest in the nation, with a total value of more than 140 million dollars.

2.) We rank first in the production of carrots, onions, watermelons and cabbage.

3.) Production totals for Texas grapefruit and cantaloupes are second largest among all states.

4.) Only three states lead Texas in agricultural exports in 1971.

I quote these statistics to impress on you the importance of Texas in domestic and international trade. We grow a lot and we ship a lot, both at home and abroad.

To fill out the impression I am trying to make, let's begin with the fact that the U.S. is the world's largest exporter of agricultural products. She accounts for over one-sixth of all farm commodities entering free world trade. As a matter of fact, total U.S. agricultural exports in 1971 were $7.8 billion compared to $6.7 billion in 1966.

Texas has a larger stake in world trade in agriculture than any other state except Illinois, Iowa, and California. At one time we had more at stake than all other states except Illinois. Obviously we have not been as aggressive as we should have been. Texas agricultural exports in 1971 were valued at $554 million compared to $495 million in fiscal year 1965-66, so we have been increasing our exports, but our rate of increase has been less than the rate of increase in many other states. The $554 million figure represented approximately 14% of the total cash receipts received by Texas farmers from marketing all crops, livestock, and livestock products in 1971.

Trade between nations is reciprocal to a great extent. For balance of payments purposes, nations buy as well as sell, and the United States is not only the world's largest seller, she is also one of the largest buyers. For example, in 1970-71, the U.S. imported $5.8 billion worth of agricultural products. Of this amount, $3.7 billion consisted of supplementary products. (Supplementary products are goods that are similar to products produced in the U.S. and other products that are interchangeable in use with U.S. commodities and which are therefore competitive.)

About $2.1 billion worth of complementary, non-competitive, products such as bananas, coffee, and tea were imported in 1970-71.

I have stated, earlier, that the U.S. is the world's largest exporter of agricultural products, accounting for over one-sixth of all such commodities. Foreign markets take the output of about 72 million U.S. harvested acres, which is about one acre out of four or 25%. On a value basis, exports have averaged about 16% of the total cash receipts from U.S. farm marketings in 1970.

Foreign markets are of major importance as outlays for many products. For example, last year, they took over half of the U.S. production of rice, wheat, and soybeans; more than two-fifths of the cattle hides and tallow; and over 33% of the cotton.

What about imports? The value of imports into the U.S. rose 4% to $5.8 billion in 1970-71. We are the second largest importer, trailing West Germany by less than $600 million.

Over the years Brazil has been our largest supplier of imported products with Mexico a close second. Mexico is a good example of the effects of imports on U.S. and Texas Agriculture.

U.S. consumers have benefited from larger supplies of fresh winter vegetable imports from Mexico. But, while benefiting the consumer, such imports have put pressure on the domestic produce industry. Also, the U.S. has experienced steady rapid inflation for several years which has caused costs to rise in the domestic industry. A real question arises as to how long and at what levels can we compete with a lower cost Mexico.

In 1970 the value of imports of fresh and processed fruits and vegetables from Mexico was more than four times as great as the value of imports in 1960. Fresh vegetables accounted for around 70% of the total. Although the U.S. has nearly doubled its exports of agricultural products to Mexico since 1963, these were still only about one-third the value of imported Mexican goods.

Mexico's most important vegetable exports to the U.S. are tomatoes, peppers, cucumbers, and strawberries. I don't need to labor on how these imports affect producers, not only in Texas, but throughout the United States. Most of you know the problem.

So, what have I really said so far? Well, I have said that the U.S. is the world leader in agricultural trade, that although Texas is among the most important states in international trade, we have fallen behind, and that even our domestic market is under fire from foreign sellers.

This, in my opinion, is a very serious and unnecessary situation. Commissioner White has also expressed his concern and has taken action by establishing the office of Export Director. The Export Director works within the Marketing Division which is under the direction of Ben Baisdon. The principal responsibility of the Export Director is, in general, market development. Specifically, the Export Director helps Texas producers and shippers seek out new markets, sell on competitive terms, and over come the procedural difficulties peculiar to international trade.

Texas producers should commit a part of their production to specified export markets on a continuous basis. They should learn and understand the most generally accepted terms of trade and what federal and state programs are available to assure that their international transactions are as successful as their domestic ones.

A seminar on international trade should be programed periodically to help inform producers and shippers of the requirements of foreign trade. Such points as financing, insurance, payments, customs regulations, tariffs, and packaging would be discussed.

Let me say in closing that we have not been aggressive in our international marketing efforts; but we should, because Texas has many products, which we could sell abroad to the Caribbean, Europe, Japan, and other areas. And, by being a stronger international competitor, we could have a more stable and stronger domestic market.

Impact of Synthetic–Substitute Products on Agriculture

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Talk given January 25, 1971, at the Rio Grande Valley Horticultural Society 1971 Annual Meeting, Texas A&I Citrus Center, Weslaco, Texas.

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Although by definition synthetics and substitutes are different, they are both man-made and both replace traditional factors of production and commodities; consequently, both will be discussed as one group. The distinction between synthetics and substitutes is the source of raw materials. Synthetics are manufactured principally from petrochemicals, such as saccharin for sweeteners. Substitutes are manufactured from agricultural raw materials such as filled milk and bacon-like soybean protein products.

We will now look at both the past and expected future impact of synthetics and substitutes on U. S. Agriculture. This is a formidable task for the next few minutes.

Herman Kahn of the Hudson Institute classifies societies throughout the world according to per capita income. Following is Kahn's classification:

Pre-industrial	\$ 50 to \$ 200 per capita
Partially industrialized or transitional	\$ 200 to \$ 600 per capita
Industrial	\$ 600 to \$ 1500 per capita
Mass consumption of advanced industrial	\$1500 to \$ 4000 per capita
Post-industrial	\$4000 to \$20000 per capita

The United States and Western Europe are now both advanced industrial societies. The Hudson Institute study ranked the nation's likely level of economic development for the year 2000. This serves as a useful basis for thought.

The post-industrial societies will be in this order: the United States, Japan, Canada and Sweden. The advanced industrial societies that have the potential to become post-industrial include: Western Europe, the Soviet Union, Israel, East Germany, Poland, Czechoslovakia, Australia and New Zealand.

The following nations will become consumer societies: Mexico, Argentina, Venzuela, Chile, Columbia, South Korea, Malaysia, Formosa and the other countries of Europe.

The rest of the world such as China, most of South America, the Arab countries and Black Africa will not have even reached the industrial stage.

In 30 years, the Hudson Institute predicts an average per capita income of $7500 in the United States. There will be only four work days a week, seven hours per day. The year will be comprised of 39 work weeks and 13 weeks of vacation. With weekends and holidays, this makes 147 work days a year and 218 free days.

Agricultural Economists predict that United States agriculture will be making some drastic changes during the next 30 years. The past change in United States farm population and number of farms is portrayed in Table 1, as well as the expected changes to the year 2000.

Table 1. Percent U. S. Population on Farms, Number of Farms of Years 1775-2000.

Year	*Percent of total Population on Farms*	*Number of Farms*
1775	95%	---
1860	80%	2.0 Mil
1925	30%	6.4 Mil
1970	5%	3.0 Mil
1980[1]	3%	2.0 Mil
2000[1]	1%	0.5 Mil

[1] Estimated

Source: U. S. Department of Agriculture, *Agricultural Statistics*, U. S. Government Printing Office, Washington, D. C. 20402

United States population is now about 204 million and is increasing at an average annual rate of about 1.5% and the future rate is expected to decline. By the year 2000, the United States population is expected to reach about 300 million. With an increased population, demand for food will likewise increase. In 1970, the U. S. agricultural plant capacity in terms of land is presented in Table 2. The expected plant capacity for 1980 is also presented.

With an increasing population, why is less land expected to be utilized in 1980 for agricultural production compared to 1970? The answer to this riddle is technological innovation which includes synthetics and substitutes. Technology is being produced and adopted at a faster

Table 2. U. S. Agricultural Plant Capacity — 1970 and 1980

Year	*Crop Acres*	*Crop Acres in Production*	*Excess Capacity*
1970	334 Mil	290 Mil	15%
1980[1]	334 Mil	260 Mil	28%

[1] Estimated

Source: U. S. Department of Agriculture, *Agricultural Statistics*, U. S. Government Prinitng Office, Washington, D. C.

rate than population growth. When we review our history, the U. S. society will truly be facing an unique situation in respect to food and fiber supply for the next 30 years.

Technological innovation has had a major influence on the changes we have witnessed in U. S. agriculture during the past half century. For example, in 1920, 8.3 persons in U. S. were supplied food and fiber products by one farm worker. By 1950, this rate had changed to 15.1 and now it is greater than 45 to 1(5). All of this has been done with less farm labor and less acres of cropland. We have substituted technology in U. S. agriculture for labor and for land. Our agricultural colleges and other research institutions have been busy producing technology and the business firms producing primary agricultural products have been busy adopting this technology.

The impact of synthetics and substitutes on commercial agriculture can be observed from the growth of agri-business firms supplying farm and ranch production inputs. Farmers and ranchers have long been aware of substitution possibilities at the resource level. During the last half century, we have witnessed the substitution of machine horsepower for animal horsepower, petroleum for grain and hay "fuel", chemical fertilizer for barnyard fertilizer, electric power for human labor and a variety of labor-saving tools.

Traditionally, the factors of production have been classified into four broad categories, i.e. land, labor, capital and management. The capital category includes a multitude of purchased inputs associated with technology. In the agregate, capital has been substituted for land which explains the reason for less expected cropland requirement in 1980 compared to the present. The ultimate effect of substituting synthetics for agricultural land will result in a reduction in the capitalized value of land for agricultural purposes. But the market for land for urban developments, recreational uses, highway uses, etc., is expected to have sufficient demand to offset the surplus agricultural land made available by the adoption of technology.

The impact of synthetics on the demand for agricultural labor will be similar to that of land. However, substitutes for labor in the form of machinery and mechanization of many operations will continue to reduce the quantity of labor required in agriculture. The returns to labor remaining in agriculture is expected to improve relative to the current situation. A higher level of skills and training will be necessary and the productivity of those remaining in agriculture will advance dramatically as more capital investment, relative to labor, is made in agriculture.

There is the problem of minimizing the relocation cost of labor which will be displaced from agriculture by synthetics. This is one of our major problems today in respect to redundant agricultural labor and marginal farmers and ranchers in the U. S. agricultural sector. Past experience reveals that many farmers' sons move into the agri-business sector for gainful employment. Consequently, the extent agricultural supply firms grow and expand as a result of synthetic developments, the opportunity for employment of displaced agricultural labor may be enhanced.

The demand for capital in agriculture has been increasing at a rapid rate and will continue to expand in accordance to the development of future technological innovations. When substitutes take place at the resource level, then capital requirements will expand relative to the degree of substitution.

So far we have focused on the resource level of U. S. agriculture in respect to synthetics and substitutes. This is the market where technology has made the most impact. Now we'll examine the synthetic-substitute situation in respect to the commodity markets.

Synthetics and agricultural substitutes are making significant changes in our traditional commodity markets. The fiber, sugar, oilseed meal and oils, animal products, citrus and dairy markets are now facing increasing competition from synthetics and substitutes as is illustrated in Table 3.

Total fiber usage is expanding at a 7.4 percent annual rate. In contrast, cotton shows a 1.8 percent annual growth and wool has a −1.5 percent annual rate; consequently, the share of the textile fiber market held by cotton and wool is now about 34 percent and 2 percent, respectively. Compared to the 1957-59 period, cotton fiber prices declined by 30 percent, wool 44 percent and synthetics by 23 percent.

Cane and beet sugar's share of the market declined from 86 percent during the 1957-59 period to 80 percent in 1968. Total growth rate of the sweetner market is 3 percent. The annual growth rate of cane and beet sugar is about 2 percent with the balance represented by synthetics. Since 1968, the average price of synthetics on a sweetner equivalent basis declined to less than 1 cent per pound in comparison to an increase of sugar prices from 9 to almost 11 cents per pound. This has created a favorable economics environment for a future dramatic expansion of synthetic sweetners in the sugar commodity market. Ultimate consumers are now being offered many commodities, i.e. soft drinks and prepared foods with synthetic sweetners.

Close examination of Table 3 reveals the trends for the other 9 selected products. Fluid milk thus far has not experienced severe competition from substitutes; however, by the end of this decade it is predicated that technology will have developed to a level where fluid milk substitutes will be available with the same taste and consistency of natural fluid milk. This will be made possible in part by flavor houses, firms specializing in producing and selling flavor extracts, which are now experiencing greatly expanded sales volume.

Meat substitutes are already starting to invade our traditional beef, pork, chicken and turkey meat commodity markets. Worthington Foods, which recently merged with Miles Laboratories, General Mills, Loma Linda Foods, Archer Daniels Midland, and Crest Products are four of

Table 3. Market Share, Growth Rate and Price of 12 Selected Agricultural Commodities and Synthetic or Substitute Product — 1957-59 and 1968.

	Market Share Held by Product		*Market Growth Rate*		*Wholesale Price of Agricultural Products*		*Price of Synthetic or Substitute Product*	
	1957-59 Percent	*1968 Percent*	*Ag'l Product Percent*	*Total Market Percent*	*1957-59 Cents*	*1968 Cents*	*1957-59 Cents*	*1968 Cents*
Cotton	56.4	33.6	1.8	7.4	33.6 lb	23.3 lb	106.0 lb[5]	82.0 lb
Wool	3.7	2.1	−1.5	7.4	134.0 lb	75.0 lb	106.0 lb[5]	82.0 lb
Cane and Sugar Beet	85.7	80.1	2.0	3.0	9.1 lb	10.9 lb	3.9 [6]	0.9 lb
Oilseed Meal	90.4	84.2	5.4	6.3	2.7 lb	4.1 lb	5.4 [7]	4.4 lb
Fats and Oils for Soap	19.7	12.3	−1.9	2.5	7.2 lb	6.9 lb	16.0 [8]	13.0 lb
Drying Oils for Paints	39.3	28.1	−2.8	3.6	13.3 lb	13.4 lb	27.8 [9]	19.5 lb
Glycerine	55.5	41.9	1.7	4.6	27.8 lb	25.6 lb	28.1 [10]	25.0 lb
Starch and Dextrin for Adhesives	16.2[1]	14.2	5.3	6.9	9.0 lb	7.8 lb	28.4 [11]	24.4 lb
Soya Meal and Casein for Adhesives	10.4[1]	8.2	2.7	6.9	7.3 lb	9.0 lb	28.4 [11]	24.4 lb
Leather for Shoe Uppers	85.5	78.1	−3.2	1.7	55.0 sq. ft.	60.0 sq. ft.	N.A. [12]	92.0 sq. ft.
Citrus juice	31.9[2]	33.8[2]	5.6	4.4	85.7 gal[4]	109.0 gal	N.A. [12]	91.1 gal
Fluid Milk	100.0	100.0[3]	0.5	0.5	543.0 cwt	617.0 cwt	N.A. [12]	540.0 cwt

Table 3. (Continued)

[1] For 1962

[2] Share of retail fruit beverage market for 1965

[3] Synthetic and imitation milk was less than 1/10 of 1 percent of the market

[4] Price of 1965

[5] Single average for nylon, polyester, acetate and acrylic fibers

[6] Saccharin and cyclamate on a sweetner equivalent basis

[7] Urea in terms of 44 percent soybean meal

[8] Cyclic surface active agents on a 100 percent active basis

[9] Phthalic alkyal resins, styrene butadiene latax and polyvinyl chloride resin on a dry basis

[10] Synthetic

[11] Urea-melamine, polyvinyl chloride and phenolic resins

[12] Not available during 1957-59 period.

Source: Corkern, Ray S. and Hoofnagle, William S., Synthetics and Agricultural Substitutes in Agricultural Commodity Markets, *The Effect of Synthetics and Agricultural Substitutes*, North Carolina State University, API Series 44, April, 1970.

several firms now making entry into the traditional food commodity markets with protein substitutes made direct from soybeans. Many are now experiencing growth demanding an expansion program. Ralston Purina and Swift and Company have also entered the meatless meat market.

Vegetable protein in the future will replace part of the animal protein in American's diets. Meat patties, casseroles, and soups school children consume at school are now likely to have a soy protein extender. The U. S. Department of Agriculture has recently permitted up to 30 percent of the meat protein in a school lunch to be replaced by vegetable protein.

Let's look at the economics of soy protein concentrate (SPC) as meat extenders. Six pounds of dry SPC are recommended per 100 pounds of ground meat. Since six pounds of SPC is normally mixed with 18 pounds of water, 100 pounds of ground meat is extended to 124 pounds. At 65 cents per pound for ground meat and 24 cents per pound of SPC, the added cost of $1.44 for SPC per 100 pounds of ground meat extends the ground meat 24 pounds reducing the cost per pound of ground meat from 65 cents to 53.6 cents. In addition to the lower cost, shrinkage is reduced resulting in a tastier, juicier product.

Two economists with the U. S. Department of Agriculture recently predicted that by 1980 vegetable protein extenders will probably displace 15 to 20 percent of the meat in meat-type food preparations in both institutional and retail markets.

Since SPC cost less than animal protein and is comparable nutritionally wider use of SPC will be used in upgrading diets for low income families. Vegetable protein keeps well and comes ready to heat which is a big advantage to the fast food businesses including the firms specializing in hamburgers.

No attempt will be made to evaluate the good or bad effects of a given synthetic or substitute in respect to agriculture. Agricultural synthetics and substitutes have been a direct result of our technological innovations which in turn have been responsible for our rapid economic development. With the production of future technology, we can be assured that more synthetics and substitutes will appear on our agricultural factor and commodity markets.

Those of us that attended this meeting today used synthetics and substitutes in transportation. The automobile is a substitute for the horse, and the tires on today's automobile are synthetic rubber tires. Synthetic rubber tires are good for us as consumers, but bad for the rubber plantation owner. Likewise, when future synthetics and substitutes make entry on the market, consumers of these products will benefit economically while the owners of the agricultural resources that employ the factors of production that produce the commodity being replaced by the synthetics or substitute will be faced with a declining demand for their factor resources and product. Running to Washington to obtain protective legislation will ease the pain in the short run; but in the long run, change will evolve.

Dramatic downward shifts in demand, as with butter because of the growth of the substitute oleomargarine, are not appropriately reflected in parity prices of supported products. Artificially high support prices thus may reinforce and accentuate the drop in the quantity consumed of the protected commodity and inadvertently promote the sale of the synthetic or substitute products. Our cotton support policy serves as a good example of this situation.

The trend in the consumption of more and new food synthetics and substitutes will be gradual. For instance, the original cup of factory-brewed coffee has now been substituted by a cup of coffee utilizing only 50 percent of the quantity of coffee beans. We are well down the road to synthetic coffee in addition to more efficient utilization of coffee beans. To a larger percentage of our population, synthetic instant coffee is the only coffee they now prefer. To another large percentage, it is close enough to brewed coffee to be preferred for price and convenience. To all of them, it is coffee—not synthetic (2).

How can agriculture compete with synthetics and substitutes? In the long run, the best line of defense is the development of new products in the traditional food and fiber commodity markets. In 1940, agriculture received 40 percent of the federal outlay for research compared to 1.6 percent in 1966. State support of our land-grant institutions has become increasingly important. In 1966 70 percent of our research funds available to agricultural experiment stations were non-federal funds. The allocation of available funds for product improvements and development is only about 3.6 percent of the agricultural experiment station funds (3). If we wish to expand the utilization of our traditional agricultural commodities in order to compete with synthetics and substitutes, more funding in utilization research will be required.

In summary, the impact of technology in the agricultural factor market has enabled our agricultural plant to produce more output with less land and less labor. In the future, we will continue to develop technology that will result in more synthetics and substitutes for agricultural factors.

The impact of synthetics and substitutes in the agricultural commodity markets have not been dramatic compared to the factor market. In the future, we can expect a greater impact of synthetics and substitutes on the agricultural commodity markets. Obtaining protective legislation is only a partial short-run solution. Development of new agricultural commodities offers a more satisfactory solution.

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ADDENDUM

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.

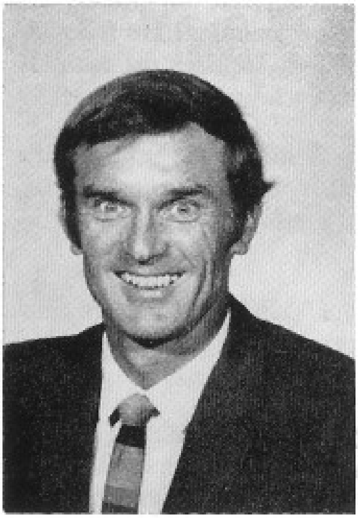
At 6 monthly meetings, September-April, subjects of interest are presented by specialists in their fields. These presentations are followed by open forums. The Newsletter announces and discusses the monthly programs and brings other news of interest to Society members.

The Society has sponsored 26 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 $5.00, which includes the Journal. Applications for membership, and annual dues should be sent to the Secretary-Tresurer, Rio Grande Valley Horticultural Society, Box 107, Weslaco, Texas.

Officers of the Rio Grande Valley Horticultural Society 1972



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Program of the Twenty-sixth Annual Institute

Rio Grande Valley Horticultural Society

January 25, 1972

MORNING SESSION: Dr. R. H. Cintron, Chairman

Address of Welcome .... Arthur Hentz, President
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Quality Control in Food Processing .... W. P. Plier, Plant Manager,
Texas Citrus Exchange, Processing Division, Harlingen

Our Valley Environment .... R. J. Steeno, Environmental
Health Specialist, Texas Department of Health, San Benito

Fresh Produce Buying in Texas .... William Brozowski, F.O.B.
Produce Buyer, Jewel Companies, Inc., McAllen

Impact of Synthetic-Substitute Products
on Agriculture .... Dr. Chan Connolly, Associate
Professor, Texas A&M University Agr. Exp. Station, Weslaco

Presentation of Arthur T. Potts Award .... Arthur Hentz,
President, RGV Horticultural Society

AFTERNOON SESSION: Dr. R. L. Menges, Chairman

Effect of Imports and Exports on
Texas Agriculture .... Ken Decker, Exports
Director, Texas Department of Agriculture, Austin

Potential for Lengthening Onion
Harvesting Season in South Texas .... Tom Longbrake,
Area Vegetable Specialist, Texas A&M University
Agricultural Extension Service, Weslaco

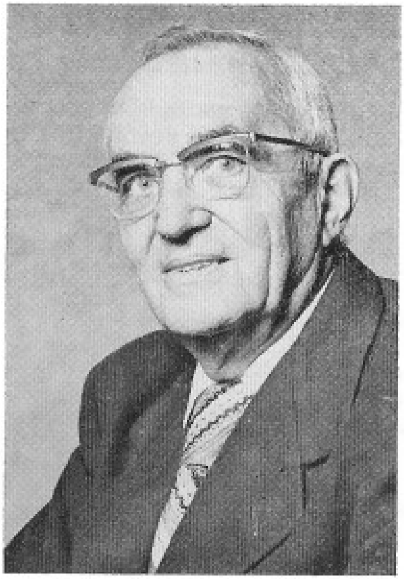
Inovations in Tomato Processing .... Dr. Harold E. Brown,
Research Chemist, USDA Crops Utilization
Research Laboratory, Weslaco

EVENING SESSION: R. T. Correa, Chairman

Trees .... Dr. Robert S. Dewers,
Ornamental Horticulturist, Texas A&M University
Agricultural Extension Service, San Antonio

Flowering Trees for Sub-tropical Regions ....
Photographic slides from the Edwin Menninger collection.
Commentary by Dr. R. S. Dewers and Henry Link

A Preview of Hawaiian Island Vegetation .... E. B. Ballard,
Manager, Ballard's Nurseries, Weslaco



DR. GEORGE R. SCHULTZ

Recipient of the Arthur T. Potts Award 1972

The 1972 A. T. Potts award winner was born in Itzehoe, North Germany in 1901. After moving to east Germany in 1920 he began his agricultural career by studying mechanical soil cultivation at Berlin. He continued studying agriculture at the University of Koenigsburg. He earned his PhD degree at the University of Berlin in 1927 under the famous German soil chemist, E. A. Mitscherlich. After two years of post graduate work at the Universities of Wisconsin and Cornell Dr. Schulz immigrated to the U.S. He worked for a time with the Dairy Herd Improvement Association in Wisconsin and managed the Keenan Soil Lab in Florida. He came to the Valley in 1938 and founded the Texas Soil Laboratory in McAllen.

In his capacity as director of the Soil Lab Dr. Schulz has provided a unique and invaluable service to Valley farmers and orchardists. His innovations in soil testing and analysis coupled with his long experience and knowledge of Valley soils, crops, and growing conditions make his recommendations unusually sound and reliable. His continuous pursuit of new knowledge and techniques and his clear reason have been beneficial and welcome to farmer, scientist and gardener alike. His two books, "Citrocraft" and "Your Soil" are widely acclaimed by Valley agriculturists for their plractical and applicable value to the Lower Rio Grande Valley area.

In addition to his greater service to our whole agricultural industry Dr. Schulz has spent much time and effort serving the Horticulture Society as director, and president.

Dr. Schulz is a member of Soil Science Society of America, the International Society of Soil Science and the Council on Soil Testing and Plant Analysis. In his community has has been active in Boy Scout work, the YMCA of the Rockies, and the Methodist church. Any left over time may find him enjoying his hobbies of photography, philosophy, gardening, grapho-analysis, or travel.

In recognition of all his unique and long term contributions to our Valley agriculture, community, and our Society, Dr. Schulz was selected as a most deserving recipient of the Rio Grande Valley Horticulture Society's 1972 Arthur T. Potts award.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY PATRON AND SUSTAINING MEMBERSHIP, 1972

The RGV Horticultural Society gratefully acknowledges the support of its Patron and Sustaining Members, which makes the publication of the Journal possible. Also, these members are recognized for their outstanding contributions to the Horticulture Industry of the Valley.

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