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Aims and Objectives of the Society

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

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

The Society sponsors an annual Institute featuring outstanding speakers from all parts of the country who present new developments in the field of horticulture. Panel discussions, social get-togethers, and a barbecue complete the all-day program.

Talks given at the Institute and reports of Valley research are published in the *Journal of the Rio Grande Valley Horticultural Society*, providing a continuing record of horticultural progress in the Valley.

Anyone interested in horticulture can become a member of the Society. The annual dues of $7.50 include a subscription to the *Journal*. Subscriptions by institutions and libraries are $10.00 a year. Applications for membership or subscriptions should be sent to the Secretary, Rio Grande Valley Horticultural Society, Box 107, Weslaco, Texas 78596.

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President

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Charles Davis Rankin

Recipient of the Arthur T. Potts Award

Charlie Rankin grew up in Corsicana, Texas. After graduation from high school he served with the United States Navy during World War II. On returning to civilian life he enrolled at Texas A&M University majoring in animal husbandry.

In college he was active in livestock and rodeo activities and in the Saddle and Sirloin Club. He was one of the founders of the Intercollegiate Rodeo Association. Always busy promoting and publicizing these activities, his training in Ag Journalism served him in good stead and was perhaps a harbinger of things to come.

After graduation from A&M Charlie served another 2 years with the Navy. This time in the Korean conflict. On returning again to civilian life he worked first with the Soil Conservation Service near San Angelo. Then in 1954 he became farm editor for a radio station in Waco with a daily ten minutes on the air.

He came to the Valley in 1955 to work on radio with KRGV, Weslaco. That same year he initiated agricultural television programming locally. First with an evening spot; later with a morning spot; and finally settled into the noontime spot where he remained for 12 years.

He has been a member of the Mid-Winter Vegetable Show board of directors since 1967 when he assumed responsibility for lining up buyers for the champion and near champion vegetables. At Charlie's insistence the proceeds go to the youth and not to the show funds. He purchases the winning market basket each year on behalf of station KURV.

Charlie's contribution to the Horticultural Society has been largely in the realm of promotion and publicity. He gives generously of his time to publicize the Institute and its proceedings. He has worked closely through the years with both Texas A&I and Texas A&M as a member of advisory committees at both centers. He twice received a state-wide award for outstanding service to Soil Conservation. He has also been given the local Soil Conservation Service District award.

Charlie has also been active in the Lower Rio Grande Valley livestock show. He has received the State 4-H Club award given to those persons who serve and help 4-H youth above and beyond the call of duty.

Last year he was invited to help write the charter guidelines for the National Weather Service which until then operated without guidelines. He feels he was asked because of his outspoken suggestions for improving the output of the

National Weather Service and because he was the author of 2 position papers on the need for changes in Ag weather reporting. These papers were prepared for the National Association of Farm Broadcasters. Charlie is a past chairman of their weather committee.

Getting accurate weather information to growers has been one of his principal concerns. When freeze threatens or hurricanes approach he stays on the air passing along the latest updates to concerned growers. Accurate price information for the growers is another of his major activities. Citrus, vegetable, and other commodity prices are reported in season. He has dedicated his life to the improvement of Valley agriculture. He is a firm sponsor of farmers and their families, particularly the younger generation. To many laymen he is the only contact between urban and rural life. He is known far and wide as Charlie Rankin the voice of Valley Agriculture.

RIO GRANDE VALLEY HORTICULTURAL SOCIETY MEMBERSHIP, 1979

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Program of the Thirty-Third Annual Institute
Rio Grande Valley Horticultural Society
23 January 1979

MORNING SESSION: George Schulz — Presiding

"The Mediterranian Fruit Fly and its Threat to the Lower Rio Grande Valley" . . . . . S. J. Ingle
Citrus Insects Research
USDA, Weslaco

"Pecans in the Valley" . . . . . George Madden
Brownwood, Texas

"Problems and Costs of Developing Crop Protectants" . . . . . J. D. Riggleman
E. I. duPont de Nemours & Co., Inc.
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Presentation of the Arthur T. Potts Award . . . . . Fred Karle
President

AFTERNOON SESSION: Rafael Cintron — Presiding

"The Freezes of 1978 - 1979 . . . . . Richard Hensz,
Director
Texas A & I Citrus Center

"Brazilian Citrus Industry" . . . . . Orlando S. Passos
Bahia, Brazil

"Hedging and Topping" . . . . . John Fucik
Texas A & I Citrus Center

"Hey, Ruby, how'd you get so sweet?"
Film of the Texas citrus industry . . . . . Texasweet Citrus
Advertising, McAllen

EVENING SESSION: Bill Carter — Presiding

"Aloe Vera Culture" . . . . . Bill Mangum
Harlingen

"Ornamental Foliage Plant Industy" . . . . . Ben Parsons
San Benito

SUMMARIES OF TALKS PRESENTED AT THE THIRTY-THIRD ANNUAL INSTITUTE OF THE RIO GRANDE VALLEY HORTICULTURAL SOCIETY

The Mediterranean Fruit Fly and Its Threat to the Lower Rio Grande Valley

S. J. Ingle
Research Entomologist
Citrus Insects Research
AR, SEA, USDA

The Mediterranean fruit fly (medfly), a native of Africa, is now distributed almost worldwide (6). It has been in the Mediterranean area since 1862, Bermuda since 1890, Australia since 1897, and Hawaii since 1910. In 1955 infestations were discovered in Costa Rica (12).

Once established in a locality medfly can spread quickly by natural flight or wind drift and is carried when infested fruit, vegetables, or soil are transported. The fly may hitchhike out of the infested area by automobile, airplane, boat, and other vehicles (12). Because of the extensive geographical distribution and wide range of host fruits attacked, medfly is ranked as the most destructive pest of citrus and numerous tropical fruits. It has over 200 hosts, over half of economic importance (6).

The medfly has 4 life stages - adult fly, egg, larva, and pupa. The adult is a little smaller than a house fly. Its body is yellow tinged with brown, the thorax is marbled with shiny black splotches, and the abdomen is oval with two fairly broad silvery bands. The wings which are usually extended and slightly drooping, are colorless except for brown or black markings (12). Adults live 30-60 days and are strong fliers. Damage to fruit begins when the adult female pierces the skin with her ovipositor and deposits 15 to 20 eggs in the puncture. This same egg puncture may be used by other medflies; several hundred eggs have been found in a single cavity. When conditions are favorable females lay about 1000 eggs during a life span.

Medfly eggs which are small, elongated, and barely visible hatch in 2 to 20 days depending on temperature. Larvae which are slender and cream-colored burrow in the pulp for 10 days to 6 weeks before completing growth. When mature, a little more than ¼ inch long, larvae leave the fruit and enter the soil, sometimes by dropping to the ground from the fruit; however, the fruit has usually dropped to the ground by the time the larva is mature. Larvae can travel short distances and are capable of jumping 4-5 inches high. This jumping or "popping" is a field aid in separating medfly larvae from those of other fruit flies native to North America. Larvae burrow ½ inch into the soil or under surface litter to pupate. The pupal period lasts 10-50 days, and after emerging flies become sexually mature in about 8 days. They mate, the female lays eggs, and the life cycle begins again. The life cycle may be completed in 17 days or

may take as long as 3 months if conditions are unfavorable. In the Lower Rio Grande Valley, conditions are such that there could be about 10 generations a year.

Fruit is primarily damaged by the burrowing of the larvae, but some fruit may also be lost because rots develop around the puncture even when the fly lays no eggs. The exact amount of damage done worldwide by this pest each year is difficult to determine but we can get some idea from the following: Some years in Greece up to half the citrus crop has been lost and damage to summer fruit has been even greater. In Sardinia as much as 80% of the peach crop has been lost. In parts of Africa and South America the pest has made commercial fruit production difficult or impossible. In North Africa in coastal and irrigated areas of high humidity the insect has been particularly damaging to peaches, pears, and apricots. In 1975 losses to citrus production in the Central American countries were estimated to be: sweet orange 28%, mandarins 50%, and grapefruit 24%. If the medfly were to become established in Mexico and cause the same crop losses suffered by Central Ameriea, the citrus industry of that country would suffer an annual loss of $5 million. If the medfly were to become established in the United States the losses to the U. S. citrus industry would be approximately $85 million annually and possibly $200 million annually to the entire fruit industry (5).

During the past 50 years medfly has become established in continental United States six times. Each time it has been eradicated. In 1929 medfly was found in 20 counties of Florida that contained 72% of Florida's bearing citrus trees. After 18 months and a cost of $7.5 million it was eradicated. It has recurred in Florida in 1956, 1962, and 1963; each time the cost of eradication has been several million dollars. On June 13, 1966, medfly was found in Brownsville, Texas. The infestation was eradicated with aerial applications of protein hydrolysate plus malathion, a bait spray, in 42 days (10). In 1975 an infestation was discovered in Culver City, a suburb of Los Angeles, California near a marina housing several boats that had recently returned from Central America. Likely medfly had been brought in on one of the boats. This infestation was eradicated in 39 days using soil insecticides, protein-hydrolysate-malation bait sprays and sterile fly releases.

Medfly first appeared in Central America in 1955 near San Jose, Costa Rica. By 1959 it had moved northward to Nicaragua and southward to Panama. In 1969 there was an interruption in normal quarantine procedures following a break in diplomatic relations between El Salvador and Honduras. Probably as a result medfly became established in El Salvador and Guatemala in 1975. Since then large areas within Honduras, El Salvador, and Guatemala have become generally infested. In 1976, the infestation spread northwest in Guatemala up to the Mexican border, and in 1977 the first fly catches were made in the southernmost corner of the state of Chiapas, Mexico (2).

The medfly infests many commercial and noncommercial fruits in Central America and Mexico, but the two primary commercial hosts are coffee and citrus. Oranges and mandarin are the most likely citrus varieties to be infested when grown adjacent to coffee (1). Coffee is the most important commercial crop that supports medfly infestations in Central America because it is an exceptionally good host for the fly and off-bloom fruit and scattered cherries

left from incomplete harvest provide a year-round source of fruit for oviposition. The presence of medfly in coffee does little harm to the crop since the bean is not damaged. Other hosts are grapefruit, rose apples, figs, loquats, natal plums, peaches, apples, and pears. Mangos, papaya, guava, avocado, and strawberry are also hosts (13).

The possibility of medfly crossing into Mexico has been anticipated. The Isthmus of Tehuantepec has been proposed as a defensible location for such a quarantine barrier that would prevent medfly from moving into the U.S. (2). It has semi-arid conditions along the Pacific coast in which few suitable host plants grow (6). The Gulf coast side has dense jungle vegetation, which contains many medfly hosts. Also, the Isthmus contains no mountains and is approximately 200 miles wide.

If medfly advances beyond the Isthmus of Tehuantepec, it will be very damaging to the economy of Mexico. The state of Veracuz, a part of which is in the Isthmus, is Mexico's largest producer of coffee and citrus. Just north of Veracruz, there is another large orange industry. In the state of Oaxaca, located beyond the Isthmus along the Pacific coast, there is another coffee production center. Also hard hit would be Mexico's winter vegetable and melon production, most of which comes to the United States. If medfly were to become established in these producing areas quarantine requirements would reduce the export of these products to the U. S. or to any country that does not have medfly.

U. S. farmers would be seriously threatened if medfly became generally established in Mexico. Tourist and other traffic between the two countries is so heavy that a workable quarantine would be almost impossible. Invasion of the medfly into the U. S. would occur again and again (2).

The strategy that has been proposed for the protection of the U. S. and the Mexican fruit industries would require constant surveillance throughout Mexico, particularly in the Gulf Coast Region. Any outbreaks occurring beyond the barrier zone would have to be detected early and quickly eradicated. Failure to do this would allow the medfly to move northward since a nearly continuous chain of host fruit areas extend to within 100 miles of the southeastern Texas border, a distance that offers no security to the Rio Grande Valley citrus and vegetable industry. Towns and ranches that have host material capable of supporting the medfly and possible wild host fruit are to be found throughout this area. In addition, the continual flow of vehicles northward from Mexico would present unlimited opportunity for transportation of the medfly by mechanical means. The danger to California and Arizona is less because of semi-arid conditions along the Pacific coast in Mexico above the barrier and the lack of a continuous chain of host fruit areas for the medfly to use in moving up the Pacific coast (6).

Experience in the U. S. has shown that medfly infestations can be eradicated by applying protein-hydrolysate-malathion bait sprays by air. However, repeated use of these materials over urban areas could produce strong public objections. Thinking has therefore centered on use of sterile insect release as a means of setting up the barrier and attacking infestations that escape it. The effectiveness of the sterile insect release method against the medfly has been demonstrated in field tests in several areas of the world. It is a sophisticated and costly technique, but has the advantage of being nonpolluting and specific against the target

insect. Resistant species do not develop as with the extended use of insecticides and there is no upset of the biological control of other insects (6).

There are several medfly rearing laboratories in the world. Hawaii, Costa Rica, Sicily, and Austria each have laboratories. The recently completed rearing laboratory built by Mexico and the United States at Metapa, Chiapas is capable of producing up to 500 million flies per week. These flies will be used in Mexico and Central America in an effort to stop the spread of the medfly.

For the sterile fly technique to work the native population must be known so an overflooding ratio of sterile to native flies can be provided. Trapping and fruit collection are used to determine the native populations (1). Two kinds of traps are used: the sticky trap, a triangular shaped piece of paper coated with stickum containing a cotton wick saturated with trimedlure; the Steiner trap, a plastic container containing a cotton wick that is saturated with trimedlure and a small amount of insecticide to kill the flies and control ants which may enter the trap. For collection, fruit is gathered, cut open and examined, or whole fruit is placed in holding cages to see if any medflies emerge (4).

Sterile fly release does not work well when native populations of mature flies are extremely large. In that case populations must first be reduced with insecticides or the eradication attempt put off until a time of year when populations are low because of climatic conditions or availability of food.

The sterile fly technique requires that large numbers of flies be reared and sterilized, as is done with the screwworm. Mass rearing of medfly is at an advanced and refined stage of development. The cost of labor and materials is about $20 per million flies (7). The rearing technique consists of keeping large numbers of adult medflies in oviposition cages and feeding them granulated sugar and yeast. Eggs are laid in the small perforations of plastic containers (300/container) that have been inserted into the cage. Once daily, the containers are collected and the eggs are washed out of the containers, volumetrically measured, and seeded onto the larval diet. There are 20,000 to 25,000 eggs per ml. Two larval diets are available: one used when the larvae are to be recovered from the diet by washing; the other when the larvae are to be recovered by the "popping method." In recovery by washing, the medium is washed through a sieve, the larvae collected in the sieve then transferred to moist vermiculite to pupate. In recovery by the popping method, the method most used, mature larvae are allowed to leave the diet by jumping and falling into collecting boxes containing moist vermiculite. When all larvae have pupated they are separated from the vermiculite and held in trays until ready to be sterilized by exposure to radiation, usually two days before emergence. They may be released in the target area as pupae or held until the adults emerge (11). The release of pupae has not been as satisfactory as adult releases: pupae are often consumed by ants, birds, and other predators; toads sometimes wait beneath ground release cages containing medfly pupae to eat the adults as they emerge and drop down upon foliage to harden and inflate their wings. Dissected toads have been found to contain up to 5000 flies (9).

Another concern is the necessity of monitoring native populations of the medfly throughout the releases. So they can be distinguished from native flies when both are caught in traps, sterile flies that are released are marked with a blue dye which was mixed with the vermiculite in which the larvae pupates. When the adults emerge and move up through the dye, their ptilinum collects

the dye before being retracted into the head. After the ptilinum is retracted into the head, the dye remains permanently with the insect. A metal bolt dipped in acetone is used to crush the head of a fly placed on filter paper. If the fly is laboratory reared the acetone dissolves the blue dye producing a blue stain on the filter paper.

Another important step in controlling the spreading of medfly is the detection of its host plants. Knowing the precise location and extent of breeding sites favored by medfly makes it possible to use suppressive biological or chemical measures quickly and efficiently. We at the Citrus Insects Research Laboratory became interested in remote sensing surveys for detection of host plants of insects in South Texas when the citrus blackfly invaded the area. Studies showed that aerial color infrared photography with a scale of 1:10,000 could be used to detect abandoned citrus orchards and small isolated plantings difficult to locate with ground surveys. This was important because unless all host concentrations of this insect were located, the success of any eradication program could be jeopardized. The same is true for the medfly. Populations of the medfly are monitored by the use of traps and by the collection and holding of infested fruit. The efficiency of both of these techniques can be greatly enhanced if the density and distribution of the host plants throughout the areas are known before traps are placed or the collection of fruit is undertaken. This is particularly true in the rugged, remote areas of Mexico and Central America where the medfly is now found: ground sampling in such areas are often conducted over such small portions of the total area that inaccurate estimates of populations are made. For this reason, we have concentrated on detecting fruit fly host plants by remote sensing studies. In Hawaii, we worked with hosts of the melon fly, oriental fruit fly, and the medfly; in El Salvador and Mexico, with hosts of the medfly. In these studies a 9-inch format camera with a 12-inch focal length lens and color infrared film was used. In Hawaii the entire islands of Lanai and Kauai were photographed. Since Lanai had large populations of melon flies, we concentrated on identifying *Mormordica* sp. (wild bitter melon), the primary host. The studies showed large patches of wild bitter melons invading pineapple fields and other open areas wherever sunlight reached the ground. When this plant was abundant large numbers of melon flies were produced. We determined that 5% of the pinapple acreage was infested with *Mormordica* sp. Personnel of the USDA Fruit Fly Laboratory in Hawaii were able to apply control measures precisely. Mangos, guavas and papayas, which are hosts of the oriental fruit fly (3) were identified. Ground data on host density and distribution from Kauai, Molokai, and Maui are being correlated with aerial photographs taken in 1978. On photographs taken near San Salvador, coffee grown under shade trees could be identified because of the uniformity of the planting patterns compared with adjacent jungle that contained a great varirety of plant species. Since about 50% shade is desired for coffee, rows of coffee and access roads through the overstory plantings can be readily seen (3). In the Pacific coastal area of southern Mexico, coffee was again easily identified. In this area, we were able to identify banana, avocado, and mango groves or single trees. In the Isthmus of Tehuantepec coffee and orchard crops were again easily identified. Surveys of this type can be conducted for less than ½ a cent per acre.

To contain the medfly in the Central American countries where it is presently located, all available control measures will have to be used: soil insecticides,

pesticides, and bait sprays applied from both air and ground, sterile fly releases, trapping, and the determination of host plant density and distribution. If all these approaches are successfully incorporated into the program medfly may be contained. Research in biological control and lure studies is urgently needed to provide backup technology in the event that the containment program does not succeed.

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Problems and Cost of Developing Crop Protectants

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In 1967 it cost an average of four million dollars to discover and develop a crop protectant up to first registration, not including the cost of a plant. In 1977 it cost 20 million.

I am going to compare the amount of work that was done to obtain the first registration for two similar Du Pont products, one in 1956 and one in 1970. Both first registrations were on apples.

Let us look at the cost of developing these data: $195 million for the one in 1956, and $915 million for the one in 1970. The estimates are expressed in 1978 dollars. They were arrived at by applying present unit cost for toxicological, metabolism, residue, and bioefficacy studies, along with estimates of time requirements, using today's level of skill. The cost increase of $720 million represents a 369% increase from 1956 to 1970.

It would cost an additional $500,000 to obtain data to support a food crop tolerance for either of these products using the current tentative guidelines. This includes the cost of new tests, as well as the cost of protocol changes in the older tests. The additional 50% increase in cost over the standard of 1970 must, in the end, be absorbed by the consumer. No one is recommending a return to the standards of 1956 but I wonder whether the consumer is really getting his money's worth when he absorbs increased costs over 1970 standards.

What are the impacts of the increase in registration cost on the future new product research and development? The increased cost will impact on the selling price of new products as they reach the user. They probably will not have much impact on the incentive for the industry to continue research aimed at discovery and development of new crop protectant chemicals.

There is another aspect that may have an effect. This involves the use and turnover of money, cash flow. To put products on the market money is borrowed from investors. The faster the investment can be paid back, the sooner earnings will begin to accumulate, and the bigger the dividends for investors. The better the health of the company the better the chance of attracting and holding investors; and the greater is the investor's incentive to put money into the research necessary to discover new products.

A cash flow chart shows how much was invested, the time when investment capital is recovered, and the accumulation of earnings in subsequent years.

Let us consider a hypothetical product with a reasonable set of assumptions: The selling price is $3.33/lb. Annual sales volume is 10 million lb. Net profit after tax is 14%. Fixed capital (cost of plant) is $20,000,000. Working capital is

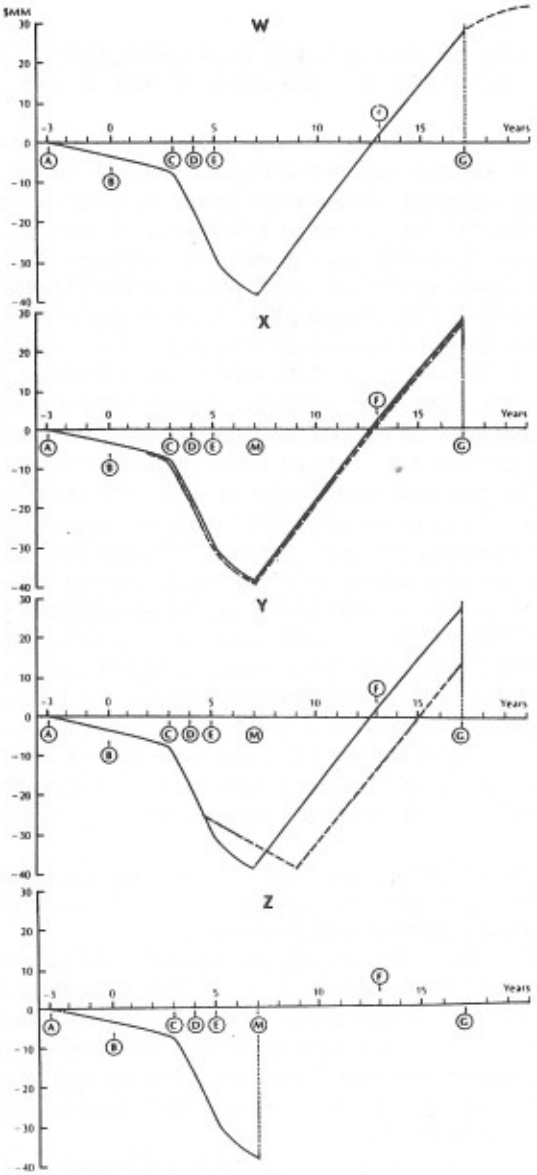

Fig. 1. Cumulative cash flow curve for a hypothetical pesticide in four situations (W,X,Y,Z). Key: A) initial synthesis and screening, year -3, B) U.S. Patent issued, year zero, C) first label registered, year 3, D) commercial plant construction, years 4 to 6, E) commercial sales begin, year 5, F) breakeven point, year 13, G) patent expires, year 17.

50% of sales. Selling and administrative costs $3,000,000/yr. Advertising and other expenses $1,500,000/yr. Cumulative R and D expenses (6 years) $14,000,000.

The cumulative cash flow chart that results from the hypothetical commercial venture represents the base case from which I want to discuss the impact of regulatory trends, especially those which result in delays (Fig. 1 W). Initial synthesis and biological testing occurred during the 3 years preceding issuance of the patent, point B at year zero. Registration at point C. Three years have elapsed since the patent was issued; construction of commercial manufacturing facilities in years 4 to 6, beginning at point D; significant sales begin in year 4 at point E. The breakeven point when stockholders have recovered their investment is year 13, point F. Beyond point F the cash position becomes positive and the stockholder begins to earn a return on the money he has risked. At point G, year 17, the patent expires, competitors can be expected to enter the market, and the slope of the line flattens out. When the cash flow curve flattens and finally parallels the axis costs equal dollar sales. No further earnings accrue. The product probably will be terminated. The length and slope of the line beyond point F interests investors; the more vertical and longer the line, the better the stock dividends - which in recent years have barely kept up with inflation.

The addition of another million dollars in cost of registration does not move the line very far (Fig. 1 X). A small price increase would easily offset the increased investment. What really costs money is registration delays (Fig. 1 Y). In 1950 it took 6 months to obtain the first food use registration; for a similar product in 1970 thirty months were required. Applying a conservative 2 year registration delay to the hypothetical product moves the whole line over by 2 years. You can see what it does to cumulative earnings. This is far more detrimental to the health of the crop protectant industry than adding costs on the front end.

This could be remedied in 2 ways: speed up registration, increase patent life. One or the other will have to happen to provide incentive to invest in the research required to discover new products.

Of even greater concern than regulatory delays are the current uncertainties regarding continuance of registration once one has been obtained. Should our hypothetical compound fail registration or RPAR review at point M (Fig. 1 Z) then the investors could lose their entire $38,000,000 investment. Granted this is a worst case situation, but it could happen. I am not trying to paint a bleak picture but in a day when practically everything could be considered carcinogenic one wonders just how far this can go.

Through all of this regulation there has to be some realism to keep investors placing money in companies for continued basic research. Without it there can be little or no progress in the area of crop protectants which are vital to the progress of agriculture in the United States and the rest of the world. Last fall at the British Crop Protection Conference in Brighton, England, only one new herbicide was introduced. I hope this is not a sign of the future.

To help we can point out stumbling blocks to speedy registration, focus on agricultural needs for your area, and concentrate on those needs by providing research data as promptly as possible, and help EPA handle registrations as promptly as possible.

I hope you have a little broader insight as to the problem areas of the future that you might not have thought about before. We eat a lot of food in this country. We have the best quality and variety of food, and contrary to what you may think the cheapest food in the world. I hope it continues.

RESEARCH REPORTS

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Survey of Bulb Diseases on Onions in South Texas

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ABSTRACT

Black mold, caused by *Aspergillus niger* van Teigh, was the major cause of bulb losses of the yellow onion varieties 'Texas Grano 502', 'New Mexico Yellow Grano' and 'Ben Shamen' in south Texas during a three-year survey. Bacterial soft rots constituted the next major disease loss problem; however, these losses were not of the magnitude of the black mold losses. Fusarium basal rot was of minor importance and Botrytis neck rot was not detected.

South Texas is the major supplier of onions, *Allium cepa* L., in the United States from March through May (5). The short-day south Texas onions are noted for their mild sweet flavor; however, the onions have a disadvantage of having a short shelf life due to postharvest diseases. Botrytis neck rot, Fusarium basal rot, several bacterial diseases and black mold have all been reported as postharvest decays of onions (6).

In south Texas, control measures for these diseases consist of field drying the bulbs in burlap bags. This type of drying system has met with variable success, depending upon the frequences of rain during the drying period.

To develop more efficient control measures, the most prevalent and destructive postharvest diseases needed to be identified so that more efficient measures could be directed at a particular disease. There is a lack of information on the importance of individual postharvest diseases of onions in south Texas. For this reason a survey of bulb diseases was conducted from 1974 to 1976 to determine the relative importance of each of the postharvest disease of yellow onion bulbs that occur in south Texas.

MATERIALS AND METHODS

Yellow onion varieties 'Texas Yellow Grano 502', 'New Mexico Yellow Grano' and 'Ben Shamen' were grown in field plots and received cultural treatments similar to commercial plantings. The onions were harvested by hand clipping when approximately 50 percent of the tops had fallen over. Similar samples were also taken from commercial fields. All onions were dried in forced air driers for 12 to 24 hours at 37.8°C.

Onion samples consisting of 50 bulbs were placed in 8.2 kg (18 Lb) mesh citrus bags, with each sample replicated three times. The bagged onions were stored for three months in large chambers at 26.7°C and 70% relative humidity

(RH) during 1974-75 and at 21.1°C and 80% RH during 1976. The bulbs were visually inspected for disease symptoms at 2 week, 1, 2, and 3 month intervals. The causal organism was identified by visual and microscopic examination and their frequency recorded. The tests were conducted from 1974 through 1976 with several tests being conducted each year.

Table 1. Percentage bulbs lost to postharvest diseases after three months in storage.

		Percent Loss [1]		
		Texas Yellow Grano 502	New Mexico Yellow Grano	Ben Shamen
Black Mold [2]	1974	44.7	46.7	--
	1975	22.0	76.0	52.7
	1976	27.8	30.0	65.6
Bacterial Soft Rot	1974	6.7	10.7	--
	1975	1.3	2.7	2.7
	1976	6.0	1.5	3.3
Fusarium Basal Rot	1974	1.0	0.0	--
	1975	0.0	0.0	0.0
	1976	0.0	0.0	0.0
Botrytis Neck Rot	1974	0.0	0.0	--
	1975	0.0	0.0	0.0
	1976	0.0	0.0	0.0

[1] Each numerical entry is an average of 3 replicates with 50 bulbs per replicate.
[2] Bulbs were stored at 26.7°C and 70% relative humidity (RH) during 1974 and 1975 and at 21.1°C and 80% RH during 1976.

RESULTS AND DISCUSSION

Black mold, caused by *Aspergillus niger* van Tiegh, was the most prevalent disease on all three varieties sampled in all tests (Table 1). Black mold losses ranged from 22.0 to 76.0 percent after three months in storage. Losses from black mold steadily increased during the 3 months testing period (Table 2). Bulb losses from black mold after two weeks in storage were generally low in most tests, ranging from 0.0 to 7.8 percent, with the exception of 'New Mexico Yellow Grano' and 'Ben Shamen' in 1976 where losses were 25.6 and 50.0 percent, respectively. The high percentage losses in 1976 were attributed to a two week rainy period prior to harvest.

Black mold causes only minor physical damage to the bulbs. The disease reduces the market value of the bulbs by producing an unattractive black

powdery mass of spores commonly found underneath the outer dry scales. *A. niger* is a common saprophyte in south Texas soils and onion bulbs are usually contaminated by spores on the outer scales. The severity of black mold is dependent on the amount of rain before and during harvest and the relative humidity levels during storage and transit (6).

Table 2. Black Mold losses of onion bulbs at various time intervals following harvest.

		Percent Loss[1]		
		1974	1975	1976
Texas Yellow Grano 502 [2]	2 Weeks	5.3	0.0	7.8
	1 Month	5.3	4.0	15.5
	2 Months	17.3	14.0	21.1
	3 Months	44.7	22.0	27.8
New Mexico Yellow Grano	2 Weeks	0.0	5.3	25.6
	1 Month	0.0	38.0	26.7
	2 Months	4.7	75.0	27.8
	3 Months	46.7	76.0	30.0
Ben Shamen	2 Weeks	--	0.0	50.0
	1 Month	--	22.7	56.7
	2 Months	--	35.3	56.7
	3 Months	--	52.7	65.6

[1] Each numerical entry is an average of 3 replicates with 50 bulbs per replicate.
[2] Bulbs were stored at 26.7°C and 70% (RH) during 1974 and 1975 and at 21.1°C and 80% RH during 1976.

Bacterial soft rots constituted the next major disease problem. The losses were not of the magnitude of the black mold losses (Table 1). Losses ranged from 1.3 to 10.7 percent after three months in storage. Several types of soft rot symptoms were evident and were typical of those described as caused by species of Erwinia and Pseudomonas (4). Attempts were not made to determine the percentage losses caused by each genus of bacteria.

Fusarium basal rot was evident in one test in 1974 but was not of major importance (Table 1). The basal rot was associated with a pink root, *Pyrenochaeta terrestris* (Hansen) Gorenz, Walker and Larson, infection. Onion bulbs are more susceptible to Fusarium basal rot infections following pink root infections (1).

Botrytis neck rot, caused by *Botrytis squamosa* Walker, was not detected during the course of this study. Botrytis neck rot occurs sporadically in south Texas; however, it can cause serious damage on onion bulbs when it does occur. Roseberg (3) and McLean and Sleeth (2) reported such an outbreak in 1959; however, since then, Botrytis neck rot has not caused serious economic losses to onion bulbs in south Texas.

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Evaluation of Controlled Release Nitrogen Fertilizers on Cantaloupes & Bell Peppers

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ABSTRACT

Several experimental controlled release N fertilizers were evaluated on cantaloupes and bell peppers in the Lower Rio Grande Valley of Texas. Vegetable yields responded somewhat to the rate of N, but not to the fertilizer type or timing of application. Increases in plant tissue N levels were caused by fertilization rates higher than those giving a yield response. Under moderate rainfall conditions, soil NO_3^--N levels were greater where slow release materials were applied preplant than where conventional fertilizers were applied in several split applications. This improved N availability in the soil could be of benefit in vegetable production.

Nitrogen (N), the plant nutrient required in greatest abundance from the soil, is frequently a limiting factor in crop production. Considerable effort goes in to supplying this nutrient for optimum yields. Use efficiency of fertilizer N is often low causing considerable waste. Losses occur through leaching, volatilization and denitrification depending on various conditions. Conventional fertilizers are applied in excessive quantities or at frequent intervals on vegetable crops to compensate for such losses. Preplant N fertilization at high rates could retard germination and early growth, while later applications increase susceptibility of fruit to infection by bacterial soft rot (8).

Controlled release N fertilizers have been developed in efforts to overcome or reduce these problems. Such materials fall into two general categories. In the first group, N is held in a complex chemical structure such as methylene urea, a reaction product of urea and formaldehyde. The second group consists of coated fertilizers such as sulfur coated urea. Release patterns can be controlled by varying conditions of manufacture resulting in many types being available.

The efficiency of controlled release materials as a nitrogen source has been demonstrated for a variety of crops and soils (2). Uses have been mostly on turfgrass and specialty horticultural applications. Rising costs have stimulated interest in the possibility that slow release fertilizers could economically improve N use efficiency in vegetable production.

Several studies have explored the potential of slow release fertilizers for peppers and cucurbits. Retardation of bell pepper early plant growth occurred in Florida with a conventional, but not with a controlled release, starter

fertilizer (1). Pepper yields in Florida increased with up to 250 lbs N/A (4), but no yield differences due to the type of fertilizer, conventional or slow release, were found. Muskmelons in Indiana (10) and cantaloupes in California (7) had lower yields using slow release than with conventional fertilizers at equivalent N rates. In Florida, watermelon yields were the same for split applications of soluble urea and preplant sulfur coated urea (5).

In the Lower Rio Grande Valley, bell pepper yield responses have been shown for up to 120 lbs N/A applied (9). Slow release fertilizers have been tried in this area in the form of coated NH_4NO_3 (3). These materials improved forage yields in greenhouse studies after leaching over noncoated NH_4NO_3. Under field conditions, cabbage yields were not affected by these coatings, but N leaching losses were reduced.

This study was conducted to evaluate two sulfur coated ureas and two methylene ureas, on cantaloupes and bell peppers in the Lower Rio Grande Valley of Texas. These materials were compared with conventional fertilizers for yield, N uptake and N transformations in the soil.

Table 1. Fertilizer treatments applied to vegetable crops in 1978. Unless otherwise indicated, all fertilizers were applied preplant.

Fertilizer	Peppers		Cantaloupes	
	Spring	Fall	Spring	Fall
	lbs N/A			
	0	0	0	0
21-0-0 $(NH_4)_2SO_4$	100 split	100	80 split	80
	200 split	100 split	120 split	80 split
46-0-0 $CO(NH_2)_2$		100		80
		100 split		80 split
Methylene Urea				
35% W.I.N.[1]	100	100	80	80
	200		120	
58% W.I.N.	100	100	80	80
	200			
Sulfur Coated Urea				
2 month release	100	100	80	80
	200			
4 month release	100	100	80	80
	200		120	

[1] W.I.N. = Water insoluble nitrogen.

MATERIALS AND METHODS

Field studies were conducted in the spring and fall of 1978 at the A&M University Agricultural Research and Extension Center at Weslaco. Treatments (Table 1) were replicated four times in the spring and five times in the fall in randomized block designs. Bell peppers (Lucky Green Giant variety) were planted in plots three 40 inch rows wide by 24 ft. long, and cantaloupes (TAM Uvalde variety) were planted in plots one 80 inch row wide by 46 ft. long. Nitrogen fertilizers were banded 6 inches below and 6 inches on both sides of the seed row, either at planting or in several split applications. Split fertilizer treatments were applied to bell peppers at thinning when plants were 4-6 inches tall, when plants reached about 8 inches tall, near bloom, and after first fruit set. Cantaloupe split fertilizer applications were made at thinning when plants had 2-4 leaves, and at the early runner stage of growth. Irrigations were made as required to keep the seed row moist until a stand was obtained, then as necessary to keep plants healthy.

Soil samples were taken with a hand probe in the center of the bed 6 inches deep prior to planting and at various intervals during crop growth. These samples were analyzed for NO_3^--N by Kjeldahl distillation.

Leaf petiole samples were taken from young mature leaves (6) once as fruit approached maturity. Total N was determined by wet digestion and Kjeldahl distillation.

Yield data were obtained by harvesting the center row of each bell pepper plot, and the entire plot for cantaloupes, in several pickings as fruit matured.

RESULTS AND DISCUSSION

Bell pepper and cantaloupe yields in the spring of 1978 responded only to the rate of N, not to the fertilizer type or timing of application. Bell pepper yields were increased by 100 lbs N/A over the no N control, but were decreased slightly at 200 lbs N/A (Table 2). Cantaloupe yields were increased slightly by 80 or 120 lbs N/A over the no N control (Table 3). Differences in yield between types of fertilizer were erratic and inconsistent, and reflected high variability between replications of treatments. Fall yields were not obtained due to heavy insect and disease pressure on both crops associated with a wet fall and further complicated by an early December freeze.

Differences in petiole N content best reflected the N treatments applied, and seems to be a good indication of N levels available to the plant. Bell pepper petiole N levels in the spring were 2.01, 2.46, and 2.68% for 0, 100 and 200 lbs N/A, respectively. Cantaloupe petiole N levels in the spring were 1.18, 1.15, and 1.28% for 0, 80, and 120 lbs N/A, respectively. These increases in tissue N at higher N fertilizer rates where yields leveled off or decreased indicate a luxury consumption of N going into vegetative growth and not fruit production. Various differences in petiole N are shown for certain treatments (Table 4). The only consistent increase in petiole N by a treatment over the no N control was for split applications of the conventional fertilizers. Slow release materials were in most situations comparable to split conventional fertilizers.

Soil N measurements indicated differences between types of fertilizer materials. Eleven weeks after planting in the spring both slow release types

Table 2. Bell pepper yields under various fertilizer treatments, Spring 1978.

Fertilizer	lbs N/A 0	100	200
	Tons/A		
21-0-0	6.15[1]	6.64	7.41
Methylene Urea			
35% W.I.N.		8.48	6.80
58% W.I.N.		6.37	6.94
Sulfur Coated Urea			
2 month release		6.95	7.58
4 month release		7.87	6.41
Ave.	6.15	7.26	7.08

[1] Statistically significant differences were found only between rates of N applied, not between fertilizer types or timing of application.

Table 3. Cantaloupe yields under various fertilizer treatments, Spring 1978.

Fertilizer	lbs N/A 0	80	120
	Tons/A		
21-0-0	20.6[1]	21.3	21.1
Methylene Urea			
35% W.I.N.		21.9	21.5
58% W.I.N.		21.3	
Sulfur Coated Urea			
2 month release		19.8	
4 month release		21.5	21.3
Ave.	20.6	21.2	21.2

[1] Differences between means were not statistically significant.

Table 4. Leaf petiole N content under various fertilizer treatments, 1978.

Material	Bell Peppers			Cantaloupes		
	Rate	Spring	Fall	Rate	Spring	Fall
	lbs N/A	%		lbs N/A	%	
	0	2.01 a[1]	1.79 a	0	1.18 ab	1.95 abc
21-0-0	100 split	2.70 b	2.30 d	80 split	1.27 ab	2.29 d
	200 split	2.63 b		120 split	1.36 b	
	100		2.11 bcd	80		2.16 bcd
46-0-0	100 split		2.06 abcd	80 split		2.24 d
	100		1.83 ab	80		1.88 a
Methylene Urea						
35% W.I.N.	100	2.40 ab	2.28 cd	80	1.09 a	2.17 cd
	200	2.39 ab		120	1.28 ab	
58% W.I.N.	100	2.04 a	1.97 abc	80	1.07 a	1.98 abc
	200	2.68 b				
Sulfur Coated Urea						
2 month release	100	2.48 ab	2.11 bcd	80	1.23 ab	1.91 ab
	200	2.77 b				
4 month release	100	2.67 B	2.31 d	80	1.08 a	1.96 abc
	200	2.75 b		120	1.32 b	

[1] Means in each column followed by the same letter are not statistically different at the 5% significance level using Duncan's multiple range test.

showed higher available N in the top 6 inches than split 21-0-0 (Fig. 1). The advantage later disappeared for the methylene ureas while the superiority of the sulfur coated ureas continued up to 20 weeks. In the fall, all preplant treatments had higher soil N levels after 3 weeks, but most inorganic soil N was leached out by 10 weeks. Rainfall during the growing period in the spring was 2.9 inches, while in the fall 15.8 inches were recorded.

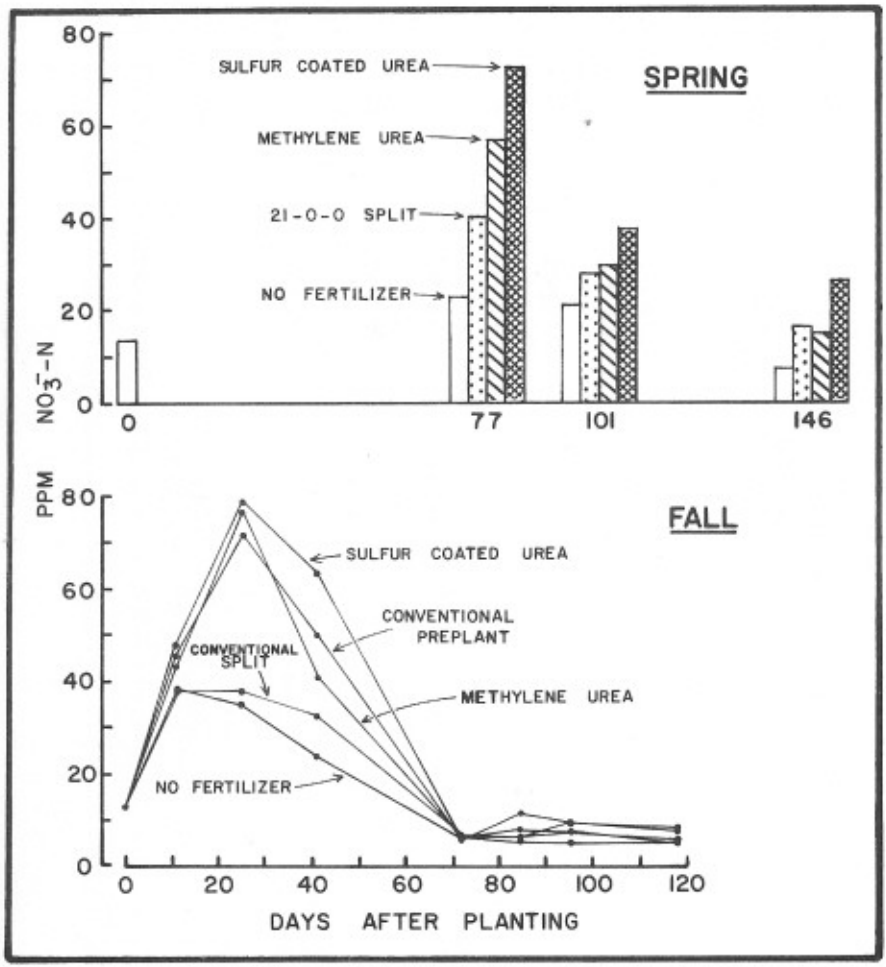

Fig. 1. Soil NO_3^--N levels under various fertilizer types, 1978.

Slow release N fertilizers were found to provide some benefits in maintaining high soil N availability. Improved inorganic soil N levels were provided by slow release materials when excess leaching did not occur, with sulfur coated ureas performing better and longer than methylene ureas. After heavy rainfall, additional N applications would be necessary regardless of which material was used. Loss of N by light rain or irrigation, however, is less when using slow release than conventional materials. Plant tissue N levels appear to be related to measured available soil N levels early during plant growth. At this time slow release materials have a disadvantage because some of the N is being held in unavailable forms. Lack of yield differences between treatments and the minimal yield response to rate of N indicate that N levels were not a limiting factor in production. Initial soil NO_3^--N levels were low at around 12 PPM. Crop and fertilizer history of a field must therefore be considered when determining fertilizer requirements. A good test for evaluating the N supplying potential of a particular soil prior to planting these crops would be most useful in this regard.

ACKNOWLEDGEMENT

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Carrot-Passion Fruit Drinks

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ABSTRACT

Carrot-passion fruit juice blends were analyzed for changes in nutritional composition due to blending and processing variables and evaluated for flavor acceptance. Nutritional analysis showed β-carotene content greater in blends prepared using Danvers cultivar carrot juice than in blends using Imperator. Blends prepared using Imperator cultivar contained more ascorbic acid, niacin, thiamine and caloric value than blends prepared from Danvers cultivar.

A nine-member taste panel, using a 9-point Hedonic scale, scored a blend containing 60% carrot juice, 15% passion fruit juice, 7% sugar and 18% water 6.4 and plain carrot juice 3.0.

Carrot juice is compatible with passion fruit juice, and an acceptable nutritious beverage can be prepared from carrots and passion fruit.

Processing of carrot juice presents several problems: low acidity, curdling, and flavor change; researchers have sought solutions to these problems for some time.

The low hydrogen-ion concentration (0.07% - 0.10%) of carrot juice necessitates the use of high processing temperatures for extended periods to sterilize the product. High temperatures, however, cause undesirable changes in flavor and nutrients (9). Bigelow and Catheart (5) found that for a number of foods, the lower the pH values, the lower the processing temperatures necessary for their sterilization. Berry (4) found that below pH 4.2 no spore-forming bacteria could be isolated from canned tomato juice. Cruess et al. (7) acidified vegetable juices to pH 4.0 with citric acid and reported satisfactory processing results. Beattie and Pederson (3) acidified carrot juice to pH 4.0 with sauerkraut juice and flash pasteurized it at 180°F with little loss of the characteristic flavor.

Stephens et al. (15) prepared carrot juice free of coagulated material by blanching carrots for 5 min in a 0.05 N acetic acid solution prior to juice extraction. The juice, however was described as having an "earthy" flavor and flat taste. Turner (16) reported that some vegetable juices and fruit juices, flat and unpalatable alone, were quite pleasing when blended with another juice. Cruess and Chong (6) prepared an orange-carrot juice blend which they described as superior in quality and flavor to any of the commercially canned vegetable juices. Saldana et al. (13) used combinations of carrot, grapefruit, pineapple juices, lemon juice concentrate, carrot and orange purees, and

commercial artificial flavors of pineapple and orange in the preparation of a variety of carrot beverages with a pleasing flavor.

The object of this work was to increase the utilization of carrots, especially of those that do not meet fresh market standards, through the formulation of an acceptable drink of good nutrient quality.

MATERIALS AND METHODS

Two 25-lb batches of carrots, one each of Imperator and Danvers cultivars, were obtained from a local packer three times during the season. The carrots were washed and trimmed, and then juiced according to the method of Stephens et al. (15). Canned single-strength juice of yellow passion fruit was obtained from Germantown Manufacturing Company, Broomall, Pa. Yellow passion fruit juice was chosen for this experiment because of its aromatic, exotic and spicy flavor and high citric acid content.

Four beverage blends from each of the two cultivars were formulated as follows: D_2 - 37% carrot and 9% passion fruit juices, D_3 - 47% carrot and 12% passion fruit juices, D_4 - 60% carrot and 12% passion fruit juices, and D_5 - 60% carrot and 15% passion fruit juices. To each beverage blend was added 7% sugar and the remaining volume was water. These blends were heated to 180°F, canned in 303 enamel cans, sealed, processed 20 min in boiling water and then water cooled. Plain carrot juice (D_1) was heated to 180°F, canned, sealed, processed 30 min at 240°F and then water cooled.

The pH of each blend was measured with a Corning model 10 pH meter (Use of a company and/or product by name by the Department does not imply approval of recommendation of the product to the exclusion of others which may also be suitable). Titrable acidity (TA) was determined as % citric acid; the samples were titrated to an end point of pH 8.2. Brix was measured with a Baush and Lomb refractometer. The moisture, ash, fat, fiber, β-carotene, protein (Kjeldahl N x 6.25), thiamine (fluorometric), riboflavin (fluorometric), and niacin (bioturbidimetric) were determined by AOAC (2) methods. Calcium and iron were analyzed with a Perkin-Elmer model 303 Atomic Absorption Spectophotometer according to the procedure described by the manufacture of the instrument (1). Ascorbic acid was determined according to Nelson and Samens (11). Total carbohydrate and caloric values were calculated according to Merrill and Watt (10). Taste tests were conducted by a trained panel of 9 judges using the hedonic scale method of Peryam and Pilgram (12).

The experiment was replicated three times with duplicate analysis of each beverage sample. All data were subjected to analysis of variance according to Steel and Torrie (14).

RESULTS AND DISCUSSION

The quality factors and nutrient composition of plain carrot juice and carrot-passion fruit drinks presented in Table 1 are the means of both cultivars. The data show that the level of passion fruit juice (9%, 12%, 15%) used contributed adequate acidity to lower the pH of the blends to about 4.0, thus permitting processing at open-bath temperatures. The pH remained the same because of the buffering system in carrot juice (3) although the amount of titrable acid

Table 1. Nutritional composition and quality factors of carrot-passion fruit drinks [z].

Analysis	D_1 [y]	D_2	D_3	D_4	D_5
Moisture %	91.86^{d} [x]	87.96^{c}	86.05^{b}	85.38^{ab}	84.62^{a}
pH	5.21^{b}	4.08^{a}	4.03^{a}	4.10^{a}	4.03^{a}
TA %	0.15^{a}	0.34^{b}	0.42^{c}	0.48^{d}	0.58^{e}
Brix	8.35^{a}	11.82^{b}	13.55^{c}	14.20^{d}	14.86^{e}
Ash %	0.70^{d}	0.30^{a}	0.41^{b}	0.49^{c}	0.52^{c}
Fat %	0.062^{a}	0.078^{ab}	0.121^{bc}	0.156^{c}	0.160^{c}
Fiber %	0.003^{a}	0.10^{b}	0.012^{b}	0.013^{b}	0.013^{b}
Iron %	0.0009^{a}	0.0008^{a}	0.0007^{a}	0.0007^{a}	0.0008^{a}
Calcium %	0.0268^{d}	0.0112^{a}	0.0140^{b}	0.0177^{c}	0.0180^{c}
Protein %	0.729^{c}	0.359^{a}	0.467^{b}	0.545^{bc}	0.597^{c}
Ascorbic Acid mg/100g	3.2^{a}	1.6^{a}	2.1^{a}	2.5^{a}	2.0^{a}
β-carotene mg/100g	10.87^{d}	4.05^{a}	5.73^{a}	6.72^{bc}	7.10^{cd}
Niacin mg/100g	0.737^{d}	0.483^{a}	0.583^{b}	0.627^{bc}	0.687^{cd}
Thiamine mg/100g	0.031^{c}	0.015^{a}	0.20^{b}	0.023^{b}	0.023^{b}
Riboflavin mg/100g	0.038^{bc}	0.026^{a}	0.033^{ab}	0.041^{bc}	0.044^{c}
Total Carbohydrate %[w]	6.66^{a}	11.41^{b}	12.92^{c}	13.44^{cd}	14.11^{d}
Caloric value Cal/100g[v]	30.15^{a}	47.72^{b}	54.58^{c}	57.22^{cd}	60.18^{d}
Taste Test[u]	3.0^{a}	5.4^{b}	5.9^{bc}	6.3^{c}	6.4^{c}

[z] Data represents the means of drinks from both Emperator and Danvers Cultivars.

[y] D_1 = Plain carrot Juice, D_2, D_3 etc. = Carrot-Passion Fruit Drinks

[x] Means followed by different letters on the same line are significantly different at the 5% level by Duncan's multiple range test

[w] Carbohydrate = 100% - (Moisture + Ash + Fat + Protein)%

[v] Caloric value = %Protein X 2.44 + %Fat X 8.37 + %CHO X 3.57 (Merrill and Watt, 1973)

[u] Hedonic Scale of Peryam and Pilgram with numerical values of 1 to 9. 1 = Dislike extremely, 9+ like extremely

increased proportionally with the quantity of passion fruit juice used from blend to blend.

Some nutrients were higher and others lower in the blends than in the plain carrot juice. The changes are attributed to formulation and processing variables and to differences in nutrient composition between carrot and passion fruit juices.

Vitamin A is the principal nutrient in carrots. A 6 fl. oz. serving of carrot-passion fruit drink D_5 would supply the following percentages of the RDA (Recommended Daily Allowance): Protein (2%), Vitamin A (400%), Ascorbic Acid (6%), thiamin (3%), riboflavin (4%), niacin (6%), calcium (3%), and iron (8%).

Table 2 shows the effect of carrot cultivar on the nutritional composition of the carrot-passion fruit drinks. Blends prepared with Imperator were higher in ascorbic acid, niacin, thiamine, and caloric value than those prepared with Danvers. Beverages prepared with the Danvers cultivar were higher only in β-carotene.

Taste test showed that carrot juice and passion fruit juice are compatible and that the blends containing 12% and 15% of passion fruit juice, were acceptable.

Table 2. Effect of carrot cultivar on the nutritional composition of carrot-passion fruit drinks.

Analysis	Carrot cultivar	
	Imperator	Danvers
TA %	0.42[b] [z]	0.39[a]
Moisture %	86.80[a]	87.55[a]
Ascorbic acid mg/100g	3.70[b]	0.78[a]
β-carotene mg/100g	5.37[a]	8.41[b]
Niacin mg/100g	0.733[b]	0.513[a]
Thiamine mg/100g	0.024[b]	0.021[a]
Caloric value cal/100g	51.41[b]	48.53[a]

[z] Means followed by different letters on same line are significantly different at the 5% level by Duncan's multiple range test.

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Oil Quality of Soybean Cultivars from the Lower Rio Grande Valley

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ABSTRACT

Seventeen soybean varieties grown in the Lower Rio Grande Valley of Texas were evaluated for yield, oil, protein and percent unsaturation of their oils. Three varieties outyielded the Texas production average of 69.2 bushels per hectare (28 bu/acre). Seven other varieties yielded more than 49.4 bushels per hectare (20 bu/acre). Three varieties had oil contents between 18 and 20%. The protein content of all varieties ranged between 37.1% and 45.6%. Ten soybean varieties produced oils with iodine numbers that indicated the presence of highly unsaturated fatty acids.

The ever increasing demand for soybeans and the adaptability of new, commercially acceptable varieties to South Texas have made soybeans a potential new crop for the Lower Rio Grande Valley of Texas (LRGV). Recent studies in the LRGV (4,5) have evaluated soybean varieties for yield and other plant characteristics. In another study (2) the chemical compositions of seven soybean varieties were evaluated and found to compare favorably with those of varieties grown in other areas of the United States. These investigations indicated the suitability of some soybean varieties for commercial production in the LRGV. The studies, however, did not evaluate the degree of unsaturation present in the oil of the soybean grown in South Texas.

MATERIALS AND METHODS

Seventeen soybean varieties were planted on July 7, 1975 at Rio Farms Inc., Monte Alto, Texas. The soil is a Willacy fine sandy loam. The planting was a randomized complete block design having 4 replications. Each plot consisted of 4, 101.6 cm beds 15.2 m long. Soybeans were planted double row with rows 25.4 cm apart. On November 15, 1975 the entire plants were harvested, placed in sacks, and then threshed in a stationary, A.C. 90 combine. The soybeans were allowed to dry at ambient temperatures.

Dried samples were ground in a Wiley Mill and sieved through a 0.2 cm screen. The ground samples were stored in air-tight containers at room temperature and analyzed for moisture, oil and protein.

Residual moisture and oil were determined on the soybean meals by AOCS methods (3). Nitrogen was determined by the Kjeldahl method (1). Protein was expressed as % Kjeldahl Nitrogen X 6.25.

Iodine numbers of the extracted oils were determined by the Wijs method (3) with a slight modification: soluble starch (Fisher Scientific Co., No. 5-517, "According to Lintner") indicator solution of required sensitivity was prepared in a glycerol base.

Duncan's multiple-range test was used to compare treatment means.

RESULTS AND DISCUSSION

Yields and bean and plant characteristics of seventeen varieties are presented in Table 1. Three varieties outyielded the average Texas production of 69.2 bushels per hectare. Seven other varieties yielded 49.4 to 64.6 bushels per hectare. All other varieties yielded less than the average soybean yield for Texas.

Table 1. Yield and seed and plant characteristics of 17 soybean varieties.

Variety	Yield [z] bu/ha	Days to Flower	Plant Height (cm)	Weight per 100 seeds (g)	% Protein [y] (N x 6.25)
D 73-9358	78.8	42	51.6	12.9	42.9
V-1	77.6	53	69.3	12.2	42.6
D 73-9360	70.6	49	56.1	13.5	43.2
F 73-9503	65.2	50	66.3	12.4	45.1
D 73-9356 (74 test)	63.0	49	59.2	10.3	42.3
Santa Rosa-RF	62.5	49	58.7	13.1	42.1
F 73-9304	60.3	50	59.2	14.7	42.8
Hardee	54.1	46	56.6	14.3	39.9
Hampton 266-A	52.9	42	48.0	18.8	42.9
F 73-9497	51.4	49	63.8	11.7	45.6
Cobb	45.9	42	52.6	13.7	37.1
F 67-5132	45.2	59	63.2	11.4	41.3
Santa Rosa (Brazil)	44.5	49	57.7	14.0	42.9
F 67-5237	41.8	57	72.4	16.1	42.5
Coker 102	37.9	46	53.6	20.7	41.9
TS-72-6	34.3	42	44.7	17.8	39.5
Jupiter	---	58	81.5	14.3	43.8

[z] Average of 4 replicates; LSD 15.1 at 5% level.
[y] Average of 4 replicates.

The number of days from planting to flowering varied from 42 to 59 but did not influence yield.

The weight of 100 seeds is an indication of bean size. The largest soybeans were produced by Coker 102; the smallest, by D 73-9356. Seed color of F 73-9304 was green; but that of all others was yellow.

Protein levels of the soybean varieties varied from 37.1% to 45.6%. The levels, slightly higher than those previously reported for other soybean varieties grown in the LRGV (2), were well within the ranges of levels for other soybean producing states (6). Protein content of the varieties under investigation did not vary significantly (Table 1).

Oil contents of meals from the seventeen soybean varieties, expressed as percent dry basis, are presented in Table 2. The oil contents of Cobb, TS-72-6 and Hampton 266A were within the average range determined for soybeans grown in northern areas (6). The values reported here, however, are slightly lower than those previously found for soybeans grown in the LRGV (2).

Table 2. Oil contents of meals from seventeen soybean varieties.

Variety	Percent Oil [z]	
Cobb	20.0	a
TS-72-6	19.9	a
Hampton 266A	18.8	a b
Coker 102	18.4	b c
Santa Rosa-RF	18.2	b c d
Hardee	17.5	b c d
Santa Rosa (Brazil)	17.5	b c d
F 67-5237	17.1	d e
F 67-5132	16.4	e f
F 73-9304	15.9	e f g
V-1	15.9	e f g
Jupiter	15.8	e f g
D 73-9356	15.4	g h
D 73-9360	14.7	h i
D 73-9358	14.6	h i
F 73-9497	14.1	h i
F 73-9503	13.3	i

[z] Average of 4 replicates:
Means followed by the same letter do not differ significantly at the 0.01 level according to Duncan's Multiple range test.

The iodine numbers of the extracted oils are presented in Table 3. Over half of the varieties tested contained oil with iodine values in the 131-138 average range considered indicative of acceptable unsaturation (6).

Table 3. Iodine numbers of oils extracted from seventeen soybean varieties.

Variety	Iodine Number [z]
D 73-9358	138.7 a
D 73-9360	138.2 a
D 73-9356	137.7 a b
F 73-9304	137.6 a b
F 73-9503	135.8 a b
F 73-9497	134.5 a b
Santa Rosa (Brazil)	134.1 a b
Cobb	132.7 a b
TS-72-6	132.2 a b
Santa Rosa RF	131.1 b c
Hardee	128.9 b c d
Jupiter	128.3 b c d
Hampton 266A	127.5 b c d
F 67-5237	125.9 b c d
V-1	125.7 b c d
Coker 102	120.4 c d
F 67-5132	118.6 d

[z] Average of 4 replicates:
Means followed by the same letter do not differ significantly at the 0.01 level according to Duncan's Multiple range test.

In this study, high yield was not necessarily indicative of high oil content or acceptable unsaturation. The highest yields were from D 73-9358. This variety had the highest iodine number (138.7) and a high protein content (42.9%) but a very low oil content (14.6%). Variety V-1, with the second highest yield, ranked very low in iodine number (125.7), had a low oil content (15.9%), but a high protein content (42.6%).

The three varieties with the highest oil content were Cobb, TS-72-6 and Hampton 266A. Yields for Cobb (45.9 bu/ha) were well below the Texas soybean average of 69.2 bushels per hectare. Cobb had the lowest protein content of all varieties investigated (37.1%) but the unsaturation present was acceptable (132.7). The second highest oil content (19.9%) was obtained from the variety TS-72-6. Yields for this variety were the lowest (34.3 bu/ha) but its unsaturation was acceptable (132.2). Hampton 266A with the third highest oil content (18.8%) gave a low yield (52.9 bu/ha) and the amount of unsaturation present in its oil was slightly below the acceptable range of 131-138.

Our study, showing the high protein content and the acceptable amount of unsaturation present in the oils produced by half of the soybean varieties tested, complements earlier studies on the potential of soybeans as a crop for the LRGV.

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The Effect of Rainfall, Fruit Growth, and Fungicide Application on Melanose Severity on Texas Grapefruit, 1976-1978

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ABSTRACT

Major outbreaks of melanose occurred with extended rainfall periods in July, 1976 and June, 1977. Only minor infection occurred in April and May of 1976 and 1977 and throughout the season in 1978. Fruit did not reach the resistant stage until late July or early August in 1976 and 1977. Some minor infection occurred with extended periods of rain as late as September in 1978. Postbloom fungicide applications were ineffective for melanose control when major infection periods occurred in the summer. In such years, an early-summer application would be needed for maximum control.

Additional key words: *Diaporthe citri, Phomopsis citri*

Melanose, caused by the fungus *Diaporthe citri*, produces a rind blemish which eliminates a considerable amount of fruit from fresh market use in some years. Conidia of the fungus are splash-dispersed from dead twigs during warm, wet weather and infect fruit, leaves and twigs. Mature tissues are not infected, but the exact size or age at which the fruit becomes resistant is not well-established. In Florida, grapefruit are considered susceptible to infection until they reach at least 2.5 inches in diameter (5), which usually occurs by mid-June. Under Texas conditions, fruit up to 2.8 - 3.0 inches in diameter is frequently infected and grapefruit may not attain this size until late July or early August in many years (3).

The extended period of susceptibility of Texas grapefruit to melanose infection and erratic rainfall patterns cause problems in timing fungicide applications. For many years, a single postbloom application of a copper fungicide was recommended for melanose control (1). In light of new information, the trend in Texas has been to delay fungicide application until late April or early May or to make a second application in late May or early June (2, 3).

We have previously studied the relationship of fruit growth, rainfall, and postbloom fungicide applications to the incidence of melanose on Texas grapefruit from 1970-75. Data collected over the last three years has confirmed the conclusions drawn from that study.

MATERIALS AND METHODS

Temperature and rainfall records used in this study were taken at the main campus of the Texas A&I University Citrus Center in Weslaco. The occurrence and length of probable infection periods (Table 1) were based on examination of weather records and observations of fruit for symptoms. The minimum criteria for infection used were those of Whiteside (4), that is, 12 hr of wet foliage with the temperature above 25 C or 18 hr of wet foliage with temperatures from 15-25 C. The number of hours that temperature and rainfall were favorable for infection from April 1 to August 1 were totaled for each year (Table 1). The time of occurrence of probable infection periods is indicated in Fig. 1.

Table 1. Effect of length of infection periods and an application of cupric hydroxide on the incidence of melanose in grapefruit.

Year	Total h favorable for infection [a]	% fruit downgraded [b]	
		no fungicide	cupric hydroxide [c]
1976	336	48	36 [d]
1977	156	17	3 [d]
1978	64	0.8	0.4

[a] Total length of periods of 12 hr or more with wet foliage and temperatures above 25 C or periods of 18 hr or more with wet foliage and temperatures from 15-25 C.

[b] Fruit downgraded by melanose to US # 2 or useful only for processing.

[c] Cupric hydroxide (Kocide 101) applied at 0.75 lb/100 gal from April 15-20 in each year.

[d] Significantly different from the control at P = 0.05.

Fruit diameter measurements were begun in April and continued at about weekly intervals throughout the season. The initial sample consisted of 288 fruit in two Citrus Center orchards, but some fruit was lost as the season progressed. A diameter of 2.8 inches was designated as the approximate size at which fruit becomes resistant (Fig. 1).

Melanose severity was rated in a 25-year-old 'Webb Redblush' grapefruit (*Citrus paradisi* Macf.) orchard. Sprayed plots received applications of cupric hydroxide (Kocide 101) at 0.75 lb/100 gal of water about April 15-20 each year. Treated and control plots were replicated on six 8-tree plots in a randomized complete block design. Melanose severity was rated on at least 20 fruit from each of 2 trees within each plot for a minimum of 240 fruit per treatment.

Additionally, in 1978, two blocks of 25-30 trees each were sprayed as above and two left as nonsprayed controls in another mature 'Webb Redblush' grapefruit orchard. Twenty-four fruit on each of two trees were tagged in

April, 1978 for a total of 96 fruit per treatment. The diameter of each fruit was measured and the fruit inspected for melanose symptoms at 3 to 4-week intervals.

RESULTS AND DISCUSSION

In 1976, fruit growth was relatively slow and most fruit had not reached the resistant stage by the end of July (Fig. 1). Minor infection periods occurred in April and May, but severe melanose damage did not occur until after 10 consecutive days with rainfall in July. In 1976, 48% of the fruit was downgraded by melanose damage (Table 1). An April application of cupric hydroxide reduced damage, but the fungicide was applied too long before the major infection period to provide acceptable control.

In 1977, the total number of hours favorable for infection was considerably less than in 1976 (Table 1). Minor infection periods occurred in April and May, but most of the damage occurred during two periods in June. Although substantial melanose damage occurred, the fungicide application was more effective because the major infection period occurred a month earlier than in 1976 (Fig. 1).

In 1978, fruit grew slowly, especially during hot, dry weather in July and did not reach 2.8 inches in diameter until late July (Fig. 1). Minor infection periods occurred in early April before the fungicide application and in June. There was little melanose damage.

In the orchard where tagged fruit was followed in 1978, some speck melanose developed on six fruit following the early April infection period before the fungicide application. After the early June infection period, seven fruit in the control and one fruit in the sprayed plots developed melanose. Following the late June infection period, five fruit in the control and one in the sprayed plots showed melanose symptoms.

In 1978, after a dry summer, 14.5 inches of rain fell from late August to early October. Some melanose did occur as a result of these rains, but injury was mostly too minor to downgrade fruit. New growth flushes and off-bloom fruit had severe melanose damage, as expected. Of the fruit tagged in April 1978, five developed speck melanose following infection periods between September 5 and October 3, and three fruit developed moderate, but superficial, damage. These fruit ranged from 2.8 to 3.4 inches in diameter on September 5 and from 3.2 to 3.7 inches in diameter on October 3. Apparently, not all of the fruit with large diameters were completely immune to melanose infection.

The 1976-1978 data re-emphasize the conclusions drawn from the earlier study (3). Major infection periods occurred in five of the eight years for which we have data. The major infection period occurred in June in three of the five years and in July in the other two. While the possibility of a major infection period in April or May can not be eliminated, more emphasis should be given to protecting young fruit during warm, wet periods in summer. Fungicide applications should be delayed as long as possible or two applications, one in April and one in early June, should be made. In some cases, growers may wish to use a fungicide in the early summer spray rather than in the postbloom spray.

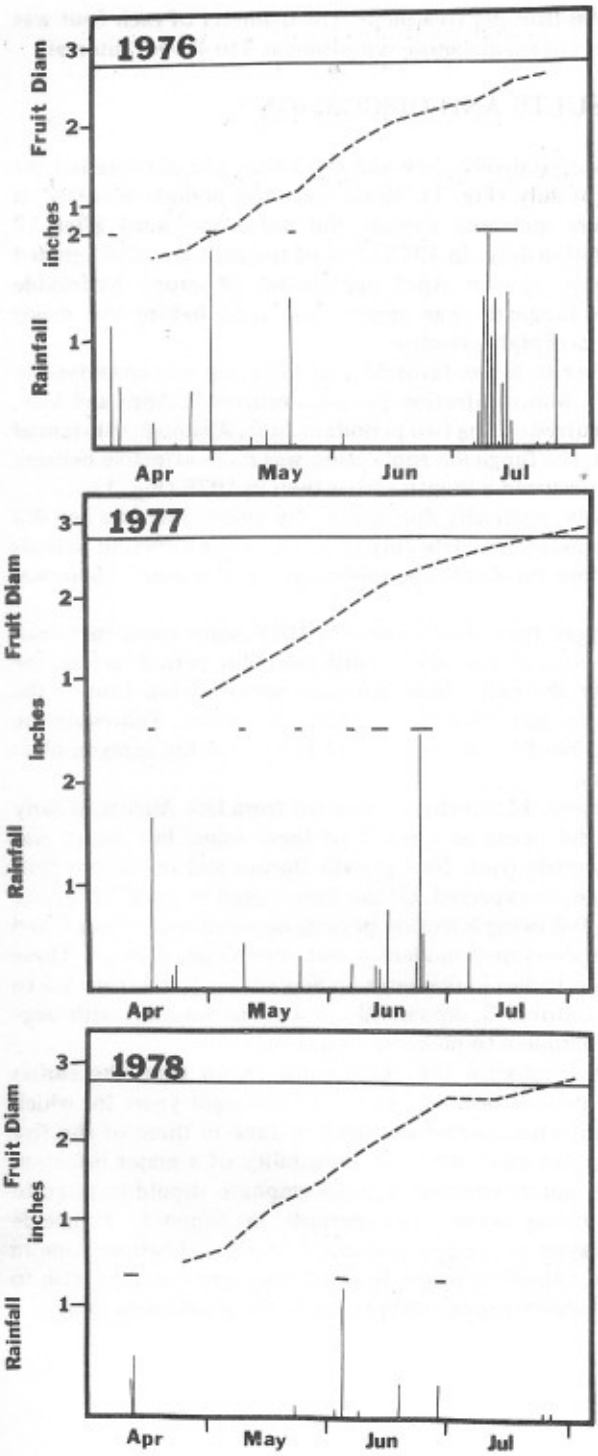

Fig. 1. Fruit growth and rainfall data from April through July 1976, 1977, and 1978. The solid horizontal line at 2.8 inches on the fruit growth graphs indicates the approximate size at which fruit are expected to become resistant. Horizontal bars over the vertical bars for rainfall indicate probable infection periods and their approximate length.

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Citrus Rust Mite Control Affected By Certain Pesticides

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ABSTRACT

Residual control of citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), was affected by the addition of certain pesticides to acaricides and by the total gallonage applied per acre. Residual control provided by Acaraben^{R} (chlorobenzilate) and Kelthane^{R} (dicofol) against this mite was reduced when copper or Supracide^{R} (methidathion) was added to the mixture. Length of control was generally shorter as the total gallonage/acre was reduced. Acaricides applied in August or September in this experiment did not provide effective citrus rust mite control during the winter months. Kelthane provided longer residual control than other materials in several instances.

Additional key words: citrus, integrated citrus pest management.

Citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), has been the number one pest of Texas citrus and the target of most pesticidal applications since the 1930s. Russeting of fruit by this mite has been the principal reason for failure to meet fresh fruit standards. The primary objective of this experiment was to evaluate the effectiveness of certain pesticides or mixtures of pesticides against citrus rust mite.

MATERIALS AND METHODS

The experimental site was located 5 miles north and 2-3/4 miles west of Mission. Each of the four plots was 15 rows wide and 6 acres in size. Trees were Ruby Red grapefruit, except that one-half of Plot II had Valencia oranges on the east and Plot III had Navel oranges on the east. Trees were reset in most of the area.

An airblast sprayer applied 150 gal/acre for the first 3 applications in 1975, while a Kinkilder sprayer was used at 50 gal/acre on 11/11/75 and 3/12/76. The grower sold his airblast sprayer and utilized the Kinkilder sprayer for awhile. Beginning on 5/10/76, a Swanson sprayer applied 80 gal/acre for the balance of the test period. Sprays were delayed on occasions because of machinery problems, adverse weather conditions, or spraying of other citrus was considered more critical.

Various pesticides (Trade, common, and chemical names) of designated formulations were as follows: 45.3% EC Acaraben^{R}, chlorobenzilate, ethyl 4,4'-dichlorobenzilate; 42% EC Kelthane^{R}, dicofol, 4,4'-dichloro-alpha-(trichloromethyl) benzhydrol; 77% WP Kocide 101^{R}, cupric hydroxide; 99.35% oil, (Orchex 796); 24.5% EC Supracide^{R}, methidathion, O,O-dimethyl phosphorodithioate S-ester with 4-(Mercaptomethyl)-2-methoxy-Δ^{2}-1,3,4-thiadiazolin-5-one; and 50% WP Vendex^{R}, Shell 14114, hexakis(2-methyl-2-phenyl-propyl) distannoxane. Trade names are used hereafter.

Infestations of citrus rust mites were determined by examination of fruit with 14X Hastings triplet hand lens similar to the method used by Jeppson et al. (1). One lens field was examined from the exposed and backside of fruit as situated on the tree, and taken from the northeast and northwest quadrants of each tree until 100 lens fields had been examined. A minimum of 25 trees was utilized for each sample. A lens field was considered infested if one or more motile rust mites were found. Undersides of leaves were examined when fruit were not available. Samples per plot varied from 4 to 8 (400-800 lens fields), but only relevant counts are shown in the tables. In Florida, 10 to 15% infested lens fields is a level at which treatment is considered necessary.

RESULTS AND DISCUSSION

In 1975 citrus rust mite population increased more following two applications of Supracide in Plot II than in other plots (Table 1). Acaraben was applied again in November to reduce their numbers.

In 1976 each plot required four applications for citrus rust mite control (Table 2). Copper was applied in each plot twice. Only one application of Supracide was used in Plot II. Several months had passed since a rust mite controlling agent had been applied so, large numbers prevailed early in the year and use of a Kinkilder sprayer at reduced gallonage did not provide adequate kill of citrus rust mites in 23 days. A Swanson sprayer was used in May when copper was added to all treatments. In March, citrus rust mite population in Plot II was smaller than in other plots, but increased more following the Supracide-Acaraben-copper mixture than in Plots I and III and required early treatment in June. Not until September did rust mite infestations stay below the 10% infested lens field levels to allow delay of further treatment. Rust mite population following the late Kelthane application was lower going into the winter than in other plots. Copper addition in May reduced the residual control of rust mites.

Carry-over populations of citrus rust mites from the 1976 season were evident early in 1977 (Table 3) in all except the Kelthane plot which had been treated later in 1976. A greater number of mites per infested lens field was also found. Plot II had been treated a month earlier than Plot I. Plots I and III were treated with Acaraben in late March. Copper was added only in the north half of Plot I in order to provide further evidence of increase of rust mite population following copper use. Counts in the north half of Plot I had higher numbers of rust mites (data not shown) as was the case in this plot when treated in June. Copper was added to Kelthane in late May to the north half of Plot IV. Larger rust mite numbers were also found in this copper-treated area. Plot I had a higher rust mite population prior to the March application than Plot III and continued to maintain a higher level during the year probably associated with the addition

of copper to one-half the plot in May. The higher rust mite populations were difficult to reduce below desired levels. This was also true with Plot IV when oil and copper were added to Kelthane. Early treatment of Plot II in late February assisted in holding rust mite population at lower levels. Following the October application, rust mite populations declined to low levels in all plots.

The carry-over population of citrus rust mites from 1977 was quite low, so, the first application in all plots was delayed until April 20 (Table 4). Pesticides were applied at that time to avoid a possible delay of treatment and to treat lower numbers before the expected spring increase in populations. Copper was applied to one-half of Plot I with Vendex and rust mite population was higher after 82 days than in other plots. Supracide was added to Acaraben and Kelthane in the April and August applications to Plot II and was followed with a higher population of rust mites than the oil-Acaraben in Plot III or Kelthane in Plot IV. Rust mites were not a problem following the October applications.

Numerous implications resulted from this experiment: residual control of citrus rust mites was reduced with smaller volumes of spray mixture per acre. Residual control of rust mites was reduced when copper or Supracide was added to other pesticides. Treatment in October or November resulted in lower winter carry-over of rust mite than did August or September applications. Counts of 10-15% infested lens fields appear too large before re-treatment according to the conditions of this experiment.

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Table 1. Citrus rust mite infestation of grapefruit following various pesticides, Mission, Texas, 1975.

Date	Post Treatment Days.	Sprayer Type [z]	Percent infested lens fields, pesticides applied [y] I	II	III	IV
4/15/75		AB	C(4)	S(5.5) - C(5)	0(5.5) - C(5)	D(6)
7/2	89		.2	.6	.6	3.5
7/2		AB	0(6) - C(4)	0(6) - C(4)	0(6) - C(4)	D(6.5)
8/13	42		1.5	4.1	.4	1.0
9/9	69		1.6	15.2	2.8	5.0
9/12		AB	C(6)	S(5) - C(5)	C(5)	D(6)
10/21	39		.2	.9	.2	1.6
11/4	52		1.5	7.0	1.5	2.7
11/11		Kin		C(4)		
11/18	66		1.6	0.0(7) [x]	4.1	5.6

[z] Type-gal/acre: AB=airblast-150, Kin=K-50.

[y] Rates/acre ( ) of concentrated pesticides were as follows in pints for C-Acaraben, D-Kelthane, and S-Supracide; gal for 0-oil.

[x] Days after treatment differing from Column 2.

Table 2. Citrus rust mite infestation of grapefruit following various pesticides, Mission, Texas, 1976.

Date	Post Treatment Days	Sprayer Type [z]	Percent infested lens fields, pesticides applied [y] I	II	III	IV
2/3/76	143		9.2	.2(84)[x]	4.5	4.2
3/10	179		61.2	19.5(120)[x]	51.9	44.9
3/12		Kin	C(5)	C(5)	C(5)	D(5)
5/4	23		16.6	13.6	8.6	3.5
5/10		S	C(5.5)-K(4)	S(4)-C(5)-K(4)	0(7)-C(5)-K(4)	D(5)-K(4)
6/9	30		4.1	5.9	5.6	17.1
6/24	45		12.2	16.5	11.6	
6/29		S		C(5)-K(3)		
7/17		S	0(5)-C(6)-K(3)		0(5)-C(4.6)-K(3)	D(6)-K(3)
7/29	12		7.0	4.0(30)[x]	7.0	1.0
8/9	23		10.2	5.5(41)[x]	13.5	2.8
8/10		S	C(5)		C(5)	
9/2	23		.7	21.2(65)[x]	.7	2.2(47)[x]
9/7		S		C(4)		
9/22	43		1.0	.6(15)[x]	1.0	8.2(67)[x]
10/4						22.0(79)[x]
10/5		S				D(6)
11/3	85		7.7	10.7(57)[x]	7.1	.2(29)[x]
12/15	127		7.8	13.7(99)[x]	6.7	0.0(71)[x]

[z] Type-gal/acre: Kin=K-50, S=Swanson-80.

[y] Rates/acre ( ) of concentrated pesticides were as follows in pints for C-Acaraben, D-Kelthane, and S-Supracide; gal for 0-oil; and lb for K-Kocide.

[x] Days after treatment differing from Column 2.

Table 3. Citrus rust mite infestation of grapefruit following treatments with a Swanson sprayer, Mission, Texas, 1977.

Date	Post Treatment Days	Percent infested lens fields, pesticides applied [z]			
		I	II	III	IV
1/4/77	147	9.8	6.3(119)[y]	1.3	0.0(91)[y]
2/16	190	7.2	-(162)[y]	1.7	0.0(134)[y]
2/28			C(4)		
3/16	218	20.0	0.0(16)[y]	9.0	1.0(162)[y]
3/30		C(4.5)-K(5)[x]		0(5)-C(4.5)-K(5)	
4/27	28	0.0	9.5(55)[y]	.2	1.2(204)[y]
5/24	55	8.9	2.6(82)[y]	3.9	20.5(231)[y]
5/30					0(5.5)-D(6)-K(5)[x]
6/8	70	30.9	11.7(97)[y]	9.7	1.1(9)[y]
6/25		0(5)-C(4)-K(5)[x]	S(4)-C(4)	0(5)-C(4)	
6/29	4	4.1	.2	0.0	4.9(30)[y]
7/12	17	13.4	2.3	3.3	9.9(43)[y]
7/13		C(6)		C(6)	D(6)
8/24	42	.2	2.5(60)[y]	0.0	.6
10/4	82	12.2	12.3(100)[y]	3.5	13.5
10/10		C(4)	S(4)-C(4)	C(4)	D(5)
11/17	38	.2	0.0	0.0	.5

[z] Rates/acre ( ) of concentrated pesticides were as follows in pints for C-Acaraben, D-Kelthane, and S-Supracide; gal for 0-oil; and K-Kocide.

[y] Days after treatment differing from Column 1.

[x] K used in only north half of plot.

Table 4. Citrus rust mite infestation of grapefruit following treatments with a Swanson sprayer, Mission, Texas, 1978.

Date	Post Treatment Days	Percent infested lens field, pesticides applied [z]			
		I	II	III	IV
3/14/78	155	0.2	0.2	0.2	0.2
4/4	176	0.0	0.0	0.0	0.0
4/20		V(1.5)-K(5)[y]	S(4)-C(4)	0(5)-C(4)	D(6.5)
6/28	69	2.3	1.8	1.8	1.2
7/11	82	11.0	8.2	2.2	2.2
8/1		V(1.3)	S(4)-D(6)	0(5)-C(5)	D(6)
10/3	63	7.9	1.7	4.2	3.2
10/24	87	15.6	6.8	5.7	1.8
10/30		V(1.5)-C(3)	D(6)	C(4)	D(6)
11/17	18	0.0	.7	0.0	.8
12/19	50	0.0	0.0	.2	.5

[z] Rates/acre ( ) of concentrated pesticides were as follows in pints for C-Acaraben, D-Kelthane, and S-Supracide; gal for 0-oil; and lb for K-Kocide and V-Vendex.

[y] K used only in north half of plot.

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Control of Rust Mite and Reduction of Citrus Nematode Populations on Texas Oranges with Temik[R]

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ABSTRACT

Soil applications of 15% granular Temik[R] at 33 and 67 lb/acre controlled citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), for 3 months or longer and significantly reduced populations of citrus nematode, *Tylenchulus semipenetrans* Cobb, on Marrs oranges for 3 successive seasons, 1976-1978. Except for longer residual mite control at 67 lb/acre, no significant difference in mite and nematode population was observed between 33 and 67 lb rates or between disc and chisel methods of Temik application. Percentage of rust mite damaged fruit at harvest was significantly lower from Temik plots than control plots in each year. Significant fruit size increases were recorded from Temik plots in 1976 and 1977. Yields from Temik plots were increased an average of 100 lbs/tree in 1977.

The soil applied systemic pesticide Temik[R] (aldicarb) was labeled in early 1978 for citrus rust mite, aphids and citrus nematode on Texas oranges. Orchard experiments to develop commercial rates and methods of Temik application were initiated in 1976 at the Texas A&I University Citrus Center. Concurrent with method development, efficacy data were gathered against citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), and citrus nematode, *Tylenchulus semipenetrans* Cobb. The present communication summarizes new and previously reported data gathered from Temik experiments conducted during the 1976-1978 seasons (6).

MATERIALS AND METHODS

Chemical formulations: Temik 15G [15% active toxicant, 2-methyl-2-(methylthio) propionaldehyde O-(methylcarbamoyl) oxime] formulated on corn cob grits was used throughout these investigations. Standard acaricides used in certain experiments for comparison to Temik for rust mite control were: Kelthane[R] MF (dicofol), 4,4'-dichloro-a-(trichloromethyl) benzhydrol; and Acaraben[R] 4E (chlorobenzilate), ethyl 4,4'-dichlorobenzilate. The nematicide standard used for comparison was DBCP, 1,2-dibromo-3-chloropropane.

Temik rates and methods of application: Granular Temik was applied successively February 26, 1976, March 16, 1977, and March 20, 1978, to a 10 to 12-year-old orchard of Marrs orange on sour orange rootstock planted on 25 ft X 25 ft spacing. Temik rates of 33 and 67 lb/acre (5 and 10 lb ai/acre

were compared to a nontreated control in a randomized split plot design with 4 replications per main treatment. Each plot was split into 2 rows of 6 trees, i.e., 48 trees/treatment, and Temik was applied by chisel to one and by disc incorporation to the other. In the chisel application, a Gandy^{R} fertilizer applicator with 4 shanks set about 16 inches apart placed the Temik in the soil 2-4 inches deep. In disc application, Temik was applied on the soil surface in a 4-ft-wide band, followed by disc incorporation 2-4 inches deep. Plots were flood irrigated with 5-6 inches of water within 48 hours following treatment. After 1976, the number of replications was reduced to three and in 1978 Temik was applied only by chisel. For comparison, 2 rows of 12 trees each, adjacent to the randomized test were treated with DBCP metered into the irrigation water at 4 gal (48.4 lb ai)/acre on March 1, 1976, and March 23, 1978.

In 1976, two of the four control plots and the DBCP plot received early season acaricide sprays for rust mite control. All plots were sprayed with an acaricide in late season when Temik ceased to control rust mite. In 1977, none of the plots received an acaricide spray until late season. In 1978, the control and DBCP plots were split with half of the trees receiving a regular acaricide program of postbloom and early summer sprays and the other half receiving only the late season spray. Plots were sprayed with Kelthane or Acaraben when 15-20% of the leaf or fruit sample had live rust mites.

Monitoring of pest populations: Populations of citrus rust mite and citrus nematode were monitored at about 4 week intervals during each of the 3 seasons.

Citrus rust mite. A minimum of 100 leaves and/or fruit per replicate were selected at random and examined for rust mite with a 10X handlens. During the 1976 and 1977 seasons mite density was estimated using a rating system of: 0 = no mites; 1.0 = 1-5; 2.0 = 6-10; 3.0 = > 10 mites/sample. In 1978, mites were counted using a 10X handlens fitted with a 1-cm^2 grid. Three grid fields were counted on each fruit at top, median and bottom locations. Similarly, 3 grid fields were counted along the midvein on the underside of each leaf. Data were expressed as mites/cm^2.

Citrus nematode. Two soil samples/replicate for nematode counts were taken at a depth of 3-6 inches from Temik treated areas at the drip line of the tree. Four samples were taken from the DBCP-treated area. Larvae were extracted by a modified Baermann funnel technique (5), counted and reported as larvae/100 cm^3 of soil.

Fruit quality, size and yield determinations: Fruit from all trees in each plot were harvested, weighed and sized in November of each season. Rust mite damage was rated on 40 fruit from each tree using grading categories as outlined in "United States Standards for Grades of Oranges" (7).

RESULTS

Control of citrus rust mite: Temik at both 33 and 67 lb/acre gave effective control of citrus rust mite for 3 months or longer in each of the 3 seasons of application (Tables 1 and 2). Generally, Temik at 67 lb had slightly longer residual activity than the 33 lb rate, but no significant difference was observed in numbers of mites due to method of application (Table 1). In 1976 and 1978, rust mite control extended through July and Temik treatments did not need an acaricide spray until August 4, 1976, and August 18, 1978. In 1977, the 33 lb

Table 1. Citrus rust mite populations in nontreated and Temik treated Marrs orange trees, 1976 and 1977 seasons.

Treatment[y]	Rate lb/acre	Application Method	Mite density [z] at posttreatment sample dates: Apr 76	May 76	Jun 76	Jul 76	Aug 76	Avg.
			l	l	l	l	l	l
Temik	33	Disc	0.0	0.0	0.0c[x]	0.8b	1.1b	0.4b
Temik	33	Chisel	0.0	0.0	0.3c	0.8b	1.2b	0.5b
Temik	67	Disc	0.0	0.0	0.9b	0.4c	0.8bc	0.4b
Temik	67	Chisel	0.0	0.0	0.1c	0.0c	0.6c	0.1b
Nonsprayed Control	- -	- -	1.7	2.7	2.9a	1.8a	1.8a	2.2a

			Apr 77		May 77		Jun 77		Avg.	
			l	f	l	f	l	f	l	f
Temik	33	Disc	0.0	0.0	0.0	0.0	1.0b	1.3b	0.3b	0.4b
Temik	33	Chisel	0.0	0.0	0.0	0.0	1.2b	1.0b	0.4b	0.3b
Temik	67	Disc	0.0	0.0	0.0	0.0	0.9b	0.5c	0.3b	0.2b
Temik	67	Chisel	0.0	0.0	0.0	0.0	0.1c	0.0d	0.0b	0.0b
Nonsprayed Control	- -	- -	0.3	0.0	1.0	2.0	3.0a	3.0a	1.4a	1.7a

[z] Average mite density per leaf (l) or fruit (f) sample based on a rating scale of: 0.0 = no mites; 1.0 = 1-5/sample; 2.0 = 6-10/sample; 3.0 = > 10/sample.

[y] Temik applications made on February 26, 1976, and March 16, 1977.

[x] Mean separation by Duncan's Multiple Range Test, 5% level.

Table 2. Citrus rust mite populations in Temik treated, sprayed control and nontreated Marrs orange trees, 1978 season.

Treatment	Rate lb/acre	Application Method	Mites/cm^2 (leaves)[z] Mar	Apr	Mites/cm^2 (fruit)[z] May	Jun	Jul	Aug
Temik[y]	33	Chisel	0.0	0.0	0.0a[x]	0.02b	3.77b	7.65b
Temik	67	Chisel	0.0	0.0	0.0a	0.02b	4.44b	6.46b
Sprayed Control[w]	- -	- -	0.0	0.0	0.1a	0.29b	0.00b	10.80b
Nonsprayed Control	- -	- -	0.0	0.4	0.4a	25.38a	51.85a	25.04a

[z] Citrus rust mite counted on leaves only in early season and on fruit only in mid season.

[y] Temik applied on March 20, 1978.

[x] Mean separation by Duncan's Multiple Range Test, 5% level.

[w] Received acaricidal sprayed on April 18 (chlorobenzilate - 4 pts.) and July 11, 1978 (dicofol - 6 pts.).

treatment was no longer effective by late June and Temik treatments were sprayed on July 6, 1977.

In 1978, a single postbloom application of Temik on March 20 provided rust mite control comparable to that attained with 2 acaricidal sprays applied at postbloom (April 18) and summer (July 11) (Table 2).

The percentage of fruit with moderate to severe rust mite damage was significantly lower in all Temik treatments compared to nontreated controls for each of the 3 seasons (Table 4). Russeted fruit from Temik treatments never exceeded 15% while in nontreated controls russeted fruit was 70% in 1976 and 65% in 1977. In 1978, the percentage of russeted fruit from Temik and the sprayed control treatments were both $\leq$10% versus 37% from nontreated controls.

There were no significant differences in the percentage of damaged fruit between Temik rates or between methods of application (Table 4).

Control of citrus nematode: Annual soil applications of Temik significantly reduced nematode populations below that of the control at most sample dates (Table 3). No significant difference in nematode populations was shown between the 33 and 67 lb/acre rates or between application methods. DBCP applied in the irrigation water reduced nematode populations generally lower than the annual Temik soil treatments (Table 3).

No yield response was apparent in the first season of Temik treatment even though nematode populations were significantly reduced (Table 4). However, there were significant increases in fruit size in 1976 with the percentage of large size fruit more than two-fold greater from Temik treatments than from nontreated controls. The sprayed control and DBCP treatments also had a similar two-fold size increase over the nontreated control. Fruit size increase appeared to be primarily attributable to rust mite control.

In 1977, there was a significant yield increase in the Temik treatments of about 100 lbs/tree over the nontreated control trees (Table 4). Temik also increased fruit size with the highest percentage (56%) of large fruit recorded from the 67 lb Temik disc treatment. DBCP and Temik treatments had comparable yields, but lack of rust mite control in the DBCP plot resulted in mite damage and fruit sizes like those in nonsprayed controls (Table 4).

In 1978, neither Temik nor DBCP increased yield or fruit size compared to the sprayed control (Table 4). Failure to control citrus rust mite either by means of Temik or acaricide sprays resulted in severely russeted fruit, reduced fruit size and yield.

Except for the slight fruit size increase in the Temik 67 lb disc treatment in 1977, no significant differences were observed in fruit yield, size or rust mite damaged fruit between Temik rates or methods of soil incorporation (Table 4).

DISCUSSION

In these investigations Temik provided excellent residual rust mite control and reduced citrus nematode populations on Marrs oranges. Heald (3) had previously shown Temik applied at 10 and 20 lb ai/acre to Valencia oranges reduced citrus nematode populations and significantly increased yield, but the yield increase was not consistent over a 3 year period (4). The combined acaricidal-nematicidal properties plus potential for improved fruit yield, size

Table 3. Effect of soil applications of Temik and DBCP on citrus nematode populations in a Marrs orange orchard.

Treatment	Rate lb/acre	Application Method	No. of larvae (in 1000's)/100 cm^3 soil					
			Mar 76	Apr 76	May 76	Oct 76		Avg.
Temik[z]	33	Disc	1.7b[y]	3.0bc	1.6b	0.7b		1.7d
Temik	33	Chisel	2.6b	8.5b	4.6b	1.0b		4.2b
Temik	67	Disc	3.0b	1.4c	2.7b	0.7b		2.0cd
Temik	67	Chisel	2.2b	6.1bc	0.5b	1.4b		2.6c
Control	- -	- -	7.8a	19.1a	14.4a	5.6a		11.7a
DBCP[x]	48	Irrigation water	0.1	0.4	0.1	0.1		0.2
			Feb 77	May 77	Jul 77	Sep 77	Nov 77	Avg.
Temik	33	Disc	2.5a	3.1b	2.1b	0.3a	1.7b	1.8b
Temik	33	Chisel	4.5a	4.0b	2.9b	0.6a	1.0b	2.1b
Temik	67	Disc	4.9a	1.7b	0.5b	0.4a	0.5b	0.8b
Temik	67	Chisel	9.5a	2.0b	1.8b	1.0a	2.1b	1.7b
Control	- -	- -	11.6a	15.9a	12.6a	1.4a	4.9a	8.7a
DBCP	None applied		0.2	- -	- -	- -	1.9	1.1
			Mar 78	May 78	Jun 78	Aug 78	Oct 78	Avg.
Temik	33	Chisel	7.4a	4.0b	2.5b	4.4a	6.0ab	4.2b
Temik	67	Chisel	6.4a	1.7b	8.1ab	5.9a	3.0b	4.7b
Control	- -	- -	3.2a	12.9a	19.4a	7.0a	19.3a	14.7a
DBCP	48	Irrigation water	5.0	0.1	0.2	0.1	0.1	0.1

[z] Temik applied on February 26-27, 1976; March 16, 1977; and March 20, 1978.
[y] Mean separation in columns and groups by Duncan's Multiple Range Test, 5% level.
[x] DBCP metered into irrigation water on March 1, 1976, and March 23, 1978.

Table 4. Effect of Temik treatment on yield, size and quality of Marrs oranges, 1976 through 1978.

Treatment	1976 Yield lb/tree	1976 Size [z] % ⩾ 252	1976 %[y] russet	1977 Yield lb/tree	1977 Size % ⩾ 252	1977 % russet	1978 Yield lb/tree	1978 Size % ⩾ 252	1978 % russet
Temik, 33 lb/acre, disc[x]	299a[w]	78a	15b	315a	44b	5b	- -	- -	- -
Temik, 33 lb/acre, chisel	312a	78a	13b	321a	38b	3b	345ab	95ab	7b
Temik, 67 lb/acre, disc	304a	83a	7b	299a	56a	1b	- -	- -	- -
Temik, 67 lb/acre, chisel	277a	88a	4b	317a	45ab	1b	330ab	94ab	8b
Sprayed Control [v]	286a	84a	25b	- -	- -	- -	354a	97a	9b
Nonsprayed Control	301a	33b	70a	218b	23c	65a	304b	92b	37a
DBCP, 48 lb/acre in irrigation water	295	82	24	297	11	47	365	95	19

[z] Percent of the total fruit weight composed of fruit 2.44 inches in diameter or larger.

[y] Percent of the fruit with moderate to severe damage caused by the citrus rust mite, *Phyllocoptruta oleivora*.

[x] Dates of application - February 26, 1976; March 16, 1977; and March 20, 1978.

[w] Mean separation in columns by Duncan's Multiple Range Test, 5% level.

[v] Foliar spray applications of acaricides made on April 18 and July 11, 1978.

and quality make Temik a candidate for inclusion in any future citrus pest control strategies. Moreover, the efficacy of Temik is not limited to these species. Hart and Ingle (2) demonstrated activity against brown soft scale, *Coccus hesperidum* L.; Boling and Dean (1) showed Temik reduced infestations of Texas citrus mite, *Eutetranychus banksi* (McG.), false spider mite, *Brevipalpus* spp., and chaff scale, *Parlatoria pergandii* Comstock. In the latter investigation, fewer predaceous phytoseiid mites were counted in trees receiving high Temik dosages, but it was not determined if this reduction in beneficial mites resulted from inadequate host food supply or from feeding on phytophagus mites (Texas citrus and false spider spp.) which had ingested Temik. More research is needed on the impact of Temik on the beneficial insect and mite complex. Because it is a soil applied systemic pesticide, contact with beneficial species is less likely than with a toxicant applied as a foliar spray. Temik provides Texas growers an alternative to the traditional program of repeated acaricidal sprays for season-long control of citrus rust mite.

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Observations of Grapefruit Tree Decline in Texas

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ABSTRACT

Tree decline resulting in leaf wilt, defoliation and stem dieback of grapefruit trees on sour orange rootstock was observed in the Lower Rio Grande Valley of Texas. Observations and routine analyses indicated changes in the soil profile associated with land leveling contributed to tree failure. Where tree decline was observed, feeder roots were generally found only near the soil surface. Leaf wilt and stem dieback appeared to be associated with an inadequate feeder root system and possibly insufficient water during the summer.

Numerous citrus trees decline each year of unknown causes. Through routine methods of examination and analyses many times the tree loss can be attributed to some specific cause. Reported here are preliminary observations on a decline of unknown cause affecting grapefruit trees in Texas.

In September 1977, following a 4-6 inch rainfall, trees in several citrus groves were observed to be wilting, showing heavy defoliation, and in severe cases, evidencing limb dieback. Trees with dieback exhibited strong sucker growth along the trunk and main framework. The declining trees were close planted (10 x 25 ft.) 'Redblush' grapefruit (*Citrus Paradisi* Macf.) on sour orange rootstock; oranges in the same groves failed to exhibit any noticeable symptoms. The symptoms appeared in isolated areas of an orchard with no apparent pattern. The outside tree row always looked better than those inside the orchard and rarely exhibited any symptoms of dieback. All groves were 10 to 12 years of age and were planted on land which had been machine leveled for efficient flood irrigation.

Symptoms observed at the time suggested root damage, possibly due to a rising water table or salt accumulation. Standard soil and leaf analyses indicated neither a high water table or excessive salt were the problem. Two trees were uprooted and the roots visually examined. The root systems of both trees appeared normal. Trees checked for tristeza were negative. Most trees appeared to be recovering with the onset of fall and were growing new healthy foliage on the outer limbs or as water sprouts.

In March 1978, symptoms reappeared and observations were renewed. Grove histories indicated good production practices. Past soil and leaf analyses from a commercial laboratory indicated possible salt accumulation and N deficiency (2.1% N). In an attempt to alleviate the salt and N deficiencies, 200 lbs sulfur/acre and a total of 190 lbs N/acre as ammonium sulfate were applied. Soil

samples were analyzed, and it was determined that this amount of sulfur and sulfate had resulted in no deleterious effect on the soil (Table 1).

Table 1.* Soil test results from defoliated trees.

Depth	pH	Ca lb./ac.	Mg lb./ac.	P_2O_5 lb./ac.	K_2O lb./ac.
0-1 in.	7.0	> 4480	> 500	51	470
1-6 in.	7.5	> 6000	> 500	31	650
6-12 in.	7.9	> 6000	> 500	18	560
12-18 in.	8.3	> 6000	> 500	38	440

* Samples analyzed by Texas Agricultural Extension Service, Soil Testing Laboratory, College Station, Texas.

A review of literature revealed a report from the Winter Garden Area of Texas (6) and several from Florida (1, 2, 8) which described symptoms similar to those encountered. These reports have labeled the malady described as a "decline" or "blight."

Additional literature indicated that high levels of sulfur could bring on an acute molybdenum deficiency and defoliation (9). Sulfate toxicity could cause defoliation and dieback (5). Leaf analysis for molybdenum and sulfur showed both to be 0.3 ppm, well within the acceptable limits.

A visual examination of the soil profile at the drip line of one of the more severely declining trees revealed an abrupt color change at 3-6 inches and a distinct textural change with depth. Observations of the soil profile in 2-3 ft. deep trenches, showed feeder roots were generally confined to layers above the color change regardless of depth. Texture analyses of the soil samples are given in Table 2.

In each of the four samples observed, feeder root growth (2 mm or less) stopped when clay content approached 30%. In the severely declining trees, samples A, B and C, this was 10-12 inches; while a deeper clay layer (14 inches) sample D, resulted in less severe decline. The decline in this case may be directly related to a restricted root system.

Ford (4) found that Cleopatra mandarin and rough lemon rootstocks stopped downward root growth when the clay under a sand reached 27% and 23%, respectively. Other work (3) showed that; in order for trees on rough lemon to avoid top dieback, 13 grams of roots per square foot column of soil were required at the tree's drip line.

The summers of 1977 and 1978 were unseasonably dry and growers were unable to maintain normal irrigation schedules due to difficulties in obtaining water from their irrigation districts. Some water districts could only provide water on a 6-week schedule during this critical period. The combination of water

Table 2.* Soil texture at various depths from 4 declining grapefruit trees.

	Depth in.	% Sand	% Silt	% Clay
Sample A	6	66	14	20
	12	56	13	31
	21	52	15	33
Sample B	3	70	9	21
	12	49	21	30
	22	49	20	31
Sample C	5	62	18	20
	10	54	16	30
	20	51	16	33
Sample D	5	65	12	23
	8	66	11	23
	14	52	17	31
	17	44	23	33

* Texture analysis by the Bouyoucos Hydrometer Method.

stress, high temperatures and heavy soil texture may have resulted in a lack of available moisture to meet the evaporative demands of the tree.

Prior to the 1962 freeze, most Rio Grande Valley citrus was grown on unleveled land, wide spaced (25 x 25 ft.) and cultivated mechanically. Following the freeze, new areas were planted and modern growing techniques were adopted. These included: land leveling, close planting (10 x 25 ft.) and complete chemical weed control. Young tree growth and production were excellent which encouraged a complete changeover to these production practices. It was not until trees reached 10 to 12 years of age and established hedge-rows that decline problems were observed.

From these observations the authors suggest that land leveling not only disturbed the distribution of surface soil but created the presence of heavy sub-surface soils near the surface. The observations made in this investigation support the idea that prior to planting citrus the soil profile should be checked to a minimum depth of 3 ft. for soil texture, drainage and water table. Most recommendations (7) refer only to soil type and give no guidelines as to changing texture, rooting depth or rootstock performance. Knowledge of soil texture and root analyses of trees growing under varying soil profiles and conditions could provide recommendations that would enable the citrus grower to predict how citrus could be expected to perform on a given soil with the rootstocks and scions of that area.

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Effect of Phosphorus Fertilization and Infection with Mycorrhizal Fungi and *Phytophthora parasitica* on the Growth of Sour Orange Seedlings[1]

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ABSTRACT

Inoculation of a fumigated field seedbed with *Glomus fasciculatus* (Thaxter) Gerd. & Trappe increased the growth and the % mycorrhizal infection in roots of sour orange (*Citrus aurantium* L.) seedlings. Application of P at 172, 344, and 688 kg/ha increased growth above the no-P treatment, but there were no differences in response among the rates of P applied. In a second experiment, Phytophthora-free, non-mycorrhizal sour orange seedlings grew more rapidly than Phytophthora-infected, mycorrhizal seedlings after transplant to containers with a non-fumigated, Phytophthora-free soil. Application of triple superphosphate at 210 mg P/liter of soil increased the growth of non-mycorrhizal, Phytophthora-free seedlings, but not that of mycorrhizal, Phytophthora-infected seedlings. Application of P reduced the % mycorrhizal infection, especially in those seedlings which were non-mycorrhizal at transplant.

Stunting of citrus seedlings following fumigation or the use of sterilized potting media has often been observed in Texas (10) and in other citrus areas (5, 9). Application of high rates of phosphorus (P) fertilizer stimulates the growth of non-mycorrhizal plants, but these seedlings generally are not as vigorous as mycorrhizal plants (5, 11, 14). High levels of soil phosphorus inhibit the reestablishment of mycorrhizal fungi (3, 11) and may result in P-induced micronutrient deficiencies (1, 11, 12). Mycorrhizal fungi generally are more easily killed by methyl bromide fumigation than are most soilborne pathogens (7). Means must be developed to produce healthy mycorrhizal seedlings free of plant pathogens or to produce adequate plant growth in the absence of mycorrhizal fungi or in the presence of pathogens.

The purpose of this study was to determine (i) the effect of P fertilization and mycorrhizal inoculation on growth of sour orange seedlings in a field seedbed and (ii) the effect of P fertilization on mycorrhizal seedlings infected with *Phytophthora parasitica* Dast. and non-mycorrhizal seedlings free of *P. parasitica*.

[1] Florida Agricultural Experiment Stations Journal Series No. 1790.

MATERIALS AND METHODS

The effect of inoculation with *Glomus fasciculatus* (Thaxter) Gerd. & Trappe on growth of sour orange (*Citrus aurantium* L.) seedlings was determined in a field seedbed fertilized with different rates of P. Triple superphosphate was applied at 0, 172, 344, or 688 kg P/ha with or without *G. fasciculatus*. Treatments were replicated 3 times on 1-m^2 plots. The entire nursery area was fumigated with SMDC [sodium N-methyl dithiocarbamate (Vapam^R)] in November, 1977 at 100 ml/m^2. The area actually seeded was refumigated in March, 1978 with methyl bromide at 75 g/m^2 applied under a 6-mil plastic tarp to assure freedom from *Phytophthora* spp. and nematodes. Each inoculated plot received 500 g (wet weight) of mixed roots and soil from pot cultures of *G. fasciculatus* on sour orange. Nitrogen was applied as $(NH_4)_2 SO_4$ at 7.8 g N/m^2 preplant and 3 and 5 months postplant. Mycorrhizal inocula, P, and N were incorporated in the top 5 cm of the seedbed. Beds were planted with 400 seed/m^2.

Seedling heights were determined on 25 seedlings/plot, 5 near each corner and 5 in the center of the plot, at 5, 7, and 9 months after planting. Roots were obtained from each plot with a tube sampler 8 months after planting to determine the % mycorrhizal infection.

In a second experiment, growth of sour orange seedlings from a raised seedbed in a shaded area which were naturally infected by mycorrhizal fungi and *Phytophthora* spp. were compared to growth of non-mycorrhizal, Phytophthora-free seedlings from flats in the greenhouse. One hundred forty-four seedlings from each of the above sources were transplanted to 6-qt (actual soil volume about 3.5 liters) pots and 144 seedlings to 2-gal (actual volume about 4.3 liters) pots. The soil used was a sandy loam, pH 7.3, containing 6 mg of $NaHCO_3$ extractable P/kg of soil. Soil was from a non-citrus area and was free of *Phytophthora* spp. and was not fumigated prior to use. Nitrogen as $(NH_4)_2 SO_4$ was added to all treatments at 0.13 g N/liter of soil and fritted trace elements were added at 26 mg/liter of soil. Triple superphosphate at 0.21 g P/liter of soil was added to half the seedlings from each source. Fertilizers were initially mixed thoroughly with the soil in a cement mixer prior to planting. Ammonium sulfate at 0.13 g N/liter of soil was added at 3, 8, 11, and 15 months after transplant. Seedlings were watered by drip irrigation. Seedlings from each source were divided into 2 replicates, each with 4 rows of 18 seedlings. Two rows were potted in the 6-qt containers and 2 in 2-gal containers with 1 row of each container size receiving P. Container size and P treatment were assigned randomly to rows within the replicate. Seedlings were budded with nucellar 'Webb Redblush' grapefruit (*C. paradisi* Macf.) 6 months after transplant.

Stem diameters at pot level were determined at transplant, 5, 10, and 18 months. Seedling height was measured at 3 months and % mycorrhizal infection determined at 5 and 22 months.

In both experiments, root samples taken at random within each replication were stained with trypan blue (8) to determine % mycorrhizal infection. Ten to 20 1-cm root pieces from each replication were rated for % infection taking into account the extent and density of infection in each piece. The presence of *Phytophthora* spp. was determined by plating seedling roots or small soil aggregates on selective agar medium containing pimaricin, vancomycin, and

pentachloronitrobenzene (13). All isolates recovered in this study were identified as *P. parasitica*.

RESULTS AND DISCUSSION

Growth of sour orange seedlings in the field seedbed was slow and erratic. Patches of vigorous seedlings appeared first in those plots inoculated with *G. fasciculatus* and the average height of seedlings in these plots was significantly greater than in the non-inoculated plots on most dates and at most P fertilization rates (Table 1). However, seedlings in many areas remained stunted even in inoculated plots. Eight months after planting the % mycorrhizal infection was significantly higher in inoculated plots than in non-inoculated plots except at the high P rate. However, seedlings in the corners of the plots were significantly taller at all dates than those in the center indicating probable invasion of mycorrhizal fungi from outside the seedbed. Application of P increased growth of inoculated seedlings slightly but high rates were no more effective than low rates. Application of P to non-inoculated seedlings did not increase growth consistently. Level of P did not affect the % mycorrhizal infection.

In a previous seedbed experiment (11), the fumigant treatment did not eliminate indigenous mycorrhizal fungi and inoculation with *G. fasciculatus* did not increase the % infection or stimulate growth. In that experiment, *P. parasitica* was not eliminated by fumigation, but it was apparently eradicated in the present experiment, along with the indigenous mycorrhizal fungi. Neither inoculation with *G. fasciculatus* nor P fertilization were completely effective in correcting the stunting. In greenhouse tests under controlled conditions, inoculation with mycorrhizal fungi has greatly stimulated growth of citrus seedlings, but field inoculations have been less effective (5, 9, 10). Application of P only partially overcomes the stunting-following-fumigation problem (10, 11, 12). Addition of inoculum to seed has proven effective in some cases (4) but, in others, preplant soil incorporation or banding below the seed has provided more effective distribution of inoculum and a better growth response (6). However, citrus seed germinates slowly and the inoculum density may be considerably reduced before roots are available for infection.

In the second experiment non-mycorrhizal, Phytophthora free sour orange seedlings grown in containers increased in height more rapidly than mycorrhizal, Phytophthora-infected seedlings (Table 2). Application of P to the non-mycorrhizal seedlings increased seedling height (Table 2) and stem diameter during the first 5 months after transplant (Fig. 1). By 5 months after transplant, all seedlings were infected by mycorrhizal fungi and those which were initially free of mycorrhizae and which had not received P were the most heavily infected. Application of P reduced the % mycorrhizal infection of both types of seedlings at 5 months after transplant, but at 22 months only significantly reduced mycorrhizal infection of those that initially were free of mycorrhizae. After the non-mycorrhizal seedlings had become infected at 5 months, the P application did not affect the rate of increase in stem diameter (Fig. 1). Phytophthora-infected seedlings grew significantly more slowly than the Phytophthora-free seedlings and application of P did not increase stem diameter, probably because these seedlings were mycorrhizal from the beginning of the experiment. Infection by *P. parasitica* apparently eliminated any beneficial effects of the presence of

Table 1. Effect of phosphorus and *Glomus fasciculatus* on the growth and mycorrhizal infection of sour orange seedlings in a field seedbed.

P level	Plant height (cm)						Mycorrhizal infection (%)	
	5 months		7 months		9 months			
	+myc[z]	-myc[z]	+myc	-myc	+myc	-myc	+myc	-myc
0 kg/ha	4.9d[y]	4.4e	9.6c	7.4e	12.5b	10.0c	64ab	44cd
172 kg/ha	5.6abc	4.7de	11.7b	8.9cd	15.6a	12.1b	57abc	48bcd
344 kg/ha	5.8ab	5.3bcd	13.0a	8.3de	15.5a	10.4c	67a	38d
688 kg/ha	6.0a	5.0cde	11.6b	8.1de	15.5a	11.1bc	49bcd	40d

[z] +myc = inoculated with *Glomus fasciculatus*; -myc = not inoculated

[y] Mean separation within each sampling by Duncan's multiple range test, 5% level

Table 2. Effect of phosphorus on the height and mycorrhizal infection of container-grown, Phytophthora-infected, mycorrhizal sour orange seedlings and on Phytophthora-free, non-mycorrhizal sour orange seedlings.

Mycorrhizal infected	Phytophthora infected	P level (mg/liter)	Seedling hgt 3 months (cm)	Mycorrhizal infection 5 months (%)	22 months (%)
+	+	210	38.8c[z]	10c	30a
+	+	0	38.8c	29b	38a
-	-	210	48.2a	18bc	15b
-	-	0	43.8b	60a	37a

[z] Mean separation in columns by Duncan's multiple range test, 5% level

mycorrhizae which is consistent with previous observations (2, 11). Innovative methods will be needed to produce healthy citrus seedlings free of nutrient deficiencies at a reasonable cost.

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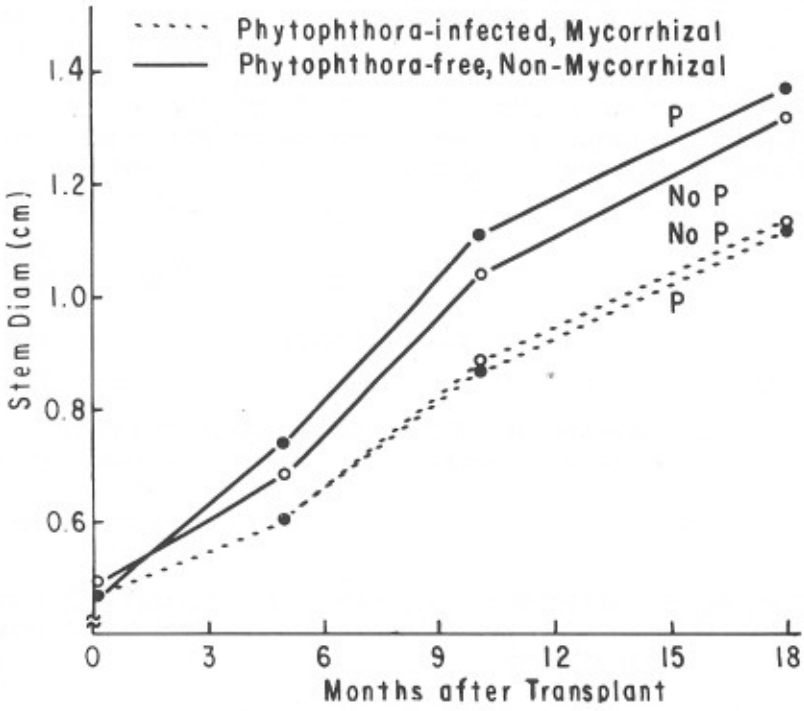

Fig. 1. Growth of Phytophthora-infected, mycorrhizal (- - - - -) and Phytophthora-free, non-mycorrhizal (————) sour orange seedlings which received phosphorus at zero (○) or 210 mg P/liter of soil (●).

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Climatological Parameters and Grapefruit Size Relationships in the Rio Grande Valley of Texas

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ABSTRACT

The diameters of Ruby Red grapefruit (*Citrus paradisi*, Macf.) were measured weekly from April through December, 1965 through 1974. Associations of climatological factors monitored at a nearby site and mean grapefruit diameters in October, November and December were determined by regression analyses. The results indicate: 1) temperature and solar radiation in the spring were positively correlated with fall fruit size, 2) soil moisture and rainfall were not significant growth limiting factors, and 3) high temperatures and solar radiation in August and September were negatively correlated with fruit diameter in late fall. Equations were developed which projected mean grapefruit diameter in October, November and December from spring climatological variables with an accuracy of 95%.

Most applied agroclimatological studies attempt to answer the critical questions of how and when does climate affect a certain crop and which climatic parameters most influence the quantity and quality of the product (4, 8, 9). When crop characteristics can be predicted in advance of harvest by monitoring the pertinent climatological factors, science begins looking for methods to augment, enhance or overcome these natural influences.

Though predictive models relating crop production and climate have been constructed for corn in Indiana (10), grapes in France (3) and other crops elsewhere, citrus has received limited research attention, especially in South Texas. Since citrus is a key element in the Valley economy and Texas red grapefruit, in particular, is considered of unsurpassed quality, more specific knowledge of climate and fruit growth relationships is of great practical as well as academic interest. This study investigated which climatological parameters relate to grapefruit growth most significantly and when they appeared to exert an influence. With these parameters an equation to predict fruit size was developed and evaluated.

STUDY SITE

Data for this study were collected at the Texas A&I University Citrus Center and the U.S.D.A. Weather Station located northeast and north, respectively, of the city of Weslaco. In this study local climatic effects (e.g., urban influences, bodies of water, and air drainage) were assumed to have negligible effect at these sites.

At latitude 26° 10' North and longitude 97° 59' West, Weslaco, Texas, is situated in the center of the commercial citrus region of the Lower Rio Grande Valley on level terrain about 75 ft. above mean sea level. The climate is subhumid to semiarid with a mean annual precipitation of 22.2 inches and an average yearly temperature of 74°F.

METHODOLOGY

Two sets of data were utilized. Numerous climatological variables were monitored at the U.S.D.A. Weather Station between 1965 and 1974 (Table 1). Over the same period, measurements of Ruby Red grapefruit diameters were made in several Texas A&I University Citrus Center orchards located about 5 mi. from the weather station. Six to 12 locations within the tree with 2 fruit per location were sampled on 3 to 6 trees in each of 2 to 4 orchards per year. Equatorial diameters were measured with a caliper once each week from early April through October. After this, biweekly measurements were taken until harvest the following spring. All orchards were irrigated when soil moisture levels indicated the need.

Table 1. Variables used in climate-grapefruit growth study.

Independent	(Monthly Mean, January through November)
	Mean Daily Temperature, °F.
	Maximum Daily Temperature, °F.
	Minimum Daily Temperature, °F.
	Number of Days ≤ 32°F. (Jan., Feb. only)
	Number of Days ≥ 90°F. (March-Nov. only)
	Solar Radiation, Langleys
	Precipitation, inches
	Daily Evapotranspiration (potential and actual)
Dependent	
	Mean Grapefruit Diameter (cm) for Oct., Nov. and Dec.

Statistical analysis of these data involved two steps: 1) computer-assisted calculation of simple correlation coefficient matrices between the independent variable (climate) and the dependent variables (fruit diameter during October, November and December) and 2) computation of step-wise multiple regression equations to predict mean fall fruit sizes based upon climatic traits of the preceding winter and spring.

RESULTS AND DISCUSSION

Previous studies of climatic influences upon citrus fruits have suggested that

grapefruit size at harvest is positively correlated with precipitation in spring and summer and with temperature in spring and negatively correlated with high temperatures in summer (2, 5, 6, 7). The significant independent variables in this study suggest some but not all these relationships hold in the subhumid environment of South Texas (Table 2).

Table 2. Correlation coefficients of weather variables that correlate significantly with the dependent variable, grapefruit diameter for October, November and December.

Independent Variable	October Diameter	November Diameter	December Diameter
Jan. Solar Radiation	+.56[a]	+.62[a]	+.60[a]
Feb. Solar Radiation	+.50[b]	+.50[b]	+.47[b]
March Solar Radiation	+.61[a]	+.62[a]	+.57[a]
April Mean Daily Temp.	+.49[b]	+.53[b]	+.49[b]
April Min. Daily Temp.	+.53[a]	+.56[b]	+.52[b]
April Solar Radiation	+.70[b]	+.70[a]	+.67[a]
May Mean Daily Temp.	----[c]	+.47[b]	+.50[b]
May Min. Daily Temp.	+.47[b]	+.51[b]	+.52[b]
May Solar Radiation	+.55[b]	+.57[b]	+.59[a]
June Solar Radiation	+.55[b]	+.61[a]	+.62[b]
Aug. Mean Daily Temp.	-.42[b]	-.45[b]	-.44[b]
Aug. Max. Daily Temp.	----[c]	----[c]	-.44[b]
Aug. Days Max. Temp. 90°F	-.65[a]	-.66[a]	-.69[a]
Sept. Mean Daily Temp.	-.52[b]	-.47[b]	-.53[b]
Sept. Min. Daily Temp.	-.65[a]	-.64[a]	-.67[a]
Oct. Mean Daily Temp.	-.59[a]	-.60[a]	-.60[a]
Oct. Max. Daily Temp.	-.64[a]	-.63[a]	-.65[a]
Oct. Min. Daily Temp.	-.49[b]	-.52[b]	-.49[b]
Oct. Days Max. Temp. 90°F	-.66[a]	-.61[a]	-.67[a]
Oct. Solar Radiation	+.72[a]	+.75[a]	+.70[a]

[a] Significant at .05 level.
[b] Significant at .10 level.
[c] ---- Records incomplete.

No moisture terms (precipitation, actual evapotranspiration, potential evapotranspiration) were related significantly to grapefruit diameter in October, November or December. This was undoubtedly due to the frequent application of irrigation water during the growing season. Since the Rio Grande Valley is characterized by extremely high rates of evaporation and limited precipitation during the summer, commercial citrus orchards are usually irrigated 3 to 6 times

from March through September. Without irrigation moisture would likely be a critical variable.

The controlling climatic parameters were temperature and solar radiation during the months of January through April. The single dominant factor, mean solar radiation in April, accounts for nearly 50% of the variation in mean fruit size from October through December. Because many previous studies have lacked radiation data, comparisons cannot be made to other areas. Average daily maximum and minimum temperatures during the spring were also positively correlated with diameter; e.g., the correlation coefficient between mean April minimum temperature and mean November diameter = +.56 (Table 2). Apparently sunny and warm conditions in spring, especially in April, are associated with larger than average grapefruit in the fall.

Conversely, temperature and radiation levels during late summer (August and September) were negatively related to diameter; the coefficient between the mean number of hot days in August ($\geq 90^{\circ}$F.) and December grapefruit size was -.69. The obvious conclusion is that citrus trees suffer from a summer overload of radiation and temperature in this subtropical environment. One may speculate that some form of shading during these hot months might prove beneficial.

Finally, October mean monthly solar radiation again was positively correlated with fruit size in October and November although the correlations with the temperature terms were still significantly negative. If a cause and effect relationship is assumed, this means that relatively cool but sunny conditions in October are more favorable for fruit sizing than hot or cloudy weather. None of the other monthly weather variables correlated significantly with the October, November or December fruit diameters.

By utilizing the significant independent variables in Table 2 in stepwise multiple regression calculations, equations which predicted the mean grapefruit diameter for October, November and December were computed. Using only the temperature and radiation variables from the period January through April resulted in coefficients of determination (R^2) which averaged .99 with standard errors ranging from .005 to .21 (Table 3). Despite the significant correlations with solar radiation and temperature in summer and early fall, inclusion of these parameters from May through October did not significantly improve the equations.

Using the same weather variables and procedure, an equation predicting the mean fruit diameter (D_x) for the October through December period was calculated. The R^2 was .99 and the standard error was .05. As an example of the equations for each individual month, the significant parameters and their coefficients for this general equation are:

$D_x = 45.65 + .024X_1 + .221X_2 + .558X_3 - .978X_4 + .016X_5 - .248X_6 + .014X_7$ where

X_1 = April mean solar radiation (Langleys)
X_2 = February minimum temperature ($^{\circ}$F)
X_3 = April minimum temperature
X_4 = April maximum temperature
X_5 = January mean solar radiation
X_6 = March maximum temperature
X_7 = March mean solar radiation.

The mean fruit diameters for October, November and December, 1965 through 1974, were calculated using the predictive equations for each of these

Table 3. Groups of weather variables that best predict grapefruit diameter in October, November and December.

Mean Grapefruit Diameter	Independent Variable	Successive Multiple Coefficients of Determination (R^2)	Standard Error
October	April Solar Radiation	Step # 1 = .49	.58
	Feb. Min. Daily Temp.	Step # 2 = .60	.55
	April Min. Daily Temp.	Step # 3 = .70	.52
	April Max. Daily Temp.	Step # 4 = .74	.54
	Jan. Solar Radiation	Step # 5 = .84	.48
	March Max. Daily Temp.	Step # 6 = .97	.25
	March Solar Radiation	Step # 7 = .99	.005
November	April Solar Radiation	Step # 1 = .49	.62
	Feb. Min. Daily Temp.	Step # 2 = .61	.59
	April Min. Daily Temp.	Step # 3 = .73	.53
	Jan. Solar Radiation	Step # 4 = .75	.58
	April Max. Daily Temp.	Step # 5 = .86	.50
	March Max. Daily Temp.	Step # 6 = .96	.31
	March Solar Radiation	Step # 7 = .99	.07
December	April Solar Radiation	Step # 1 = .45	.66
	March Max. Daily Temp.	Step # 2 = .57	.64
	March Solar Radiation	Step # 3 = .72	.55
	Days April Max. $\geqslant 90^{\circ}$F	Step # 4 = .76	.58
	Feb. Solar Radiation	Step # 5 = .80	.61
	Jan. Solar Radiation	Step # 6 = .85	.65
	Feb. Min. Daily Temp.	Step # 7 = .99	.21

months and compared to the actual measured diameters. Comparison of the reported and predicted sizes and their relationship to the mean April solar radiation for 1965 through 1974 show the differences between the calculated and actual values varied between 2 and 3% (Fig. 1). The variability of the fall fruit size and April solar radiation relationship suggests that the fruit is subject to this climatic influence indirectly through bloom development, fruit set or some critical physiological stage which occurs at different times each season (1).

CONCLUSIONS

This study indicates warm and sunny days and warm nights from January through April are associated with large grapefruit sizes in October, November and December. High temperatures in August, September and October tend to reduce fruit sizes. Regression equations with seven terms, January, March and April solar radiation, February and April minimum temperatures, and March and April maximum temperatures accounted for 99% of the variation of grapefruit

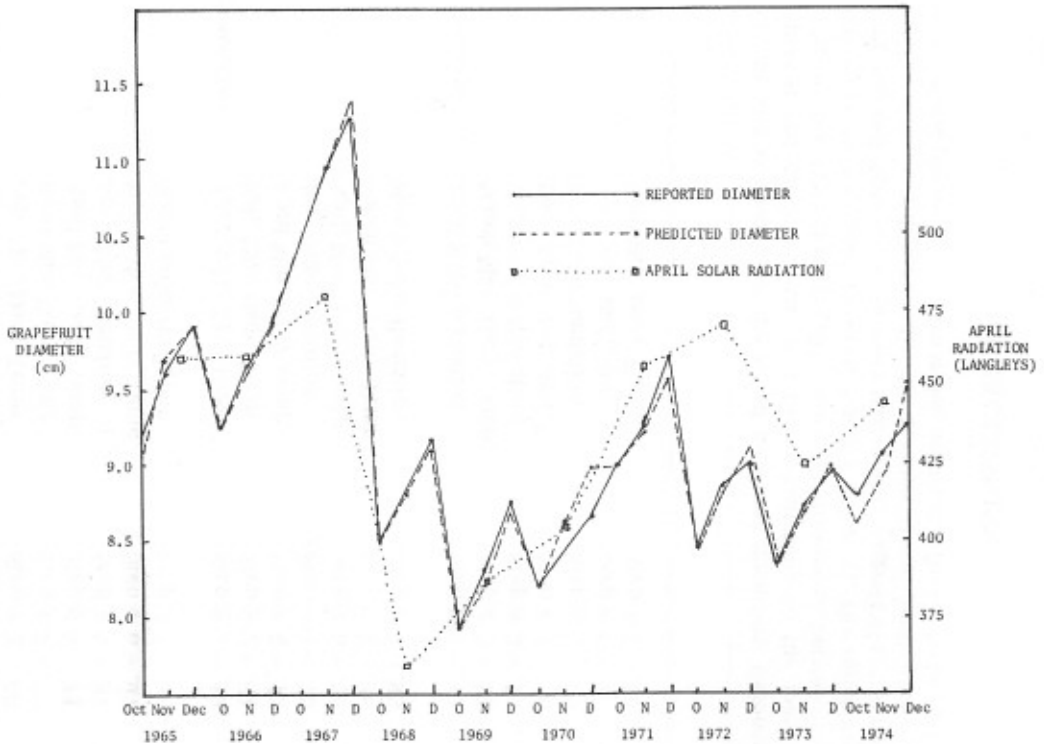

Fig. 1. Mean April solar radiation, reported and predicted mean grapefruit diameter for October, November and December, 1965 through 1974, Weslaco, Texas.

diameters in October, November and December and predicted diameter values with a ±5% error.

While the correlation of these climatic factors with grapefruit size are high, the nature of the relationships needs definition. At present, these conclusions apply directly only to the immediate area around Weslaco. Extension of the study to include fruit quality and yields and a broader range in sampling sites would be necessary to develop a more inclusive and exacting picture of the role climate plays in producing Texas red grapefruit. The ultimate goal, of course, is to improve fruit quantity and quality through cultural practices which enhance the positive and ameliorate the negative climatic influences.

ACKNOWLEDGEMENTS

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Potential Evapotranspiration in the Lower Rio Grande Valley

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ABSTRACT

Potential evapotranspiration (PET) in the Lower Rio Grande Valley can be adequately calculated from weather records for the summer months (May through September) with either the Penman or the Jensen-Haise method. The Penman is the more accurate method during the rest of the year. A frequency analysis of 3 years data from Weslaco, Texas using the Penman method showed, among other things, that daily PET ranged from 0.8, 2.6, and 4.4 mm/day at the 10, 50, and 90 cumulative frequency percentages during the winter period of minimum water requirement to 4.4, 6.9, and 9.3 mm/day at the respective percentages during the peak summer period.

Potential evapotranspiration (PET) is "the amount of water transpired in a unit time by a short green crop, completely shading the ground, of uniform height and never short of water" according to Penman (12). This definition implies a short grass or a fully developed low-growing agricultural crop. The concept has been further expanded by the American Society of Civil Engineers (ASCE) (1) to state that the conceptual PET reference crop has sufficient depth or layers of leaves to absorb most of the solar radiation before it reaches the soil surface, and has sufficient aerodynamic roughness to be representative of typical agricultural crops. This concept of a crop capable of maximum evapotranspiration for the prevailing conditions is used in this paper.

Estimates of evapotranspiration derived from the PET are needed in the design and management of irrigation systems and for irrigation scheduling and hydrologic applications. Accurate estimates of PET are required in crop growth and yield models. The information can also be used to estimate the rate of field drying of crops, determine the rate of effluent disposal by pond or irrigation, and predict soil drying for onset of trafficability.

Weather records provide the information needed to calculate the PET, or water requirements of a specific crop at a particular stage of growth. Actual evapotranspiration is PET multiplied by a crop coefficient. The coefficient (1, 3, 5, 7, 15) adjusts for the deviation of the crop at a particular stage from the conditions defined for PET. The coefficients range up to 1.0, although for certain crops that value is never reached because of physiological or other characteristics--such as low plant density, high stomate resistance, or xerophytic

adaption. Experimentally determined coefficients exceeding 1.0 have been reported where Penman's original definition was the basis, or where energy advection or other special conditions prevailed.

METHODS OF ESTIMATING POTENTIAL EVAPOTRANSPIRATION

Empirical methods of determining PET from weather records may be limited in usefulness to the climates under which they were developed, and even the theoretically based methods may require local calibration when transposed to other climates. The ASCE (1) compared 16 published methods of calculating PET against lysimeter measurements at 10 worldwide locations. These included the well-known Blaney-Criddle (2) and Jensen-Haise (6) methods. Of the 16 methods, the Penman (12) and Kohler et al. Lake evaporation (8) performed best under worldwide conditions. The latter two methods were rated among the five best in coastal conditions and among the three best under inland semiarid to arid conditions. The ASCE Committee concluded that no one method is presently available that accurately estimates PET without adjustment under all climatic regimes.

LOWER RIO GRANDE VALLEY STUDY

We are making ongoing comparisons of daily PET amounts calculated by nine different methods, and an additional five variations of selected methods. The methods being investigated consist of the eight found best by the ASCE (1) and the Priestly-Taylor (13) approach. Weather records of solar radiation, air temperature, vapor pressure (dew point) and wind movement from the Soil and Water Research Farm, Weslaco, are used for this. The daily PET results can vary widely, and the relationships among the methods change with the seasons. The two methods to which we have given the most serious attention as useful indicators of PET in the Lower Rio Grande Valley are the Penman (12) and the Jensen-Haise (6).

Both the Penman method (12) and the Kohler et al. method (8) are combination methods, which means they attempt to take into account both the energy required to sustain evaporation and the mechanism required to remove water vapor from the evaporating surface (sink strength).

We used the form of the Penman method reported by Kincaid and Heerman (7):

$$PET = 0.000673\ [C_a(R_n - G) + 15.36\ C_b\ (1.1 + 0.017W)\ (e_s - e_d)]$$

where,

PET is potential evapotranspiration, inches per day

C_a and C_b are mean air temperature weighting factors determined from the slope of the saturation vapor pressure-temperature curve.

R_n is daily net radiation, langleys

G is daily net soil heat flux, langleys

W is total daily wind movement, miles

e_s is mean saturation vapor pressure, mb

e_d is saturation vapor pressure at mean dew point temperature, mb

Net radiation (R_n) and soil heat flux (G) are estimated by equations that use

total daily solar radiation, mean daily air temperature, and saturation vapor pressure at dew point.

The Jensen-Haise method (6) uses measurements of the two most important weather factors, temperature and solar radiation. The appeal of this method is the ease with which the required data can be collected and the simplicity of calculation as follows:

$$PET = 0.0112 (T_m - 20) R_{sc}$$

where,

PET is potential evapotranspiration, inches per day

T_m is mean daily air temperature, degrees Fahrenheit

R_{sc} is total daily solar radiation, equiv. depth of evap., inches.

The coefficients reported here and used in our analysis were developed from field observations in the Lower Rio Grande Valley by the U.S. Bureau of Reclamation (15). We converted the results of both methods to metric units.

Figure 1 shows the means and positive and negative standard deviations of daily PET at Weslaco, as determined by months, by the Penman and Jensen-Haise methods using data from 1975, 1976, and 1977. The illustration shows that the results of the two methods are quite similar from May through September, when the respective average PET rates were 5.83 and 5.82 mm/day. During the rest of the year, the Jensen-Haise method indicates lower PET than the Penman method, resulting in a 14 percent lower estimate on an annual basis. The PET discrepancy between the methods was greatest in February, when Jensen-Haise averaged 35 percent less (1.50 mm per day) than Penman.

The average standard deviations of PET were 1.71 and 1.43 mm/day for the Penman and Jensen-Haise methods, respectively (Fig. 1). The greater standard deviations associated with the Penman method may be partly explained by the greater day to day variability due to the inclusion of vapor pressure and wind movement, which are neglected in the Jensen-Haise approach.

The suitability of these methods in the Lower Rio Grande Valley has been substantiated with measurements we made with a 2m x 2m x 1.5m precision weighing lysimeter at the Soil and Water Research Farm, Weslaco. We found that summertime cotton evapotranspiration in 1973 and 1974 was closely approximated by both methods from the time 70 percent of the ground was covered, when soil moisture was not limiting, until the uninhibited evapotranspiration was retarded by onset of maturity of the determinate variety (Tamcot SP-37). Penman values agreed on the average with lysimeter measurements made with Penjamo wheat during January, February, and March 1978 (crop coefficient of 1.0). This spanned the period of rapid evapotranspiration from head emergence to onset of ripening. The Jensen-Haise method seriously underestimated PET during this winter period.

FREQUENCY DISTRIBUTIONS

Figure 2 shows daily PET values calculated by the Penman method for 1975, 1976, and 1977. Both day to day and year to year variations are apparent from an examination of the patterns of the plotted points. During the period investigated, the annual rainfall ranged from more than 50 percent above normal to slightly below the longterm average of 600 mm (682 mm, 918 mm, and 591 mm, in chronological order). In contrast with the other years, the last half

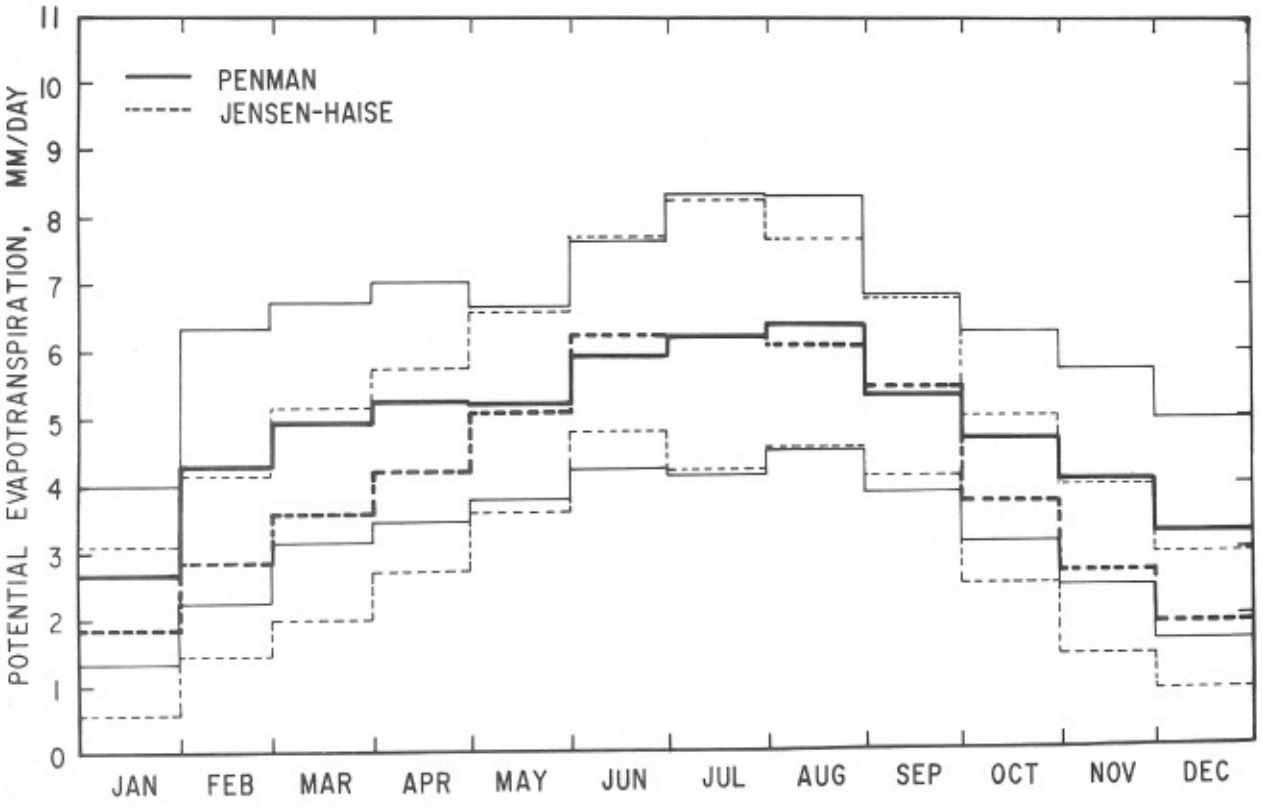

Fig. 1. Means and positive and negative standard deviations of potential evapotranspiration (PET) computed from Weslaco, Texas weather records using the Penman and Jensen-Haise methods.

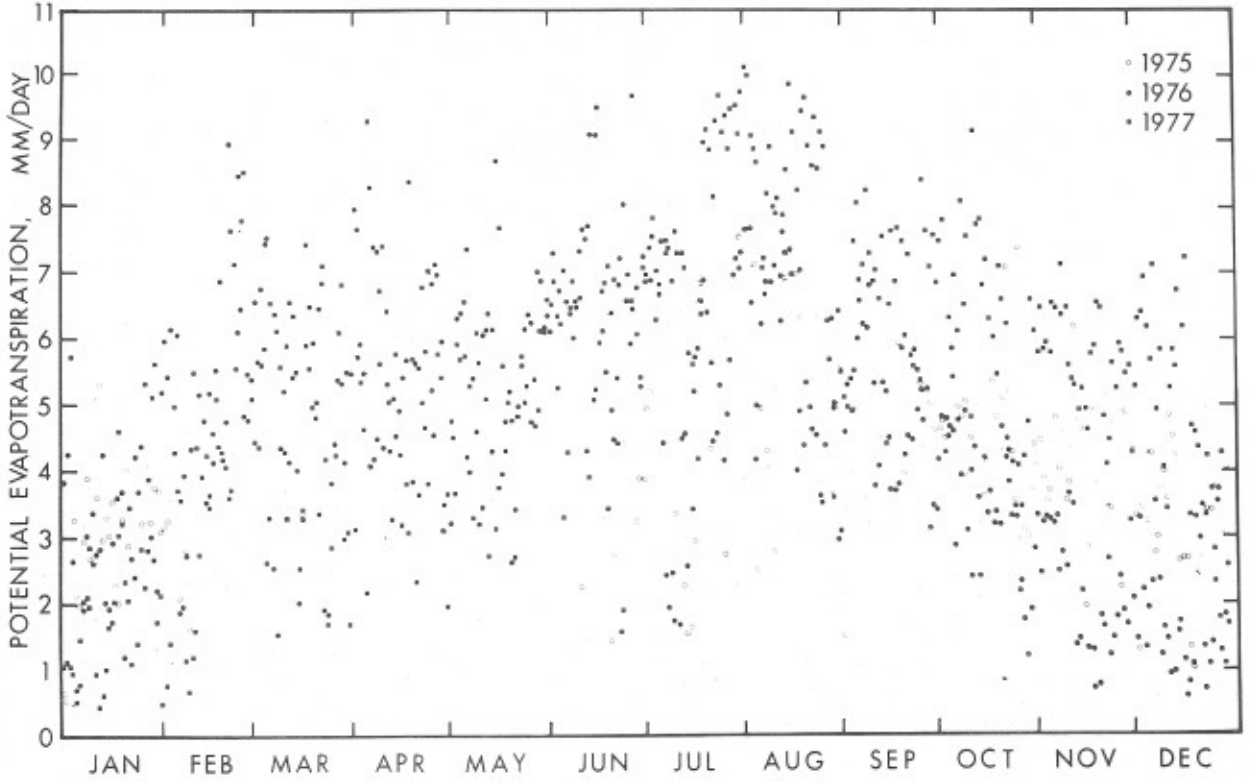

Fig. 2. Daily potential evapotranspiration (PET) at Weslaco, Texas computed by the Penman method for 1975, 1976, and 1977.

of 1977 was dry and warm, so that PET rates were higher than for the other years (Fig. 2). Rainfalls in the July through December periods were 550 mm in 1975, 969 mm in 1976, and 290 mm in 1977.

The wide scatter of daily data are represented as frequency curves in Fig. 3. Since weather systems are erratic in frequency and duration, PET tends to be cyclic and erratic in line with the associated weather systems. Frequency curves based on overlapping periods of less than 40 days each undulated markedly. These fluctuations were considered to be the result of chance reinforcement by superimposition of cycles from two or more years rather than established seasonal effects. Thus, the data reported here are smoothed by using 40-day running averages. A much shorter period would have been best if long-term PET values had been available to produce averages not affected by cycles of particular years. Similar analytical difficulties have been encountered with evapotranspiration data from other climates (10, 14, 16).

The illustration shows that median (50 percent) PET rates range from 2.6 mm/day at the winter low to 6.9 mm/day at the summer high. However, the wide range of daily values clearly shows the need for frequency distribution analysis as a guide to water management planning. Of interest for irrigation system design are the 75 to 90 percent cumulative frequency curves, although it would seldom be necessary to design for 1-day peak values. Design situations depending upon evapotranspiration for drying or effluent disposal would properly be considered in terms of the 10 percent or 25 percent curves.

Figure 4 shows the expected PET rates during the period of peak use (July 24 through August 22). This graph gives the average daily rates of various frequencies for periods ranging from one to 30 consecutive days. The figure was developed using the analytical procedure of Pruitt et al. (14). It illustrates well why mean values are not adequate for predicting PET requirements in the design of irrigation projects or farm systems. The discrepancies in peak one-day values between Figs. 3 and 4 are due to smoothing errors in Fig. 3 caused by use of the 40-day running average.

The shape and position of the curves of Fig. 4 are influenced by the weather that prevailed during the peak-water-requirement-period of the 3 years studied. Table 1 shows that the average air temperatures varied on both sides of the 29.4C 30-year average for Weslaco reported by Orton et al. (11). Besides having the highest temperature, 1977 experienced much solar radiation and lack of rainfall (Table 1). The percent of possible sunshine hours was estimated from daily solar radiation by using a coefficient of 0.70 in the transposed Hargreaves equation (4).

Table 1. Meteorological conditions during the period of peak potential evapotranspiration (PET), July 24 through August 22.

	1975	1976	1977
Average daily temperature, °C	28.1	29.2	30.2
Average daily solar radiation, langley	505	494	596
Percent of possible sunshine hours	65	63	86
Total precipitation, mm	106	28	3

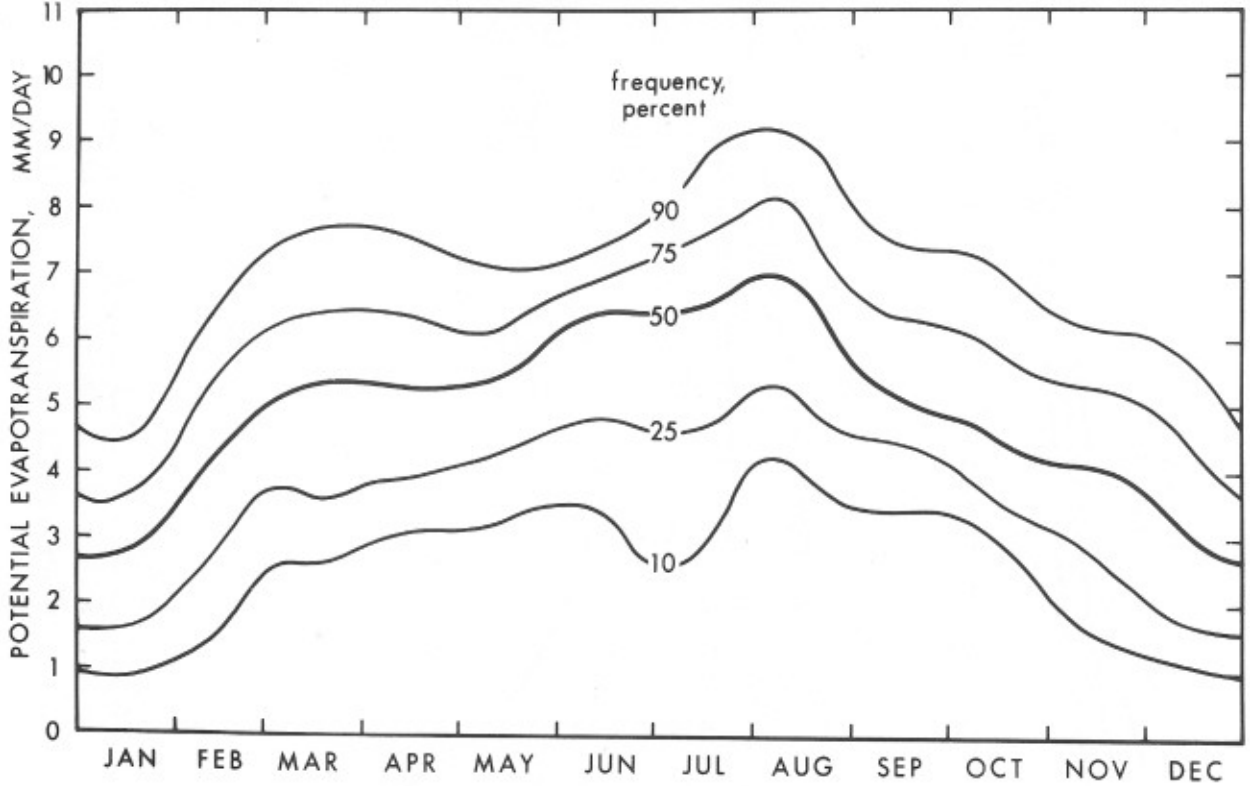

Fig. 3. Frequency distribution of daily potential evapotranspiration (PET) at Weslaco, Texas.

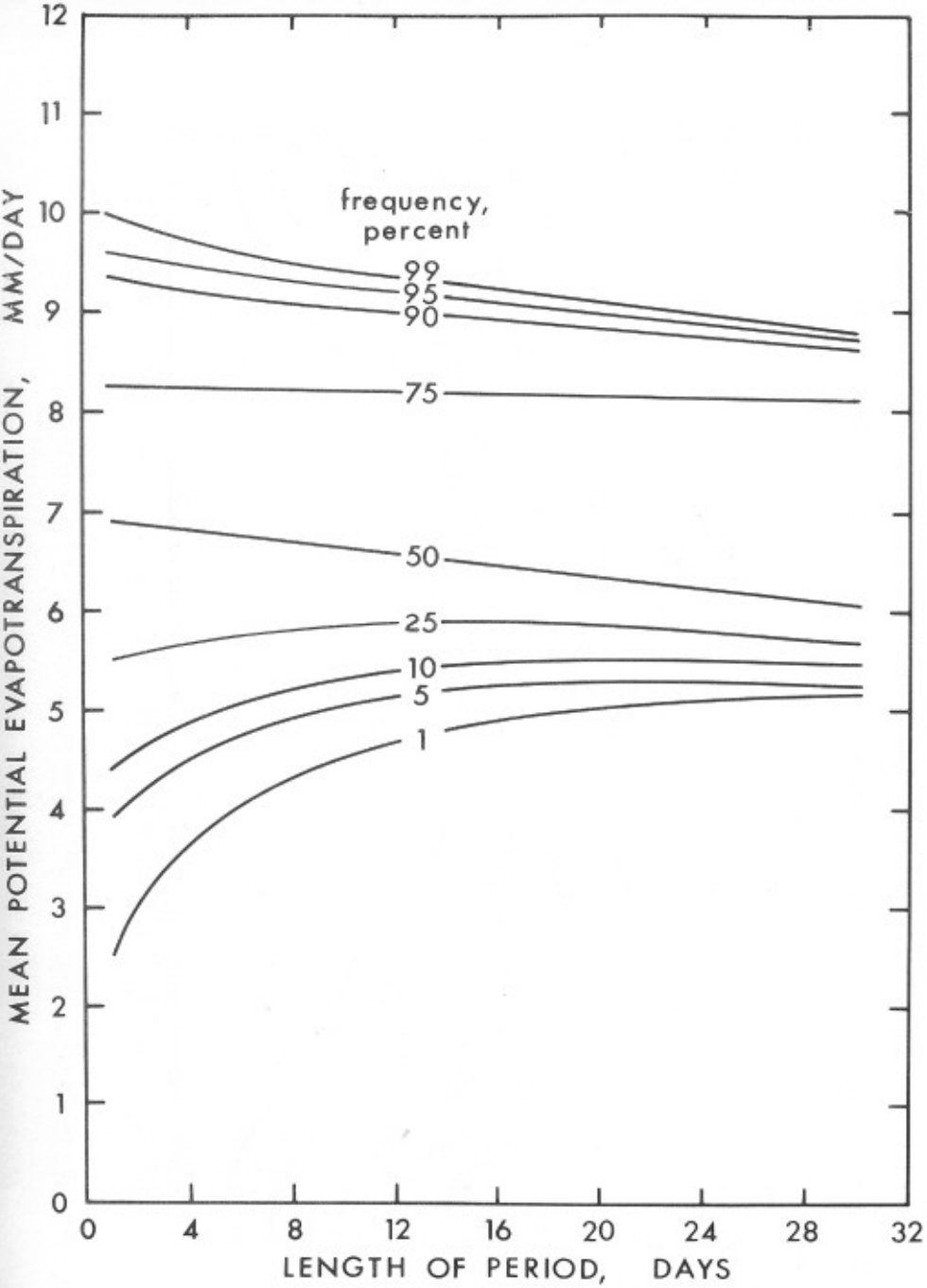

Fig. 4. Frequency distribution of mean potential evapotranspiration (PET) for one to 30 consecutive days during the peak period at Weslaco, Texas.

The meteorological conditions of this analysis are well within the range of circumstances previously encountered at Weslaco (11). However, compared with long-term PET records (not presently available), the values shown in Fig. 4 for the cumulative frequencies of 75 percent and more may be too high for periods exceeding 5 days. This is because of the unusually long period of sustained high PET rates in 1977 (see Fig. 2) that went into preparation of Fig. 4.

CONCLUSION

The Penman and Jensen-Haise methods both adequately represent PET in the Lower Rio Grande Valley during the summer (May through September), and the Penman method is the more accurate during the rest of the year.

The PET frequency distributions presented here should be useful in water management and design decisions. Although we recognize that analysis of 3 years of data may not precisely represent long-range expectations, the frequency distributions presented can serve satisfactorily until additional years of record make possible more refined information. The curves presented here can be a practical aid in water management applications in that they provide a grasp of the trend of PET throughout the year and an acquaintance with the range of values experienced day to day and seasonally.

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Seasonal Nitrogen Concentration and Reflectance of Seven Woody Plant Species

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ABSTRACT

Leaf N concentration of six of seven rangeland plant species decreased from March to June or October. Visible light reflectance of five of these species was positively related to leaf N concentration: reflectance decreased as N concentration decreased.

Leaf N concentration is inversely correlated with reflectance for some crops (3, 12) because leaf N concentration is positively correlated with chlorophyll concentration. Reflectance measurements can be used to follow changes in leaf chlorophyll concentration (2, 11) and thereby distinguish remotely among some woody plant species (8, 9).

Little data are available on either N concentration or reflectance of leaves at different times during the growing season for rangeland plants. The optimum season to inventory rangeland plants is important to the range manager. "Multiseasonal photography," or taking photographs at different seasons of the year (6), is based on the theory that reflectance of an object at a specific time is discrete and can be separated from the reflectance of other objects at another time. This technique has been used successfully to identify both shrub and tree species (7).

Our objective was to study the relation of leaf N concentration and visible light reflectance of seven rangeland plant species during spring, summer, and fall. A knowledge of leaf N concentration of woody plant species during the three seasons will help to understand past and future studies on leaf reflectance characteristics as affected by the pigment concentration in the leaves.

MATERIALS AND METHODS

Seven woody plant species, nomenclature after Correll and Johnston (4), were used in this study: anacua (*Ehretia anacua* (Teran. and Berl.) I. M. Johnst.), cenizo (*Leucophyllum frutescens* (Berland.) I. M. Johnst.), coyotillo (*Karwinskia humboldtiana* (R. & S.) Zucc.), hackberry (*Celtis laevigata* Willd.), honey mesquite (*Prosopis glandulosa* Torr.), live oak (*Quercus virginana* Mill.), and Mexican persimmon (*Diospyros texana* Scheele). These are common species on

south Texas rangelands. Anacua and hackberry are major species on bottomland range sites. Live oak is abundant on deep sands and grows in formations ranging from dense, uniform stands to frequent thickets or motts in underbrush. Honey mesquite is a dominant species throughout the area and grows on a variety of sites (deep sands, sandy loams, clay loams, heavy clays) (5). Cenizo grows in either dense or sparse stands on shallow soils. Mexican persimmon and coyotillo are common species that grow predominantly on either sandy loam or shallow soils.

Leaves of these species were collected during three different times of the year: spring (March), summer (late June), and fall (October) to determine leaf reflectance and N concentration throughout the growing season. Leaves were collected from all portions of the plants. For reflectance measurements, one leaf was collected from each of 10 trees of each species. Detached leaves were immediately wrapped in plastic wrap and stored on ice to minimize dehydration.

For N assay leaves were collected from each of the same 10 trees and composited. These samples were washed with distilled water, air dried for 48 hours at 65°C, ground in a Wiley mill through a 1 mm mesh screen thoroughly mixed, and stored in sealed jars. Total N was determined on three subsamples from each composited sample of each species for each of the three collection dates. Nitrogen was determined by the Kjeldahl method (10).

Total diffuse reflectance of upper (adaxial) surface of single leaves over the 0.35- to 0.7-μm visible light waveband was measured with a Beckman Model DK-2A spectrophotometer, equipped with a reflectance attachment. (Mention of a company or trademark is included for the readers' benefit and does not constitute endorsement of a particular product listed by the U.S. Department of Agriculture over others that may be commercially available.) Data are given for the 0.55 μm wavelength. These data have been corrected for decay of the barium sulfate standard to give absolute radiometric data (1).

RESULTS AND DISCUSSION

Many more leaves were collected for N analyses than for reflectance measurements. Therefore, we did not conduct a correlation analysis. However, the analysis of variance showed significant ($p=.05$) differences among species' means for both N concentrations and reflectance measurements.

Leaf N concentration was highest in March for all plant species except anacua and generally decreased most from March to June with a smaller decrease from June to October.

As the season progressed, leaf reflectance decreased for all plant species but cenizo (Fig. 1). Cenizo's leaf reflectance increased because its leaves became whiter as the season progressed; thus, visible light reflectance increased (9).

If we exclude the data for cenizo and anacua, there is a positive relation between leaf N concentration and reflectance for the remaining five species: reflectance decreased as N decreased. This is not in agreement with results for crop plants where reflectance has been found to be inversely correlated with leaf N content (12). We observed, however, that leaves were darker green in June and October as compared with March. This suggested that as the season progressed leaf N decreased as green pigments increased which decreased reflectance. We

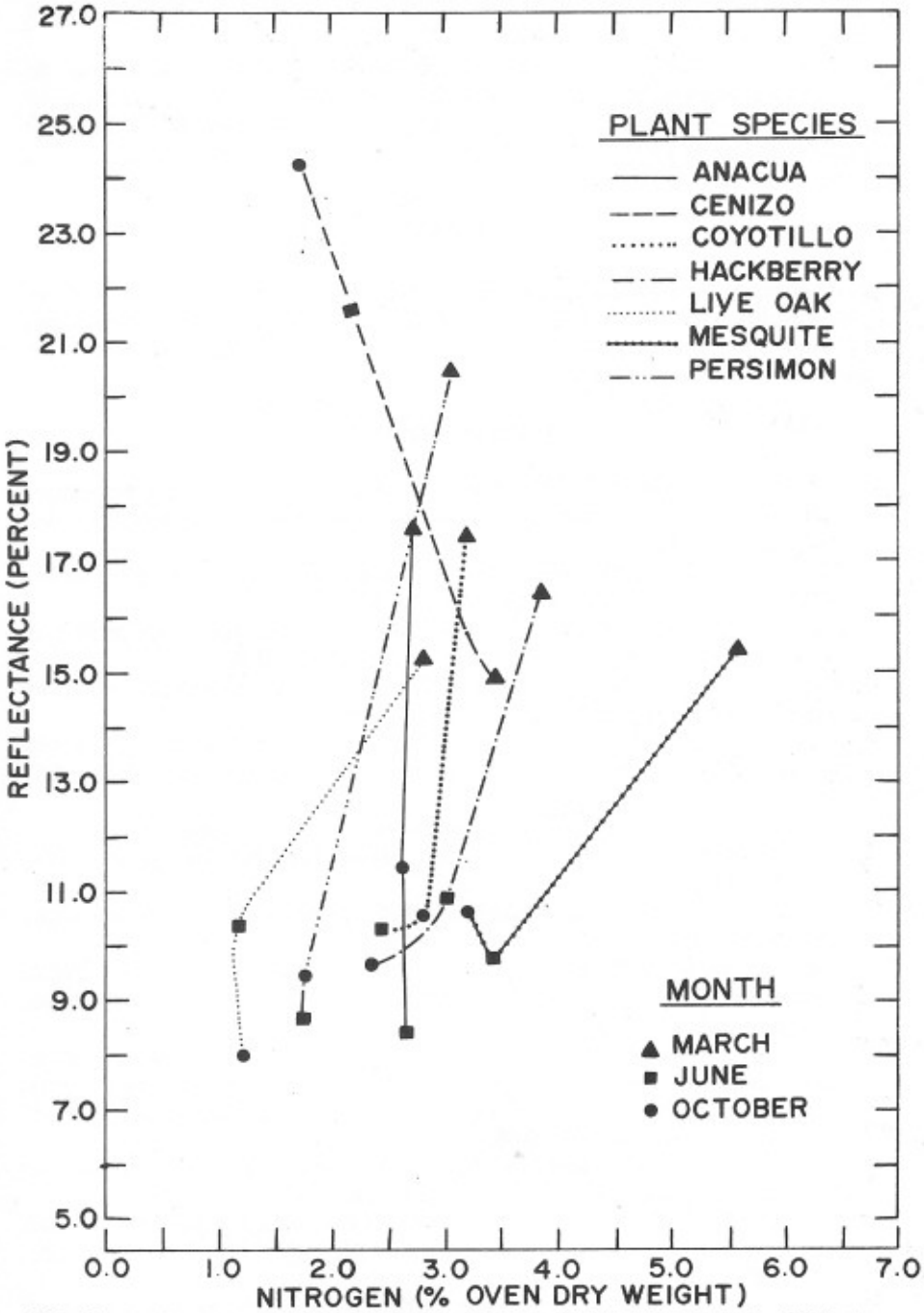

Fig. 1. Leaf nitrogen concentration and percent reflectance at the 0.55 μm wavelength for seven rangeland plant species during the spring (March), summer (June), and fall (October).

think that this unusual phenomenon needs to be brought to the attention of range researchers as soon as possible.

Our next step is to make additional measurements so that we can do a regression analysis of seasonal visible light reflectance differences on those for N and chlorophyll concentration. Then, we can use leaf reflectance measurements, as affected by leaf chlorophyll concentration, to predict leaf N concentration.

ACKNOWLEDGEMENT

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Effect of Pix on Reflectance of Cotton Plant Leaves

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ABSTRACT

A growth regulator (1,1-dimethyl-piperidinium-chloride, Pix) was tested on cotton (*Gossypium hirsutum* L., 'Tamcot SP-37') in the field and in greenhouse pot (soil) and growth chamber (sand) cultures. Leaves collected from plants grown in the three experiments were measured for reflectance, thickness, water content, and chlorophyll (chl) concentration.

Pix-treated cotton leaves of all three experiments had higher near-infrared (0.85 μm wavelength) light reflectance than nontreated leaves, which was associated with increased leaf thickness (more cell wall-air interfaces). Pix-treated, field grown leaves 15 days after treatment and growth chamber-grown leaves for all times of measurement had lower visible light (0.55 or 0.65 μm wavelength) reflectance than nontreated leaves, which was associated with increased total chl concentration in mg/g of leaf tissue on a dry weight basis.

Growth chamber-grown, Pix-treated leaves (low water content) had lower reflectance at the 2.20 μm wavelength in the near-infrared water absorption region than nontreated leaves (higher water content).

Reflectance and transmittance of a plant leaf have been explained on the basis of critical reflection of light at the cell wall-air interface of the spongy mesophyll tissue (2, 4, 6, 13, 14, 18, 23, 24). Sinclair et al. (18) hypothesized that leaf reflectance derives from the diffuse characteristics of plant cell walls. Light reflectance from a leaf is generally reduced over all wavelengths when the leaf is infiltrated with a liquid (24). Most reflectance, therefore, originates internally and is reduced when the cell wall-air interfaces are eliminated. Internal refractive index discontinuities other than cell wall-air interfaces are responsible for some of the near-infrared light (0.75 to 1.35 μm) reflected by a leaf (4, 14, 24). In general, leaves with compact mesophylls had the lower reflectance, and leaves with porous mesophylls had the highest reflectance (6). Results indicated that the mesophyll arrangement within leaves of a plant canopy affected the magnitude of a signal reaching the detector of a remote sensor.

Cycocel, a plant growth retardant, affected cotton plant (*Gossypium hirsutum* L.) leaf reflectance (5). (Mention of a company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the USDA over others that may be commercially available.) A related chemical

[1,1-dimethyl-piperidinium-chloride, now called Pix (17) rather than DPC (9)] shows great promise in regulating canopy structure in a short-season cotton integrated pest management system (16) because of its biological activity, including possible affects on photosynthesis (3, 7, 8, 9, 10, 22).

Chemical growth regulators promise cotton farmers a new management tool for controlling undesirable vegetative growth and for reducing late season and overwintering insect populations. A less dense plant canopy provides fewer hiding places for insects. A compact plant that allows more light penetration and air movement in the canopy makes insecticide applications more effective, reduces boll rot losses, decreases the probability of lodging, and provides greater harvest efficiency.

Our objectives were to test the effect of Pix on cotton plant leaf light reflectance and to relate possible Pix-induced reflectance differences to changes in leaf mesophyll structure and chlorophyll concentration.

MATERIALS AND METHODS

The biological activity of Pix (1,1-dimethyl-piperidinium-chloride) was tested on cotton (cv. 'Tamcot SP-37') in the field and in greenhouse pot and growth chamber sand cultures.

Field experiment. 'Tamcot SP-37' cotton was planted in double drills 20-cm apart on 102-cm centers in a Hidalgo Sandy clay loam (Typic Calcustolls). The distance between beds was 102 cm from center to center. Two treatments replicated three times were used: (a) Pix applied using 75 g of active ingredients (a.i.)/ha at the first bloom stage, and (b) a control (nontreated). Reflectance and growth measurements were made at 10-day intervals, beginning 15 days after the Pix application.

Plants received 30 cm of water, 10.2 cm from rain and 20.3 cm from two irrigations, one at the time of planting. The insecticide Guthion was applied twice, once at pinhead square stage and once at one-third-grown stage.

Greenhouse experiment. 'Tamcot SP-37' cotton plants were grown in a mix of one part Perlite : 200 parts Hidalgo sandy clay loam in 11.4-liter plastic pots. A 10-20-5 fertilizer was added to the mix to give an equivalent of 67.2 kg N/ha. Plants were irrigated with 300 to 350 ml of rain water every two days. There were three plants in each pot.

The experimental design was a split-plot in a randomized complete block with five replications. The main plots were a control and Pix applied at rates of 15, 30, and 60 g a.i./ha in 252.5 liter/ha of distilled water (hand-held applicator, 8003 E teejet flat fan nozzle, 1.7 bar pressure, 3.6 km/h speed); subplots were three times of sampling for measurements: 15, 25, and 35 days after Pix application. Pix was applied at the seventh leaf stage, 34 days after plant emergence.

Plants were sprayed once with De-fend and Kelthane to control leafminer and red spider mite, respectively.

Plants were grown with a daylength of about 13.2 h. Mean daily temperature ranged from 28.3 to 31.1 C, and relative humidity from 71 to 92%.

Growth chamber experiment. Plants were started in peat pellets (Jiffy pots), and two days after emergence transplanted to washed sea sand contained in 4.0-liter glazed crocks. There were three plants per crock.

Plants were irrigated with distilled water for two days after transplanting, then nutrient solution (Hyponex house plant food, 7-6-19) was used. One-half strength solution was used for the first four weeks of growth.

The experimental design and Pix application were the same as that described for the greenhouse experiment, except that Pix was applied at the seventh leaf stage, 24 days after plant emergence, and times of sampling were 15, 24, and 35 days after Pix application.

Plants were sprayed once with Kelthane to control red spider mite. Mean daily temperature ranged from 20.5 to 30.5 C, and relative humidity from 61.0 to 91.0%. A 12 h light-dark cycle was used. Light intensity was about 8600 lux at the plants' apexes.

Methods for all experiments. Leaves of the same chronological age were collected for leaf reflectance, thickness, area, water content measurements and chlorophyll analyses 15, 24 or 25, and 35 days after Pix application. Immediately after harvest field leaves were wrapped in polyethylene to minimize dehydration, stored on ice, and transported to the laboratory. Greenhouse and growth chamber plant leaves were harvested one-at-a-time and measured immediately.

Measurements of thickness, diffuse reflectance, and fixation of tissues were completed within about 6 h after leaves were collected. Leaf thickness was measured with a linear-displacement transducer and digital voltmeter (10). Water content of leaves was determined on a dry-weight basis; leaves were oven-dried at 68 C for 72 h and cooled in a desiccator before weighing.

Tissue pieces sampled from the center of leaves were fixed in formalin-acetic acid-alcohol, dehydrated with a tertiary butanol series, embedded in paraffin, stained with the safranin fast-green combination, and transversally microtomed at 12 μm thickness (12).

A Beckman Model DK-2A spectrophotometer equipped with a reflectance attachment was used to measure total diffuse reflectance on upper (adaxial) surfaces of single leaves over the 0.5 to 2.5 μm waveband. Data were corrected for decay of the barium sulfate standard (1) to give absolute radiometric data.

To reduce the enormous amount of spectrophotometrically generated data and facilitate interpretation, five wavelengths were selected from the 41 wavelengths measured at 0.05 μm increments over the 0.50 to 2.50 μm waveband. Wavelengths selected were 0.55, 0.65, 0.85, 1.65, and 2.20 μm; representing, respectively, the green peak, chlorophyll absorption band, a wavelength on the near-infrared plateau, the 1.65 μm peak following the 1.45 μm water-absorption band, and the 2.2 μm peak following the 1.95 μm water-absorption band.

The t-test (19) was used to test statistically the differences between means of data from Pix-treated and nontreated field-grown cotton plants. The analysis of variance was applied to data from greenhouse-and growth chamber-grown plants at each of the selected wavelengths; Duncan's multiple range test was used to compare mean differences statistically ($P = 0.05$). Total chlorophyll was determined by a routine method (11). Spectra were drawn with a computer-attached plotter.

RESULTS AND DISCUSSION

Because there was little difference among the three times of measurement, except for the visible light reflectance made on the first measurement of field-grown cotton, the reflectance spectra for the field, greenhouse, and growth chamber experiments shown in Fig. 1 are based on averages for the three measurement times.

In general, greenhouse (Fig. 1B) and growth chamber (Fig. 1C) results were similar to those from the field (Fig. 1A). Therefore, most emphasis will be given to the field results.

Pix-treated, fully expanded, field-grown leaves (higher total chl concentration, 2.23 mg/g) had significantly ($P = 0.05$) lower visible light reflectance (0.55 and 0.65 μm wavelengths) than nontreated leaves (lower total chl concentration, 1.57 mg/g) at 15 days after Pix application; whereas, the growth chamber, Pix-treated leaves had significantly lower reflectance at the 0.55 μm wavelength than the nontreated leaves throughout the study. All growth chamber, Pix-treated leaves were alike statistically (Fig. 1).

Pix-treated leaves had significantly ($P = 0.05$) higher near-infrared light reflectance (0.85 μm wavelength) than nontreated leaves for all three experiments (Fig. 1). Reflectance differences between Pix-treated and nontreated leaves ranged from 1.57 to 1.98%.

Pix treatment increased near-infrared light reflectance because treated leaves, (using the 35 day measurement of the field experiment as an example, Fig 2) were thicker (0.327 mm) than nontreated leaves (0.293 mm), and they apparently had more cell wall-air interfaces in the leaf mesophylls (4, 6). Near-infrared light reflectance increases as the number of air spaces in a leaf mesophyll are increased (4, 13, 14, 18, 20, 23, 24). Pix-treated leaves also had longer palisade cells (upper half of transection) and more spongy parenchyma cells (lower half of transection) than nontreated leaves (Fig. 2). The affect of Pix on mesophyll structure influences CO_2 assimilation (21). Unpublished data (H. Walter and H. W. Gausman, Weslaco, Texas) showed that Pix-treated field- and growth chamber-grown leaves had lower CO_2 assimilation than nontreated leaves; however, greenhouse-grown leaves treated with Pix at 15 g a.i./ha had higher CO_2 assimilation than nontreated leaves for the measurements made 25 and 35 days after application.

Pix-treated, growth chamber-grown leaves had significantly lower reflectance ($P = 0.05$) than nontreated leaves at the 2.20 μm wavelength in the near-infrared water absorption region (Fig. 1). This was apparently caused by the larger water content of Pix-treated leaves (79.4 to 79.7%) than nontreated leaves (77.8%). Reflectance increases as leaf water content decreases in this spectral region.

CONCLUSION

It is feasible that Pix might influence the light reflectance and leaf structure of some horticultural crops and thereby increase their photosynthesis or yield.

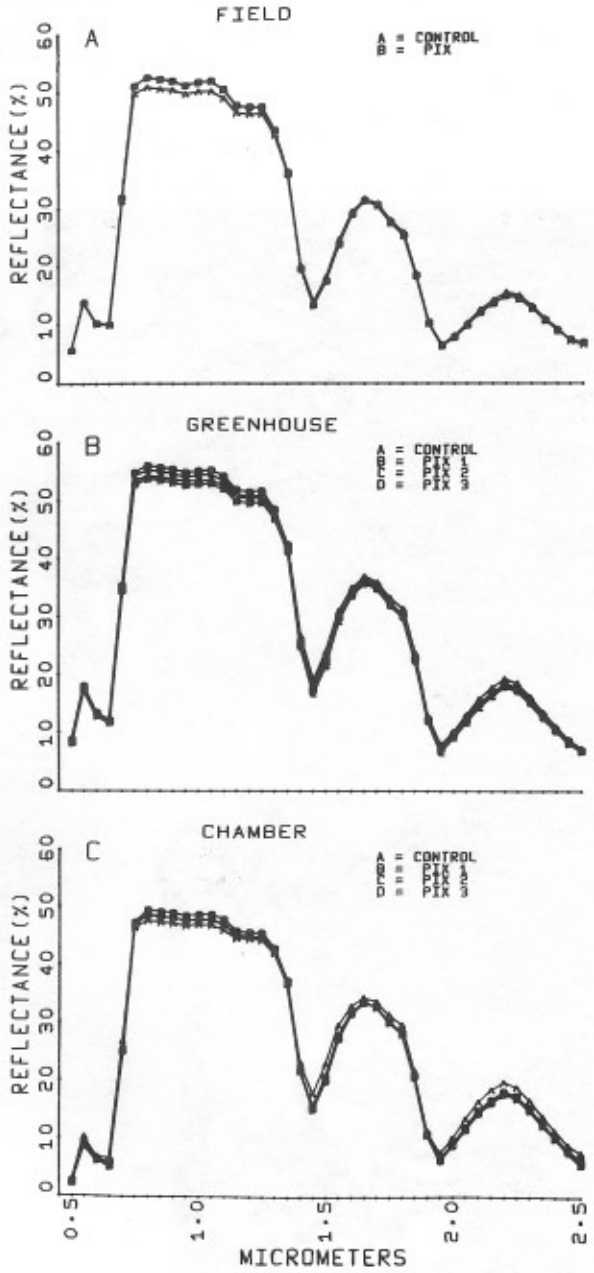

Fig. 1. Effect of Pix on reflectance over the 0.5 to 2.5 μm waveband for leaves of cotton plants grown in the field (A), greenhouse (B), and growth chamber (C).

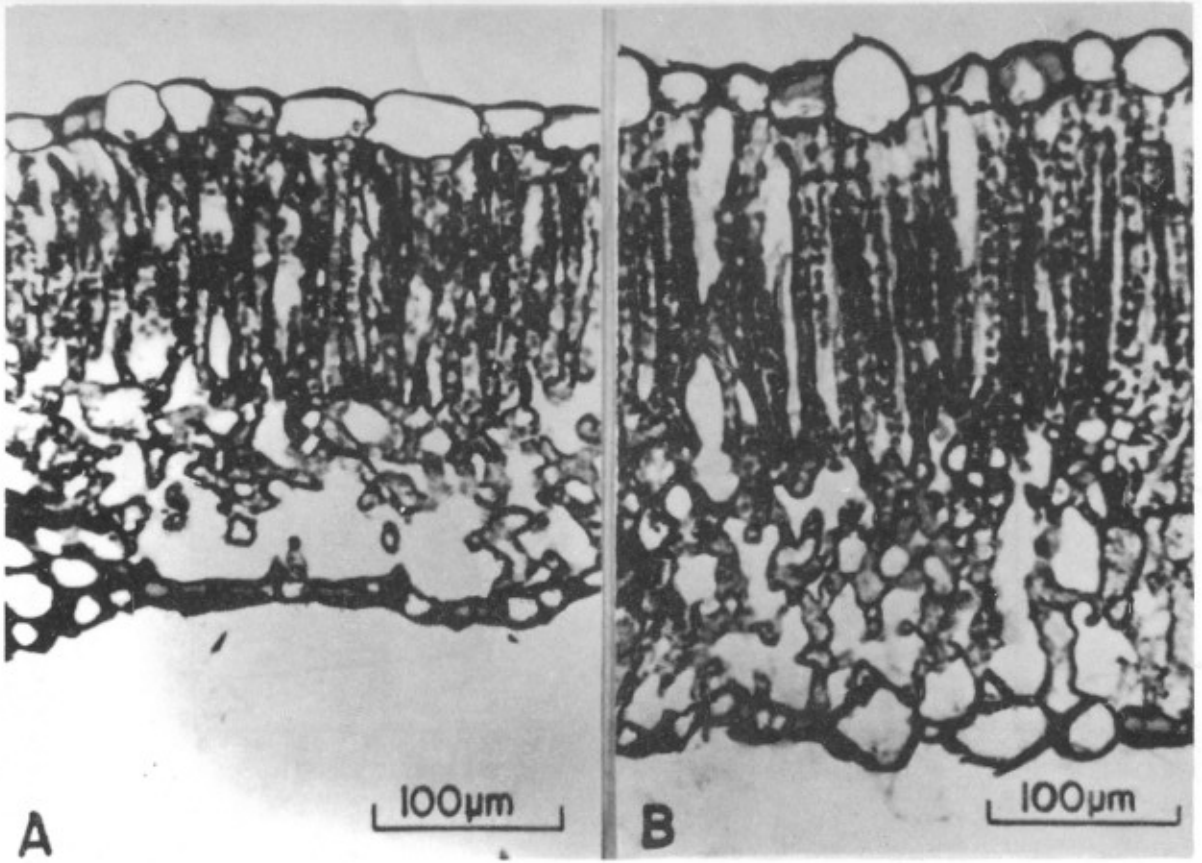

Fig. 2. Transections of field-grown, nontreated (A) and Pix-treated (B) cotton leaves 35 days after treatment.

ACKNOWLEDGEMENT

We thank Maricela Garza for making the leaf transections and Maria Rodriguez for assisting with data analyses.

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Influence of Lime on Fertilizer Response by *Petunia hybrida*

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ABSTRACT

Studies were conducted to determine the influence of lime on fertilizer levels required for maximum flowering of petunias grown in peat:perlite medium. Constant feed fertilization with 2 g of 20-8-15/liter resulted in maximum flowering when medium was limed; in nonlimed medium flower production was greatest when fertilized with 0.5 g/liter. More flowers were produced in limed medium (73/plant, max) than in nonlimed medium (28/plant, max).

Petunias are used extensively in decorating homes and outdoor landscapes. They can be grown either in plant beds or in containers for greater flexibility in landscape designs. Desirable plants have stems of adequate size to support the branches and blooms.

Recent studies have shown the importance of fertilizer rate on flower stalk production by *Chlorophytum* (2). The soil fertility and plant nutrient level needed for petunias under Michigan conditions have been determined (1). Data are limited on fertilizer and lime requirements for container grown petunias. We conducted studies at the Texas Agricultural Experiment Station at Dallas to determine the influence of lime and fertilizer rates on flowering of petunia grown in peat:perlite medium.

MATERIALS AND METHODS

Peat:perlite (1:1 v/v) was placed in 15 cm plastic pots. Hydrated lime was mixed into one-half the pots at the rate of 1.5% w/w. Initial pH was 6.5 for the limed and 4.5 for the nonlimed medium. One 10 cm tall petunia (*Petunia Hybr* Vilm., common garden petunia) seedling was transplanted into each pot and pinched back to a height of 6 cm. Treatment rates consisted of 0, 0.5, 1.0, and 2.0 grams of water soluble 20-8-15 fertilizer per liter with micronutrients. The were applied by irrigating the plants with water containing these fertilizer rates 3 times a week. Sufficient water was applied at each irrigation to provide about 300 ml of drainage per pot. Identical treatments were applied to limed and nonlimed plots. Treatments were replicated 4 times. Flowers were counted 43 and 66 days after transplanting. Plants were grown in a greenhouse with sun; day lengths ranged from 13.5 to 14.3 h.

RESULTS AND DISCUSSION

Twenty-three days after transplanting initial flowering was sparse and not influenced by fertilizer treatment (Fig. 1). The flowering intensity of plants grown in the limed medium was first observed to be influenced by fertilizer rate during the count taken 43 days after transplanting. Plants receiving no fertilizer produced 1.5 blooms/plant while fertilized-limed plants produced about 18/plant. Plants grown in nonlimed medium produced about 2 blooms/plant but differences between fertilizer rates were not evident.

As length of growing time increased, plant response to higher fertilizer rates increased when grown in limed medium. At 66 days plants receiving 0, 0.5, 1.0, and 2.0 g/liter rates produced 10, 37, 49, and 73 blooms/plant, respectively. Studies have shown that nitrogen fertilizer requirements of beets (4) and carrots (3) can be influenced by growth time. Sixty-six days growth resulted in increased blooming of nonlimed plants but maximum blooms, 28/plant, were produced with 0.5 g/liter (Fig. 1 B). At the 2 g/liter rate number of blooms were not significantly different from the nonfertilized plants (6 blooms/plant).

This study indicated that lime influences the fertilizer requirements of petunia grown in peat:perlite medium. Although the mechanism for lime influence on fertilizer requirement was beyond the scope of the study, initial pH measurements did suggest a pH influence.

Among those treatments we employed the most desirable fertilizer level for bloom production by petunia grown in peat:perlite appears to be about 200, 80, and 150 ppm N, P, K, respectively, (1 g 20-8-15/liter) during the first 40 days of growth. Best growth after 43 days might be achieved with 400, 160, and 300 ppm N, P, K, respectively. Lime mixed into the medium at the rate of 1.5% (w/w) enhanced fertilizer response and flowering.

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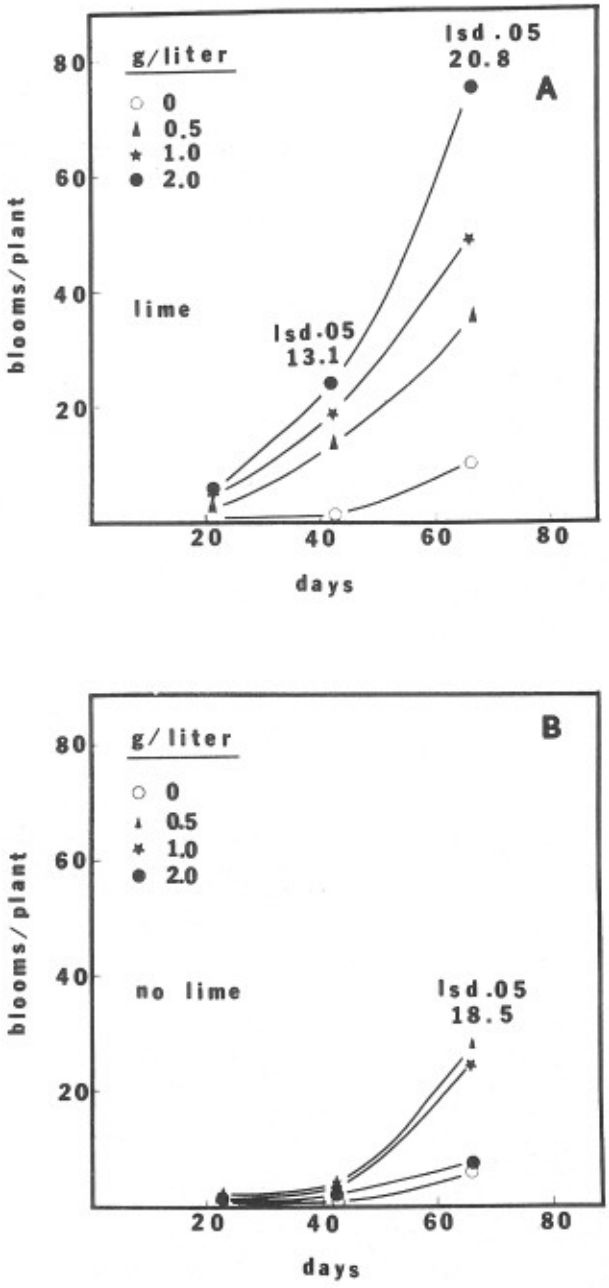

Fig. 1. Bloom production by petunias grown in peat:perlite at 4 levels of fertilization, A) limed, B) nonlimed.

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Effects of Light, Media, and Hormone Treatment on Leaf-Bud Cuttings of *Scindapsus aureus*

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ABSTRACT

Scindapsus aureus (Devil's Ivy) leaf-bud cuttings were treated or not treated with root promoter and then placed in five different media under two light regimes. Hormone treatment resulted in more primary roots than no hormone. The longest primary roots and the most secondary roots occurred in the absence of hormone treatment. Cuttings growing in vermiculite had the longest primary roots and the most secondary roots. Continuous light produced longer primary roots and more secondary roots than daylight only.

The wholesale ornamental nursery industry has expanded enormously during the last decade. Foliage plants, citrus trees and other subtropical plants produced in the Rio Grande Valley are marketed throughout the United States.

This study investigated techniques for propagating *Scindapsus aureus*. Five rooting media, two light periods and two hormone treatments were compared.

MATERIALS AND METHODS

Four benches, 50 x 250 x 15 cm and one meter tall, were constructed to contain five equal sections.

The five media, which are characterized in Table 1, were assigned randomly to the sections of each bench.

On 1 October 1978 the leaf-bud cuttings of *Scindapsus aureus* were taken. Each cutting was 1.5 cm long and contained a single leaf. Half of the cuttings were given a dust treatment with Rootone F (root promoter plus fungicide, Amchem Products, Inc.). Twenty cuttings were placed in each section of the bench. Two benches contained hormone treated cuttings and two contained untreated cuttings.

One bench of treated cuttings and one bench of untreated cuttings received only daylight (10000-21400 1x). The other two benches received continuous light. During the hours of darkness, light was provided by four 240 centimeter 40 watt cold white fluorescent lamps located 130 cm above the benches. Night light intensity measured 1000 1x on the leaf surface of the cuttings.

During the propagation period, length of daylight ranged from 12 hours 20 minutes (first of October) to 12 hours 14 minutes (fifth of December). Temperature ranged from 19° to 28° C as measured by five thermometers in

five different locations. Relative humidity ranged from 75 to 100 percent. Depending on the temperature of the greenhouse the cuttings were manually irrigated one to three times a day with tap water, pH of 7 and electrical conductivity 1.6 millimhos.

Some characteristics of the media used in the experiment are shown in Table 1. The length of primary roots was measured and the number of primary and secondary roots was counted.

Table 1. Characteristics of the media.

	pH	Porosity (%)	Particle Size (mm)
Sand	6.5	37.5	0.05 - 2
Vermiculite[z]	6.5	65.0	3 - 6
1:1 peat-perlite[y]	5.6	50.0	1.5 - 3
1:3 peat-perlite	6.3	70.0	1.5 - 3
1:1 peat-vermiculite	5.8	55.0	3 - 6

[z] Number 2 horticultural grade vermiculite
[y] Canadian peat moss, coarse perlite

RESULTS AND DISCUSSION

Statistical analysis of the data is summarized in Table 2. The continuous light regime produced the greatest length of primary root and the greatest number of secondary roots (P=0.01). Other studies have shown that extended light period leads to greater photosynthesis and that greater photosynthesis initiates more and better quality roots (1, 2, 4).

Cuttings growing in vermiculite had the longest primary roots and the greatest number of secondary roots. Vermiculite had high porosity (Table 1) which makes more oxygen available for root initiation and growth (3).

Hormone treatment resulted in more primary roots than no hormone with differences highly significant. However, the longest primary roots and the greatest number of secondary roots were found in the absence of hormone treatment (P=0.01).

Based upon these findings *Scindapsus aureus* cuttings are best rooted in vermiculite. The use of artificial light to extend normal daylength is beneficial. Application of Rootone F is not economical as untreated cuttings produced the longest primary roots and the greatest number of secondary roots. Additional studies are needed using different variables and plants.

Table 2. Influence of light, media and hormone treatment on growth of primary and secondary roots of *Scindapsus aureus* leaf-bud cuttings.

	No. of Primary roots			Lengths of Primary roots (cm)			No. of Secondary roots		
	Statistical	Best		Statistical	Best		Statistical	Best	
Treatment	Results[1]	Treatment[2]	Mean	Results	Treatment	Mean	Results	Treatment	Mean
light	NS	- -	- -	**	L_2	4.6	**	L_2	6.2
media	NS	- -	- -	**	V	5.69	**	V	8.6
hormone	**	H_1	4.1	**	H_o	5.0	**	H_o	7.7
L X M	NS	- -	- -	**	L_2+V	7.0	NS	- -	- -
L X H	NS	- -	- -	NS	- -	- -	NS	- -	- -
M X H	**	P:3P+H_1	5.4	*	V+H_o	6.9	NS	- -	- -
L X M X H	NS	- -	- -	NS	- -	- -	NS	- -	- -

[1] NS = non-significant, * 5% probability level, ** 1% probability level.

[2] H_o = without hormone, H_1 = with hormone, P:3P = 1:3 peat and perlite, L_2 = continuous light, V = vermiculite.

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Dolichos Lablab, A Potential Forage Legume in South Texas, Can Improve Pastures and Beautify Homes

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ABSTRACT

Dolichos lablab, a forage legume, introduced from Australia and Russia, is presently being tested at the USDA Farm, Weslaco, Texas, as a high protein forage for livestock. This plant also makes an attractive ornamental vine that can be used to beautify yards and homes while increasing soil nitrogen.

Dolichos Lablab, a forage legume also known as lablab bean and hyacinth bean, introduced from Australia and Russia has potential for south Texas rangelands. It is a large seeded annual or biennial vine that produces strong seedlings which develop into vigorous summer-growing plants 3 to 4 feet (0.9 to 1.8 m) long without support. Trifoliate leaves are large, with oval-shaped leaflets 4-6 inches (10-15 cm) long with a smooth upper surface and slight pubescent underneath. Seeds planted in soils 70°F or warmer germinate in 6 to 8 days. Plants will produce blue to reddish-purple flowers in about 40 days from seeds planted in March and will continue to bloom and produce seed until the first frost. About 1800 seeds are needed to make 1 lb. (4,000/kg).

Several other introductions or lines of *Dolichos* from other countries, such as China, India, Pakistan, Zambia, and Malaya also show good potential for forage. Some of these lines produce different colored flowers, exhibit different growth habits, and are poor or late bloomers. *Dolichos* has been reported to grow from 10 to 30 feet (3.0 to 9.1 m) in a single summer and will quickly cover a fence or trellis (1).

Dolichos lablab is reasonably drought resistant and will grow in areas having rainfall as low as 20 inches (510 mm) provided there is summer incidence. In the Lower Rio Grande Valley, it is being grown in a sandy clay loam soil, but it is adapted to a wide range of soils.

These plants are widely used in Australia for livestock forage or pasture (3, 4). Currently, it is being tested at the USDA Farm, Weslaco, Texas, as a high protein forage for livestock. Average crude protein content for the growing season is 17% as compared to 8% for most improved grasses. It produces 3,000 lb of dry weight forage per acre per cutting (3365 kg/ha) (2), with three to four cuttings per year. Presently it is being harvested as hay, but livestock grazing might be the most practical method of harvest. These plants are not very cold tolerant and do not survive the winters in the Lower Rio Grande Valley of Texas.

New seedlings are required each year. In frost free areas, the plants do well as perennials (4). Presently, seed source is limited in southern Texas, but some is commercially available in Mexico.

Most *Dolichos* lines tested at the USDA Farm in Weslaco became well adapted to climatic conditions and showed no signs of nutritional problems. However, introductions from Malaya and Pakistan showed effects of iron chlorosis.

As a legume, *Dolichos* can produce and utilize its own nitrogen (N) when it is properly inoculated with bacteria (*Rhizobium* Spp.). These bacteria live in gall-like nodules on the roots of plants belonging to the family *Leguminosae*. *Rhizobium* convert the gaseous N in the soil air (air is 78% N) to organic nitrogen compounds--a process known as nitrogen-fixation. The association of N-fixing bacteria with the legume host is of mutual advantage. The bacteria obtain much of their food requirements from the legume and in return provide the legume with N by producing enough organic N compounds to meet their requirements and those of the host plant.

When leguminous plants or their older roots die, the N compounds in the root nodules are broken down into forms of soil N which becomes available to other living plants. By this process, soil N reserves are provided.

This legume also makes an attractive ornamental plant (Fig. 1). The climbing vines are ideal around fences and trellises. As an ornamental *D. lablab* would beautify yards and homes and also increase the N supply of the soil.

ACKNOWLEDGEMENT

We thank Drs. Marvin D. Heilman and Maurice J. Lukefahr, USDA Scientists, for their assistance in making *Dolichos* seeds available.

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Fig. 1. *Dolichos lablab*, an introduced forage legume that makes an attractive ornamental. Top -- Individual bloom of a mature plant. Bottom -- Colony of blooming plants.

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In Vitro Propagation of *Rosa chinensis*, Jacq. var *minima* "Red Cascade"[1]

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ABSTRACT

A method for *in vitro* propagation of the miniature China rose (*Rosa chinensis* Jacq.) is presented. Axillary buds were cultured on a basal inorganic salt formulation with vitamins, amino acids, a carbohydrate, and 2 mg/liter indole-3-acetic acid. Rooted plantlets developed in about 2 weeks. Plants were successfully established in soil.

Rapid clonal propagation of many herbaceous plants through tissue culture methods recently has become a commercial practice for many growers (1). There has been limited application of these methods in propagation of woody ornamentals, as woody plants do not readily grow *in vitro*. A procedure for *in vitro* cloning of a miniature rose by axillary bud culture is described which could have commercial application.

MATERIALS AND METHODS

Vegetative axillary buds (1-3 mm) from *Rosa chinensis* Jacq. were excised from greenhouse-grown plants. The buds were surface sterilized and rinsed 3 times in sterile water prior to culture. Cultures were incubated in 16 hour photoperiod (20 $\mu EM^{-1}s^{-2}$) at 27± 2°C.

Establishing clean cultures was a major problem. The duration (10, 15, 20, 25 min) of surface sterilization in solutions of 10% (v/v) sodium hypochlorite plus 2 drops of the surfactant Tween-20/100 ml was examined. Each treatment involved 40 axillary buds.

Comparisons were made between Gamborg's B-5 inorganic salts (2) with (in mg/liter): myo-inositol, 100; nicotinic acid, 1; pyridoxine-HCl, 1; thiamine-HCl, 10; casein hydrolyzate 2,000 and 2% (w/v) sucrose, and Murashige and Skoog inorganic salts (3) with (in mg/liter): myo-inositol, 100; thiamine-HCl, 0.4; adenine sulfate·$2H_2O$, 80; and 3% sucrose. Both media were solidified with Phytagar at 7,000 mg/liter and the pH adjusted to 5.7 prior to autoclaving 15 min at 121°C. Five levels of kinetin, 2, 2.43, 2.86, 5.44 and 8.88 mg/liter with 2 mg indole-3-acetic acid (IAA)/liter were tested on both basal media. Ten explants were cultured per treatment.

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[1] Technical article 15277, Texas Agricultural Experiment Station.

Four phytohormone combinations (1 mg IAA/liter; 2 mg IAA/liter; 1 mg IAA/liter and 0.21 mg kinetin/liter; 2 mg IAA/liter and 0.21 mg kinetin/liter were examined on Gamborg's B-5 medium for both root and shoot development.

RESULTS

With 10 min surface sterilization, 95% of the cultures were contaminated; 15 min, 75%; 20 min 95%; 25 min, 2.5%. The 20 and 25 minute treatments burned the plant tissue so 15 min was chosen. The presence of powdery mildew, *Sphaerotheca pannosa* var *rosae* on the stock plants increased the contamination by 90% as compared to explants from plants lacking any apparent powdery mildew.

After one month the greatest shoot development was exhibited in culture on Gamborg's B-5 medium. All explants on the Murashige and Skoog formulation were chlorotic while those on Gamborg's B-5 were a dark green color. Root and shoot development were effected by the 4 phytohormone treatments. All combinations produced shoots but the presence of kinetin suppressed rooting. After eleven days 50% of the cultures on 2 mg IAA/liter developed shoots and roots (Fig. 1). After 5 weeks in this medium the plants were transferred to 5 cm^2 pots containing a mix of 1/3 peat, 1/3 perlite and 1/3 calcined clay. These plants were placed in high humidity, and the humidity gradually reduced during a two week period to harden the plants. All explants survived transfer to pots.

DISCUSSION

The method described for *in vitro* propagation of the miniature China rose has commercial application potential. This rose is about 18 inches in height with 3-5 main shoots per plant. In conventional propagation schemes shoot tips about 6 inches in length are used. One mother plant could provide 3-5 cuttings. However, on each shoot there are 5-8 axillary buds which could be cultured *in vitro*. Instead of 3-5 plants derived from a mother plant, there is the potential for 9-15 plants. The *in vitro* process can also be carried out throughout the year and could be useful in providing rapid increases in new varieties.

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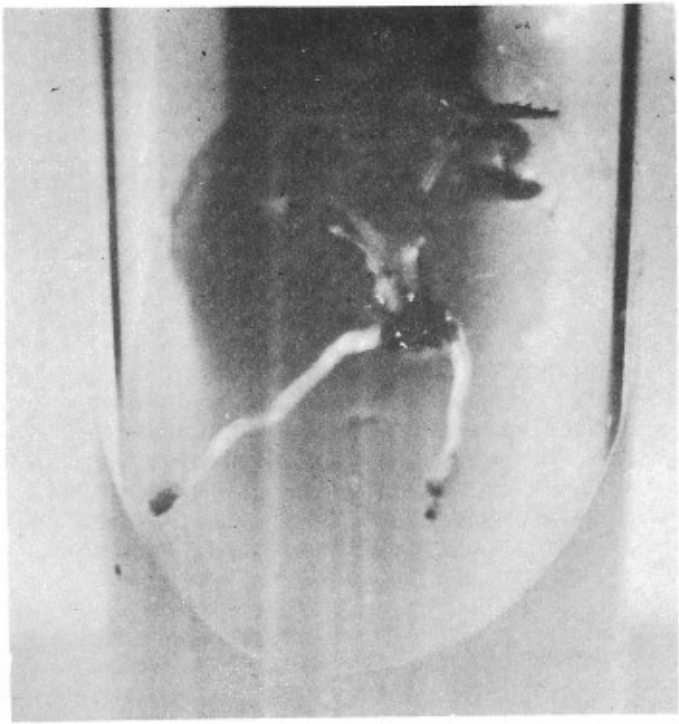

Fig. 1. Axillary bud of *Rosa chinensis* Jacq. after 15 days in culture. Both root and shoot development has resulted.

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Seed Soaking; An Alternative Method of Seedling Height Control[1]

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ABSTRACT

Seeds of *Zinnia elegans* cv. 'Cactus Flowered' soaked in succinic acid 2,2-dimethylhydrazide (SADH), 2,3-dihydro 5,6-diphenyl - 1,4 oxathiin (Chlormequat), and (2-chloroethyl) trimethylammonium chloride (UBI-P293) at 2500 and 5000 ppm for 2, 8 or 12 hr were germinated and the seedlings grown under 10.8 and 32.4 klx illumination. Greatest reduction in hypocotyl length resulted from UBI-P293 treatment which also reduced germination. Chlormequat was less effective in preventing hypocotyl elongation but had no adverse effects on germination.

Additional index words: seed soaks, stem elongation

Growth retardants are widely used to control plant height by the reduction of internode length (9). The chemicals have been applied as foliar sprays, soil drenches and to a limited extent as soil amendments (2, 11, 13). Cathey (3) and Gugenhan (7) demonstrated that when SADH was applied as a foliar spray to garden annuals at the time the main stem began to elongate, stem height was reduced by one-third but flowering was not delayed or reduced. Chlormequat used either as a foliar spray or as a soil drench was effective in the reduction of internode length on a number of species. Cathey and Stuart (5) found that Chlormequat applied as a drench to pot chrysanthemums retarded growth for 11 weeks. Samen (12) showed that foliar treated plants are not usually dwarfed as much as those receiving a soil drench.

Application of growth retardants should be timed with certain stages of plant growth and development to be most effective. Initial treatments on bedding plants are usually applied at the first true leaf stage with later repeat applications as necessary. In previous work residual growth retardation was demonstrated in both germinated seeds and cuttings from treated parent plants. Kimmins (8) reported a similar phenomenon with peppers.

Illumination influences seedlings growth and development and must be optimum for the production of compact plants (14). Carpenter and Beck (1) demonstrated that *Tagetes* grown under high illumination was more compact than when grown under low illumination. During extended periods of low

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[1] Technical article 13532, Texas Agricultural Experiment Station.

illumination there is extensive stem elongation in seedling plants. Commercially, it is impractical to artificially increase illumination; but during early growth stages, treatment with growth retardants could reduce shoot elongation (4, 5, 6).

Even under optimum light conditions some species, such as *Zinnia elegans*, tend to develop spindly stems before true leaves are expanded; thus production of compact plants is difficult. Treatment prior to initial hypocotyl extension is necessary for compact plants to be produced. For this to occur, the treatment has to be performed prior to or shortly after germination. Since growth rate is extremely rapid following germination and receptive surface area small, spray treatments are ineffective. Retardant absorption by the underdeveloped roots at this stage would not effect a rapid enough response. As a result of preliminary trials SADH, chlormequat and UBI were chosen because they reduced plumule length without any apparent adverse effect on root development.

MATERIALS AND METHODS

Each treatment for the trials consisted of 42 seeds soaked for 2, 8 or 12 hr in 2 concns (2500 and 5000 ppm) each of the above chemicals. Control seeds were soaked in distilled water for corresponding lengths of time. Seeds were planted in a 1:1 mixture of shredded sphagnum peat moss and fine grade vermiculite in 12 x 15 cm flats. The flats were placed in growth chambers in a randomized block design under either 10.8 or 32.4 klx illumination. Temperature was maintained at 24°C until germination and the cyclic temperatures of 24°C for 12 hr and 18°C for 12 hr were used to simulate optimum growing conditions. Germination percentage, stem length to cotyledon leaves, internode length to first true leaves, leaf width and length were recorded at 16 and 30 days following treatments.

RESULTS AND DISCUSSION

Percent germination was unaffected by either SADH, Chlormequat or the different light levels. UBI treated seeds exhibited the greatest reduction in germination with reduction decreasing as soaking time increased under both light regimes (Table 1).

Table 1. Effect of UBI-P293, time and concentration at two light levels on germination.

	High illumination			Low illumination		
	2	8	12	2	8	12
Control	17.5a	19.5a	18.09a	19.5a	17.5a	15.5ab
2500	16.5a	15.0ab	9.5b	12.5bc	11.5bc	5.0b
5000	17.5a	15.5ab	10.0b	16.0ab	10.0c	9.0cd

Means in each column followed by different letters are significant at the 0.05% level according to Duncan's Multiple Range Test.

Under low illumination reduction of hypocotyl length in control plants appeared to be related to soaking times, but under high light no such relationship was apparent. Reduction of hypocotyl length of the seedlings under low light was greatest when seeds were soaked with 5000 ppm UBI for 12 hr. Chlormequat at 2500 ppm and UBI at 5000 ppm were equally effective at the 2 hr treatment and were not different from 5000 ppm of chlormequat for the 8 hr period.

Under high illumination greatest reduction in hypocotyl length was attained from the use of UBI for both the 2 and 12 hr soaking periods, both concns being equally effective. Chlormequat for the 12 hr treatment was next best, both concns producing equal hypocotyl reduction (Fig. 1). The 8 hr treatment proved to be least effective overall and seemed to produce some stimulation, an effect sometimes noted in growth regulator studies (10). No treatment resulted in any significant effect on leaf width or length.

The result of these trials indicate that seed treatment may be a possible method to effectively control hypocotyl elongation.

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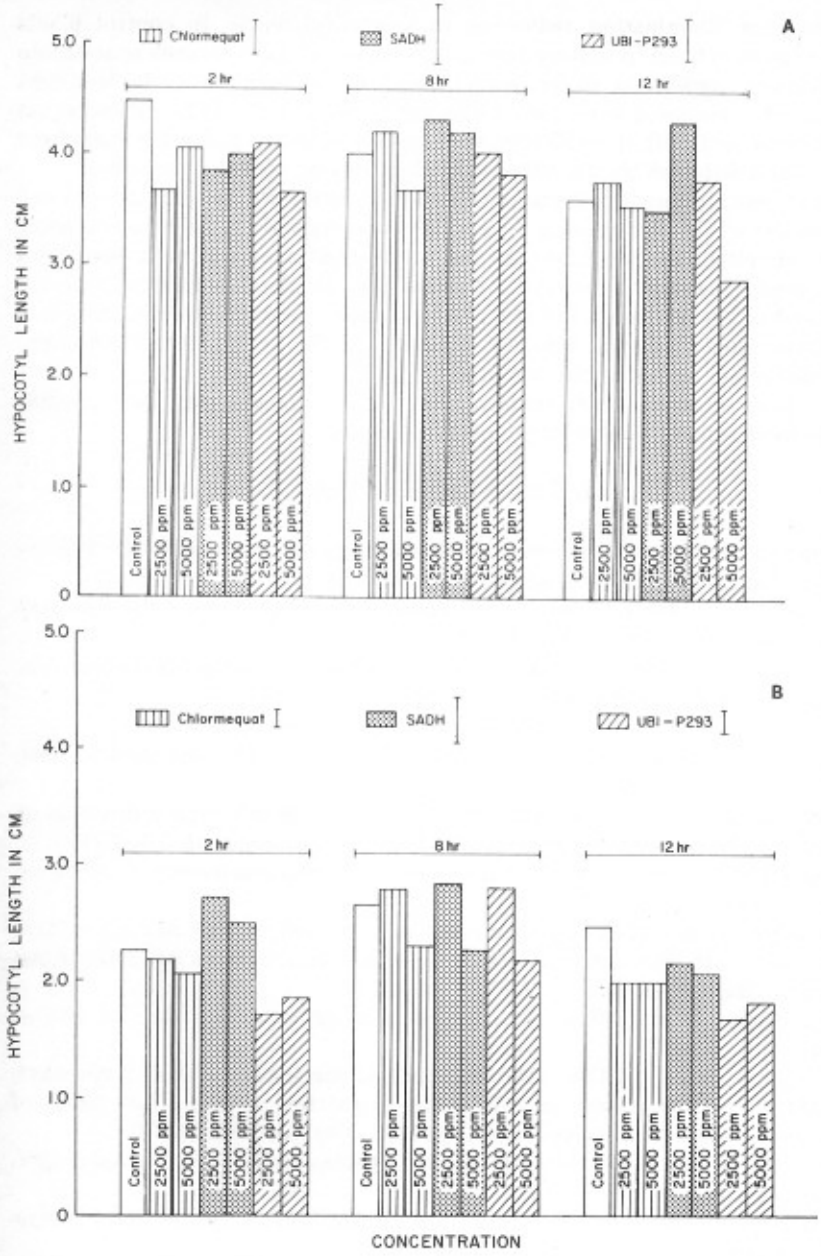

Fig. 1. Effects of soaking *Zinnia* seeds in growth retardants for 2, 8 or 12 hr on hypocotyl length of seedlings after 16 days under: A) low illumination (10.8 klx), B) high illumination (32.4 klx). All treatments compared under each time period. Bar length indicates LSD at 0.05 for each chemical.

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Propagation and Establishment of Two Rare and Endangered Native Plants from Southern Texas

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ABSTRACT

Mexican buttonbush (*Cephalanthus salicifolius* H. & B.) and scarlet hibiscus (*Hibiscus cardiophyllus* Gray) are two woody plants belonging to the native flora of southern Texas. Both species are threatened with extinction because of the extensive clearing of native vegetation for agricultural crops. Both species can be propagated from cuttings, and make desirable ornamentals.

The clearing of natural vegetation in southern Texas for crops has depleted or is rapidly destroying several native plant species. The Rare Plant Study Center of the University of Texas at Austin listed 69 plant species in the South Texas Plains vegetational area as rare and endangered (3). Everitt (2) described 20 rare and endangered species of native plants that have potential as ornamentals in the Lower Rio Grande Valley of southern Texas. Our objective was to describe the propagation and establishment of Mexican buttonbush and scarlet hibiscus, two of these species.

Mexican Buttonbush

Mexican buttonbush is a spineless, deciduous shrub or small tree of the madder family: Rubiaceae (1). It reaches a height of 3 to 4 m, has large lanceolate leaves, and bears showy white flowers (Fig. 1 A).

Twenty-four softwood cuttings of Mexican buttonbush were taken in February 1978 from a natural population of this species near La Joya in southwestern Hidalgo County, Texas. The cuttings were placed in tap water in plastic bags and transported back to the U.S. Department of Agriculture laboratory in Weslaco, Texas where they were dipped in Rootone and placed in pots (16 cm diameter x 16 cm height) in a mist bed for two months. (Trade names are included for the benefit of the reader and do not imply an endorsement of or preference for the product listed by the U.S. Department of Agriculture.) Twelve of the cuttings developed roots and were transferred to the greenhouse. In June 1978, four potted plants were transplanted to the Weslaco laboratory lawn. They grew rapidly during the summer and early fall, reaching heights ranging from 60 to 80 cm by October 1978. An attempt to propagate this plant from seed was unsuccessful.

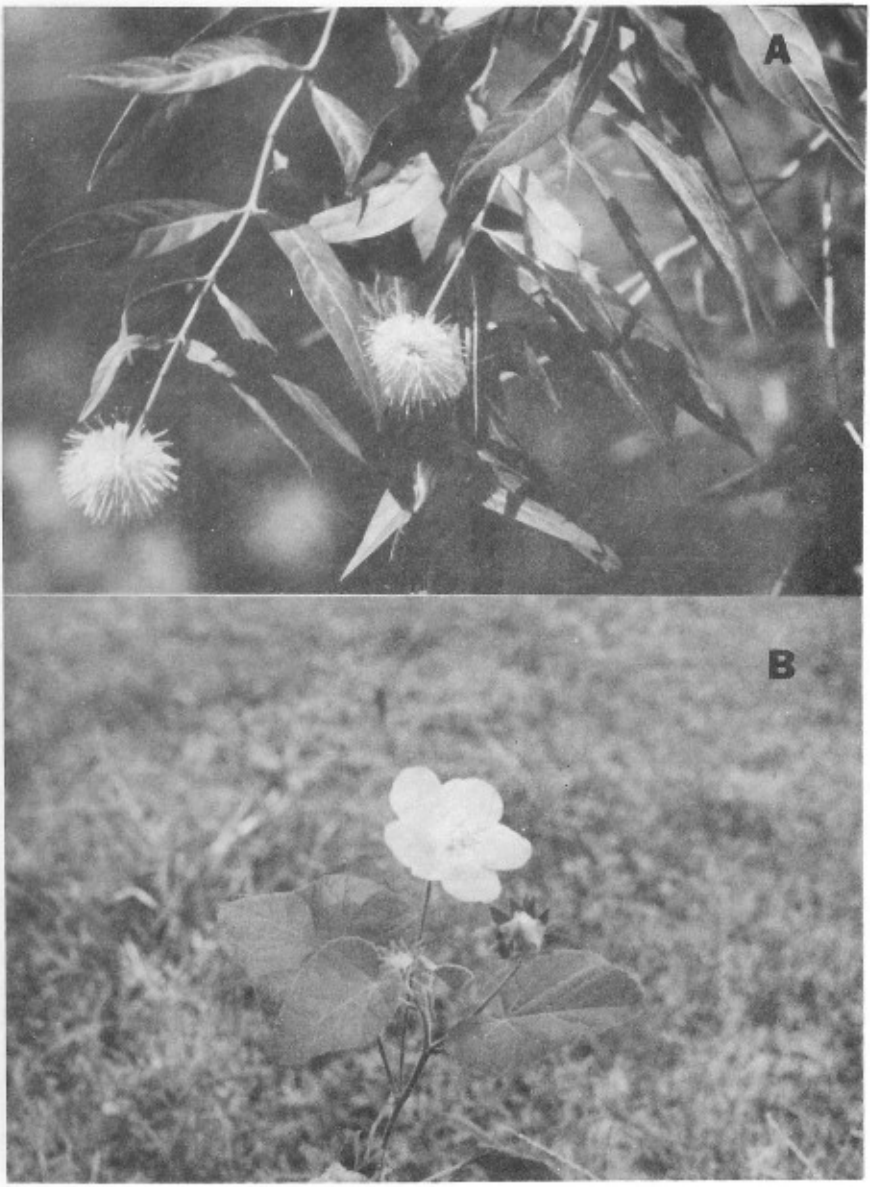

Fig. 1. Mexican buttonbush (A) and scarlet hibiscus (B).

Mexican buttonbush has a high water requirement and needs ample moisture particularly during the hot months of July and August. Therefore, it grows best in moist loamy or clay soil under partial shade. This plant should be grown on the east side of the house to avoid the afternoon sun. Some plants have been successfully transplanted to residences in Hidalgo County.

Scarlet Hibiscus

Scarlet hibiscus is a woody-based perennial subshrub of the mallow family: Malvaceae (1). It reaches a height of 60 cm and has showy crimson to rose-red flowers and large ovate leaves (Fig. 1 B).

Thirty softwood cuttings of scarlet hibiscus were taken in June 1978 from a natural population near Guerra in southwestern Jim Hogg County, Texas. Field and laboratory procedures were the same as those described for the Mexican buttonbush cuttings, except that the hibiscus cuttings were transported to the laboratory on ice because of the hot summer temperatures. After remaining in the mist bed for 6 weeks, 20 cuttings developed roots and were transferred to the greenhouse. By early September 1978, several cuttings began to flower. The cuttings grew rapidly, ranging from 40 to 50 cm in height by October 1978. An attempt to propagate this plant from seed was unsuccessful.

Scarlet hibiscus makes a nice potted plant, or it can be transplanted to the yard. Potted plants that were transplanted to the laboratory lawn in October 1978 look very promising. This species is versatile -- it grows in either partial shade or full sun, and it adapts well to various soils. In its native environment, this species grows on well drained droughty sites such as gravelly hills or around boulders, but it also does well under wet conditions. It is relatively tolerant to cold, since it grows as far north as Del Rio in Val Verde County, Texas.

Both the Mexican buttonbush and the Scarlet hibiscus withstood the winter of 1978-79 at Weslaco without injury. On the morning of 10 December 78 temperature at the 5 ft level was below 26 F for 2 hours and reached a low of 24 F; and on 3 January 79 there were 11 hours below 26 F with a minimum of 23 F. With the coming of spring both specimens resumed vigorous growth.

ACKNOWLEDGEMENT

We thank Fernando Martinez, Jr. for his assistance in the field and laboratory work.

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Response of St. Augustinegrass to Nitrogen, Phosphorus, and Two Additives in the Lower Rio Grande Valley of Texas.

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ABSTRACT

An experiment testing combinations of nitrogen (N) and phosphorus (P) fertilizers with two soil/plant additives, Medina[R] and Cytex[R], on St. Augustinegrass was designed to provide both educational and practical experience for students in a basic horticulture class. Grass color, condition, cover and weediness were rated on treatment day (March 10), April 12, and June 12 by 8 to 12 persons. The lowest color, condition and percent weeds ratings were on April 12 while the percent cover increased with each date. Plots receiving N generally had the best color, condition, and cover and the fewest weeds. P did not improve the performance of N and resulted in poor color and condition ratings when applied alone. The color, condition and cover of the additive plots was noticeably better than the controls which received no fertilizers or additives. Significant plot interactions suggested sunlight and other growing conditions influenced the response of the grass to P and the growth regulating effect of Cytex.

Lawn care recommendations for the Lower Rio Grande Valley come from research on southern lawn grasses done elsewhere but presumably tempered by local experience (2, 11). However, Valley soils and climate are unique enough that to adopt fertilization and other maintenance programs used in the South or even other areas in Texas is questionable (7, 13). Despite Duble and Novosad's advice (6) to allow for native soil fertility in developing the optimum lawn fertilization program, few studies on the response of Valley lawn grasses to fertilizers and soil or plant additives have been conducted. This is particularly true of Floratam, the new St. Augustine Decline resistant strain of St. Augustinegrass, *Stenotaphrum secundatum*, (15). This paper reports the results of a fertilizer and soil/plant additive lab exercise conducted by students of a general horticulture class. The outcome illustrates that a simple but well-planned and executed experiment, though set-up primarily as an instructional tool, can yield valid and useful information.

PROCEDURE

On March 10, two replicate plots, 18 X 40 ft, were laid out on the lawn around Texas A&I Citrus Center. Each replicate was then divided into 12, 6 X 10 ft subplots. Replicate 1, immediately north of the Center office building, was shaded until noon by a large ash tree. The second replicate was 75 ft west of replicate 1 and in full sun from early morning until late afternoon. The grass was

primarily Floratam St. Augustinegrass mixed with 5 - 10% common Bermuda grass, *Cynodon dactylon*, and assorted lawn weeds.

The fertilizer treatments were: (1) nitrogen (as urea, 45% N) applied at 1 lb N/100 ft^2; (2) phosphorus (Guano-phos, 3% citrate soluble P_2O_5, 28% rock phosphate, a product of Lare-tex Feed and Mineral Co., Laredo, TX) at .15 lb P_2O_5/100 ft^2; (3) N + P at 1 lb N and .15 lb P_2O_5/100 ft^2 and (4) the non-fertilized control. Each fertilizer plot was sprayed with either: Medina Soil Activator (Medina Agricultural Products Co., Inc., Hondo, TX, .5% magnesium, .1% iron, .05% zinc, pH = 2.00) at 1.25 pt/gal water/100 ft^2; Cytex (Atlantic and Pacific Research Inc., North Palm Beach, FL, 1.14% N, .106% P, 1.12% potassium, 62.7 ppm iron, pH = 4.9 and 100 ppm kinetin equivalents of cytokinin) at 3.33 oz/gal water/100 ft^2; or no additive at all. The 12 fertilizer-additive treatments were randomly assigned to the subplots within the 2 replicates. Prior to treatment the plots were evaluated for color, condition, cover and weediness. Color and condition were rated from 1, poor, to 5, excellent. Condition was defined as lushness of grass, blade width and density, freedom from blemishes and disfigurations, and overall appearance other than color. Cover was expressed as percent of total plot covered with plant growth and weeds as percent of total vegetation on each plot. The plots were rated again on April 12 and June 12 by 8 to 12 raters. Inital ratings and treatment applications were made by students from a general horticulture class. Citrus Center employees did the April and June ratings. Although limited time and resources necessitated evaluating results with a rating system, this method is commonly employed in turf and lawn research (5, 12, 15, 18).

The data were subjected to standard analysis of variance after assuring the assumptions of normal distribution and homogeniety of variances were met (14). The range of percentages for cover and weeds did not justify transforming these values prior to analysis.

RESULTS

An apparent decrease in color, condition, and percent weeds occurred over all fertilizer and additive plots on the April rating date (Table 1); while grass coverage increased steadily throughout the rating period. By June color and condition had improved, cover had reached its highest level, and weed growth remained unchanged. These overall trends should be kept in mind when considering the treatment results.

Color. Nitrogen appears to be the key to good grass color since both urea treatments averaged significantly higher color ratings than the phosphorus and control plots (Table 2). Except for the plot receiving N + P only, P seemed to result in poorer color. Both additives increased color ratings in the N and non-fertilized control plots, but in the Cytex + P and P alone plots color was no better than the non-treated control. While the average color ratings of the 2 replicates did not differ, the poor color of the P plots in full sun (2.7) compared to those in the shade (3.4) made the fertilizer-replication interaction highly significant.

Condition. As with color, the means of the N plots had the highest condition ratings (Table 3). Neither Medina nor Cytex increased the ratings of the N and N + P plots but both improved the condition of the non-fertilized control. The

Table 1. Changes in color, condition, cover and weediness of all plots of a Floratam St. Augustinegrass fertilizer and additive trial, March to June, 1979.

Date	Color[z]	Condition[z]	Cover (%)	Weeds(%)
March 10, 1979	3.5_B[y]	3.2_B	84.4_A	12.0_B
April 12, 1979	3.2_A	2.9_A	87.3_B	9.6_A
June 12, 1979	3.6_B	3.6_C	94.2_C	10.2_{AB}

z Ratings: 1 = poor, 5 = excellent

y Means in columns separated by Duncan's Multiple Range Test, 1% level.

Table 2. Color ratings of Floratam St. Augustinegrass resulting from fertilizer and additive treatments.

Fertilizer[z]	Additive[z]			Fertilizer Means
	Medina	Cytex	None (Control)	
N	4.0_E[y]	3.9_{DE}	3.2_{BC}	3.7_B
N + P	3.6_{CDE}	3.7_{CDE}	3.9_{DE}	3.8_B
P	3.3_{BC}	2.8_{AB}	3.0_{AB}	3.0_A
None (control)	3.5_{BCD}	3.4_{BC}	2.6_A	3.2_A
Additive Means	3.6_B	3.4_{AB}	3.2_A	

z Means separated by Duncan's Multiple Range Test, 1% level.

y Color ratings: 1 = poor, 5 = excellent. Values are means of the March, April, and June ratings.

Table 3. Condition ratings of Floratam St. Augustinegrass resulting from fertilizer and additive treatments.

Fertilizer[z]	Additive[z]			Fertilizer Means
	Medina	Cytex	None (control)	
N	$3.6^y{}_{DE}$	3.7_E	3.2_{CDE}	3.5_B
N + P	3.5_{CDE}	3.6_E	3.7_E	3.6_B
P	3.2_{CDE}	2.7_{AB}	3.1_{BCD}	3.0_A
None (control)	3.2_{CDE}	3.0_{BC}	2.4_A	2.9_A
Additive Means	3.4_B	3.2_{AB}	3.1_A	

z Means separated by Duncan's Multiple Range Test, 1% level.

y Condition = vigor, blade size and density, freedom from blemishes and spots, etc. 1 = poor, 5 = excellent. Values are means of the March, April and June ratings.

Table 4. The percent of area covered by Floratam St. Augustinegrass in plots receiving fertilizer and additive treatments.

Fertilizer [z]	Additive [z]			Fertilizer Means
	Medina	Cytex	None (control)	
N	$88.4^{y}{}_{BC}$	91.1_{C}	87.4_{BC}	89.0_{BC}
N + P	91.3_{C}	92.5_{C}	90.5_{BC}	91.4_{C}
P	89.6_{BC}	84.4_{AB}	88.1_{BC}	87.3_{AB}
None (control)	87.1_{BC}	89.3_{BC}	78.9_{A}	85.1_{A}
Additive Means	89.1_{AB}	89.3_{B}	86.3_{A}	

[z] Means separated by Duncan's Multiple Range Test, 1% level.
[y] Coverage (percent) values are means of the March, April, and June ratings.

Table 5. The relationship between rating date, fertilizer treatment, and location to the percent of weeds in plots of Floratam St. Augustinegrass.

Date[z]	Fertilizer[z] N Replicate		N + P Replicate		P Replicate		None (control) Replicate	
	1	2	1	2	1	2	1	2
March 10	20_{D}	4_{A}	14_{C}	6_{A}	6_{CD}	3_{A}	28_{E}	4_{A}
April 12	14_{BCD}	3_{A}	4_{A}	4_{A}	8_{ABC}	1_{A}	42_{F}	1_{A}
June 12	13_{BC}	3_{A}	7_{AB}	5_{A}	13_{BCD}	1_{A}	37_{F}	2_{A}

[z] Means, averaged over all additive treatments, are separated by Duncan's Multiple Range Test, 1% level.
[y] Replicate 1 was semi-shaded until ca. 1:00 PM; rep. 2 was in full sun from early morning until late afternoon.

Table 6. The relationship between rating dates, additives, and replicate location on the percent weeds in plots of Floratam St. Augustinegrass.

Date[z]	Additive[z] Medina Replicate[y]		Cytex Replicate		None (control) Replicate	
	1	2	1	2	1	2
March 10	19_{BC}	5_{A}	18_{BC}	5_{A}	21_{BC}	3_{A}
April 12	17_{B}	3_{A}	7_{A}	3_{A}	26_{C}	1_{A}
June 12	20_{BC}	3_{A}	6_{A}	4_{A}	26_{C}	1_{A}

[z] Means, averaged over all fertilizer treatments, are separated by Duncan's Multiple Range Test, 1% level.
[y] Replicate 1 was shaded until ca. 1:00 P.M; rep. 2 was in full sun from early morning until late afternoon.

combination of Cytex + P rated no higher than the untreated plots. Again a significant fertilizer-replication interaction resulted from the P plots in full sun being rated only 2.5 compared to the shady P plots' 3.4.
to the shady P plots' 3.4

Cover. Though the dominant influence on increase in cover was time (Table 1), N or N + P did improve coverage over the non-fertilized control and the additives provided some benefits where no fertilizers were applied (Table 4). Again Cytex with P alone proved no better than the plot receiving neither fertilizer nor additives. The only difference between replications was for the P only treatments where the sunny locations' cover, 85%, was significantly less than the shady plots' 90%.

Weeds. The major differences in the percentage of weeds resulted from the interaction of the 2 replications with the fertilizer and additive treatments. Both N and N + P visibly decreased weed growth with time in the shady plots, Rep. 1, but had no effect in the sunny plots, Rep. 2 (Table 5). P alone had no effect on weediness in either location. No fertilizer in the shady plots favored an increase in weeds but caused no change in the sunny plots. Of the additives, only Cytex significantly reduced weed growth and then only in the shady plots (Table 6). Much of Cytex' effect may have been due to an initially low percentage of weeds in the N, P only, and non-fertilized plots compared to the Medina and no additive plots.

DISCUSSION

Because of the subjective nature of the evaluation system, wide variation within each characteristic rated was anticipated. Consequently, plots with treatment means which could not be separated at the 1% level or better would likely not be visibly different to the average viewer.

With no definitive studies on growing St. Augustinegrass under Valley conditions, one can only speculate on the causes of the significant decreases in color, condition and percent weeds and the increase in percent cover from March 10 to April 12. Since spring root growth in both St. Augustine and Bermuda grass have been reported to lag behind leaf growth by several weeks, warming air temperatures probably activated top growth while the grass roots remained dormant in still cool soils (4). As a consequence the roots could not provide an adequate supply of nutrients to the stems and blades. Following this line of reasoning, sites where sunshine and temperatures favor the most rapid growth should show the greatest stress. The significantly poorer color of the sunny replicate compared to the shady replicate 1, and the slightly improved color of the plots which received some foliar nutrition via the additive sprays support this theory. By June, renewed root growth coupled with several inches of rain undoubtedly enabled the grass to respond fully to the fertilizer nutrients and additives.

Nitrogen's association with better color, condition, increased cover and reduced weediness all confirm its general use on Southern lawn grasses (3, 6, 11, 17). However, since P evoked no noticeable changes except for possibly reducing weed growth, its general use seems questionable. In fact where the grasses' nutrient supply and growth rate are unbalanced, e.g. the Cytex plots, which had no N, P alone can actually be detrimental.

While field crops have not benefited from soil applications of Medina, this amount of iron (95 ppm/plot), in an organic chelate solution, could possibly improve color especially under early spring climatic conditions (16). The actual quantities of nutrients and growth regulator in the Cytex spray, 7 g. N, 1 ppm iron and 1.6 ppm kinetin/plot, were sufficient to elicit some response in the growth or appearance of the grass (8, 10). The cytokinins have been associated with several photosynthetic processes (9). The higher color and condition ratings of the shady plots which received Cytex and the Cytex + P only plots could well be manifestations of cytokinin activity.

The concomittant increase in grass cover with decrease in weeds tend to support the popular tenet that a well-fed, vigorous lawn will rapidly fill bare spots and crowd out weeds. Statistically, however, the initially large disparity in weed population between the replicates exerted a disproportionate influence. Further experimentation using plots more uniform in weediness would help confirm these particular results.

A final comment on the execution and evaluation of the experiment is directed to teachers, youth leaders, farm-home demonstrators or any others involved in the educational process. Though simple in concept, planning and executing this test provided a valid, relevant and practical learning experience as judged from student enthusiasm. While the characteristics used in rating the treatments were not quantitative, they are the aspects by which the majority of people appraise lawns and were thus meaningful to the raters who represented a good cross-section of lawn viewers.

CONCLUSIONS

The positive response of St. Augustinegrass to N and its neutral to negative response to P were compatible with general turf management experience and the fertility levels of Valley soils. The response to the soil/plant additives most likely resulted from supplying readily available nutrients, particularly iron, and/or a growth stimulus, cytokinin, at a critical stage of the grass's development. The overall results confirmed some well-established fertilizer recommendations for Southern grasses but also suggested further research on the effects of Valley soils and climate is needed.

Though simple, the experiment had sound educational value. General horticulture students learned the techniques of planning, executing and evaluating an experiment whose results were meaningful and applicable to them as home owners.

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