Proc. Fla. State Hort. Soc. 89:55-59. 1976.

INFLUENCE OF PREVAILING WINDS AND HEDGING ON CITRUS FRUIT WIND SCAR[1,2]

L. G. Albrigo
University of Florida,
Institute of Food and Agricultural Sciences,
Agricultural Research and Education Center,
P. O. Box 1088, Lake Alfred, FL 33850

Additional index words. orange, 'Temple,' grapefruit, windbreaks.

Abstract. **Seasonal patterns of wind direction and speed were analyzed and wind scar development was examined for several years. Average wind velocity was highest during the spring when young fruit are most susceptible to wind damage. While many fruit developed severe wind scar by May, few additional fruit were damaged severely after May. Annual variation in amount of wind scar could be primarily explained by the total hours of high spring winds from bloom through May. As most of the damaging spring winds were westerly or easterly, hedging mature trees N-S afforded appreciable wind scar protection to fruit inside the grove.**

Wind is recognized as a problem to citrus production in many areas of the world (Australia (3, 6), South Africa (2, 5), California (1, 10, 12), Florida (9)). Both tree damage (1, 3, 6, 10, 12) and fruit damage (2, 3, 5, 6, 10) can occur. Citrus fruits are readily damaged by the midrib or edges of older leaves rubbing on the tender young fruit 0 to 8 weeks after petal fall (3, 5). Less severe damage can occur from 9 o 12 weeks after petal fall and normally little damage occurs after that (5). The bruised area darkens and subsequently a wound periderm is formed that expands as the fruit grows (2, 5). With earlier scarring (0 to 8 weeks post-bloom), the initially damaged tissue is completely sloughed off leaving a smooth silvery or brownish blemish.

Several researchers have found that shelters or windbreaks can be beneficial for citrus plantings (1, 2, 3, 5, 6, 9, 10, 12). For windbreaks to give successful citrus fruit protection, the spring winds should have a primary direction (6) and windbreaks should be placed perpendicular to this primary wind direction (6, 11). Metcalf (7) stated that winds of 15 to 20 mph (24 to 32 kph) probably caused some fruit damage. Windbreaks should reduce wind speeds below damaging levels.

Florida packinghouses commonly eliminate 15 to 30% of the fruit because of wind scar. These studies were initiated to determine whether Florida spring winds have speed and direction characteristics that would make windbreaks effective, and whether wind damage to Florida citrus fruit is similar to that reported in other citrus growing areas.

Materials and Methods

Monthly average wind speed data for 18 years and hourly wind speed and direction data for 1971 through 1976 at Lakeland, Florida were obtained from the U.S. Department of Commerce, NOAA National Weather Service.

Wind scar elimination data for 3 Polk County 'Valencia' groves during the 1972-73 through 1975-76 seasons were obtained[2] and these wind scar levels were compared to the Lakeland wind data.

In the 1974-75 and 1975-76 seasons, fruit from Clermont, Fellsmere, Lakeland, Dundee, and *Lake Alfred groves* were examined in the following ways to assess wind damage:

1. Fruit were examined after high spring winds for fruit damage and the tree parts responsible for the abrasions were identified.
2. Newly damaged fruit were observed and tagged weekly and/or healthy fruit remaining were tagged on a given date and reexamined at maturity.
3. Fruit samples were graded to determine any influence of time, grove conditions, or location in the tree canopy on the amount and severity of wind scar.
4. Wind scar grades used included: clean, slight, moderate, moderately severe, and severe. Severe and moderately severe scarring were considered to be eliminations under good packinghouse grading. Moderate wind scar was considered to be detracting but not severe enough to be eliminated for fresh fruit.

Results and Discussion

The highest average wind speeds for 18 years at Lakeland, Florida coincide with the spring months when citrus fruits are most susceptible to wind damage (Fig. 1).

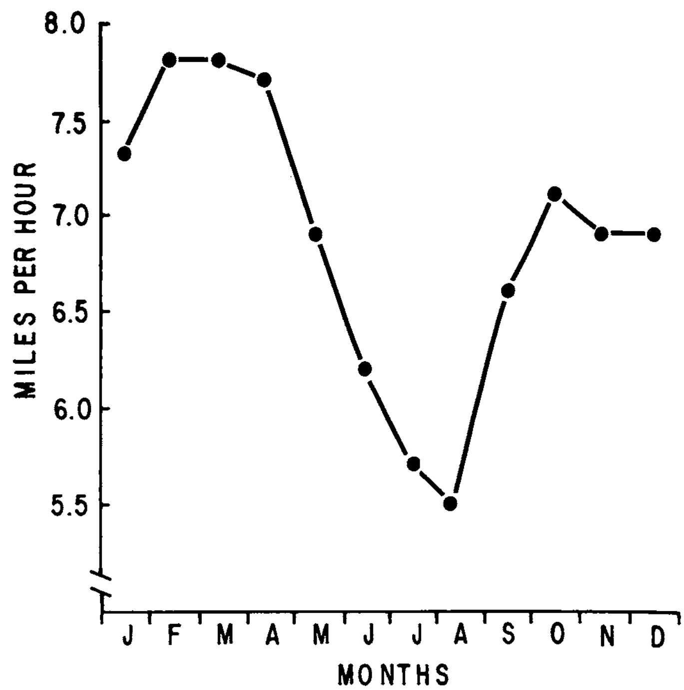

Fig. 1. Monthly average wind velocity at 50 ft ht in Lakeland, Fla. from 1941 to 1958. Data courtesy of U. S. Department of Commerce, NOAA National Weather Service.

Weather Service wind records, when available, are usually from anemometers located 40 to 50 ft (12 to 15 m) above the ground. Some reduction in wind speed occurs at tree or ground level depending on the vertical distance to and roughness characteristics of the ground or vegetation (7, 11). An example of this wind reduction is presented in Table 1. A 16 ft (5 m) wind speed of 8 mph (13 kph) or greater oc-

[1]Florida Agricultural Experiment Stations Journal Series No. 187.
[2]The author wishes to acknowledge the Gulf & Western Food Products Corp., Fellsmere; Dr. C. W. McCoy, Agricultural Research and Education Center, Lake Alfred, and Mr. J. G. Georg, U. S. Department of Commerce, NOAA National Weather Service, Lakeland, for their assistance with this work.

curred when 60 ft (18.3 m) wind speeds were above 17 mph (27 kph). Metcalf (7) stated that 15 to 20 mph (24 to 32 kph) winds resulted in wind scar, but the anemometer ht was not mentioned. In the present study, early spring wind scar damage occurred at a 50 ft (15.4 m) speed of 17 mph (27 kph), which according to Table 1 corresponds to 8 to 9 mph (13 to 16 kph) or slightly higher at tree top. Interpretation and use of weather data must take into account the location and ht of the sensors.

Table 1. Relation of wind speeds at 16 and 60 ft heights in a citrus grove near Lakeland, Fla.

Recorded 16 ft wind speed[z]	60 ft wind speed[z] Avg	Range
mph	mph	mph
8-9	24.3	17-32
10-11	27.2	24-35
12-13	33.8	27-39
14	34	34

[z]Anemometers on tower in clearing with citrus trees 50 to 100 ft to east and west.

Details of Lakeland spring winds (50 ft (15.4 m)) from February through May 1971-76, are presented in Fig. 2. Only winds above 12 mph (19 kph) are summarized and probably only those above 15 mph (24 kph) should be considered potentially damaging to citrus fruits. The major wind direction is from the southwest, and westerly or easterly winds account for the bulk of the higher spring winds.

When data from pest management plots located in the Green Swamp and near Lake Alfred were considered in relation to the Lakeland wind records from bloom through May, yearly wind variations were seen to play some role in the amount of wind scar developing in a given year (Table 2). Years with spring winds in excess of 20 mph (32 kph) were years when wind scar was highest. In the 1974-75 season, one block bloomed 5 weeks earlier than the other 2, and the young fruit in the early bloom block were therefore exposed to several more hr of these high winds. A 10% increase in wind scar resulted. In the 1973-74 season, fruit were exposed to 15 more hr of 18 to 20 mph (29 to 32 kph) winds and 39 more hr of 15 to 17 mph (24 to 27 kph) winds than the later bloom fruit of 1974-75 were exposed to, but only 5% more wind scar occurred. Clearly, not all the difference in wind scarring can be accounted for by the hr of higher wind speeds.

Some additional factors in wind scar formation may include distribution of speed, direction, and duration of winds in relation to time after bloom. The fruit is more susceptible at petal fall than later (2, 5). A given high wind lasting 1 or 2 hr the 1st week after petal fall will cause more damage than the same wind later when the fruit is larger and the surface less susceptible to damage. The outer wall and cuticle of an orange are less than 0.5 μm in thickness just after petal fall and 1.5 to 2 μm in thickness by June.[3] It is also likely that after a certain number of hr of a given speed of wind have occurred from one direction, all potential damage has been done from abrasions resulting from wind movement of leaves, branches, and fruit in that direction. Stronger winds or a different wind direction must occur to cause more damage.

Another subtle factor that can increase the amount of severe wind scar is how early damage occurs to the fruit surface. Since the resulting wound periderm grows in proportion to the fruit growth (see Dodson's figures (5)), an

[3]Unpublished data of the author.

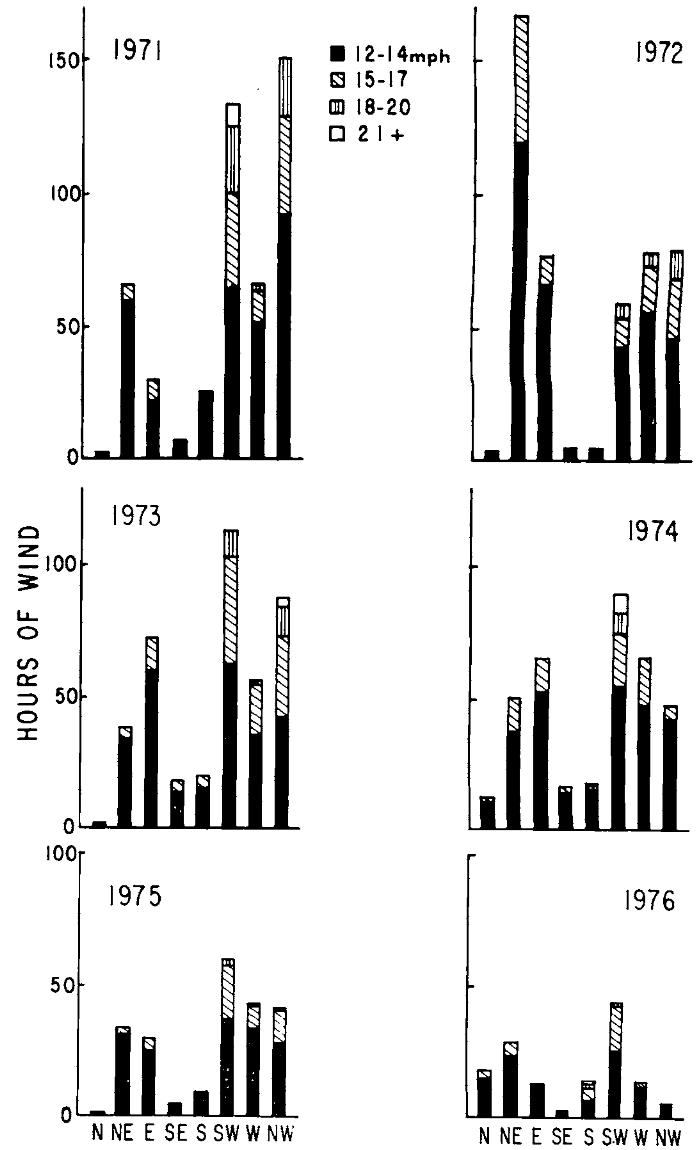

Fig. 2. Hours and direction of February through May winds of 12 mph or greater at 50 ft ht for 1971 through 1976 at Lakeland, Fla. Data courtesy of U. S. Department of Commerce, NOAA National Weather Service.

Table 2. Influence of hours of high wind speeds from date of bloom through May on development of 'Valencia' fruit wind scar in Polk County, Fla.

Year	Bloom date[z]	Wind scar[z]	Avg wind speed[y]—mph 15-17	18-20	21+
	full bl.	%	hr	hr	hr
1972-1973	4/4	9.5	49	0	0
1973-1974	3/10	27.3	114	21	4
1974-1975	2/7[x]	32.0	129	16	14
	3/15	22.6	75	6	4
1975-1976	3/1	16.0	58	12	0

[z]Bloom dates and wind scar data are for pest management plots at 3 locations (Green Swamp, Polk City, and Haines City).
[y]Wind speed hr supplied by U.S. Dept. Commerce, NOAA National Weather Service, Lakeland.
[x]One block bloomed 5 weeks earlier than the other 2.

early blemish of 1 cm^2 surface area will be larger at harvest than if the injury occurs later.

In March 1974, 1 to 2 days after a recorded 50 ft (15.4 m) ht wind of 17 mph (27 kph), examination of 'Valencia' fruitlets revealed dark, bruised areas on the sides of many of the fruit. The bruises could often be associated with an adjacent older leaf that had obviously caused the damage. Similar observations were made on grapefruit near Fellsmere, Florida. Less often branches appeared to be the cause of the abrasions.

When young fruit were tagged at the time of wind scar development in 1975, it was found that most of the scarring developed by May (Table 3). The following year, when oranges and grapefruit were tagged for severity of wind scar in mid-June and then reexamined in late August, only 4% of 507 fruit graded showed any increase in wind scar blemish from their earlier grade. This agrees with Dodson's conclusion (5) that most of the citrus fruit wind scar occurs in the 1st 12 weeks after bloom.

Data collected from a young grapefruit grove near Fellsmere showed that additional scarring can occur the 1st half of May, particularly to fruit in the northeast sector of the tree (Table 4). This grove was very exposed on all sides, and the young grapefruit trees were set on a wide spacing. The large increase in damage in the northeast tree sector was probably caused by an observed increase in northeasterly winds in late spring (from monthly National Weather Service records not shown). Wind scar damage in the southwest tree sector steadily increased from date to date.

Further influence of tree exposure on fruit wind scarring was examined for 'Valencias' in the Clermont area. A site with N-S hedged and open spaced blocks on the east and west sides of a large hill was selected. In the N-S hedged blocks, more severe scarring developed on the fruit of the exposed tree side of the 1st row than either on the protected side of the 1st row trees (west exposure, N-S block) or on the fruit of the 5th row trees of the west or east exposed blocks (Table 5). In trees with east exposure (Table 5), less severe fruit wind scar occurred on the 5th row trees hedged and running N-S than on open spaced trees in the 3rd row running E-W. N-S hedging, therefore, might provide some grove self-protection from wind scarring.

Table 3. Wind scar development before and after May 1 in 1975-1976 season.

Variety/ time measured	Fruit wind scar			Total fruit sampled
	Clean-slight	Moderate	Severe	
	%	%	%	
Valencia				
bloom to May[z]	13	33	54	-15-
May to Sept.[y]	90	10	0	-29-
Temple				
bloom to May[z]	39	40	21	-67-
May to Sept.[y]	87	10	3	-78-

[z]All fruit on individual limb units were tagged by May 1.
[y]All these fruit were still clean or only slightly damaged in early May.

Table 4. Wind scar development on young 'Marsh' grapefruit trees under 'flatwoods' conditions near Fellsmere, Fla.

Date sampled	Tree[z] sector	Wind scar grade				Total fruit sampled
		Clean-slight	Moderate	Mod. severe	Severe	
		%	%	%	%	
3-28-75	SW	43	33	16	8	-421-
	NE	59	25	12	3	-503-
4-29-75	SW	31	38	18	13	-225-
	NE	59	29	7	5	-378-
5-14-75	SW	11	45	24	20	-75-
	NE	28	32	21	19	-94-

[z]Approx 2 ft strip from top to bottom of tree canopy harvested from 2 different trees on each date, trees 10 to 12 ft tall.

Table 5. Wind scar development by 4-24-75 on 'Valencia' oranges on 12-yr-old trees near Clermont, Fla.

Row	Tree sector	Rows run	Wind scar grade[z]			Total fruit sampled
			Clean-slight	Moderate	Severe	
West exposure			%	%	%	
1	West	N-S	41	34	25	-191-
1	East	N-S	50	42	8	-106-
5	West	N-S	65	31	4	-156-
5	East	N-S	60	33	7	-100-
East exposure						
1	East	N-S	47	33	20	-159-
5	East	N-S	47	48	5	-133-
3	North	E-W	53	30	17	-122-

[z]All fruit taken from a horizontal strip (4 to 7 ft heights) from 3 trees of approx 12 ft ht. Close planted trees in solid hedges except wider spacing in Row 3 on eastern exposure.

Data in 1975 from a tall, mature 'Marsh' grapefruit block hedged N-S near Dundee, Florida also supports the idea that this grove configuration offers considerable internal self-protection from wind damage. The 2nd and 8th internal rows had less severe wind scar (2 and 7%) than the 1st row (31%). Reestablishment of higher winds at the tree tops farther into the grove after the initial calm created above the 1st trees by wind rise at the 1st row windbreak may have caused the higher wind scar level of the 8th row (4, 8, 11). Tops of 2nd row trees had only 14% severe wind scar in 1976 (data not shown) compared to 28% in row 1 (Table 6). Another contributing factor to more damage in the 8th row may be wind turbulence created some distance behind the windbreak row (8).

Because wind scar reduction under N-S hedging practices appeared promising, a comparison was made in 1975-76 of the wind scar in the hedged grapefruit block near Dundee and wind scar in a grapefruit block of similar age and ht but planted to a wide spacing about 3 miles (5 km) north of Dundee (Table 6). Wind scar damage was uniformly distributed from top to bottom of the west side of the westerly exposed 1st row trees in both groves. The east side of the 1st row trees was more protected and this was most pronounced in the hedged block particularly when the reduction in moderate wind scar is considered. Hedging gave more protection to the internal 8th row trees in comparison to the open planting. Moderate wind scar damage was particularly reduced. The fruit in the tops of the 8th row trees of the hedged block were poorly protected indicating that high winds had again reached tree top level. In the open block, the middle of the west side of the trees in the 8th row had considerable severely damaged fruit. This was consistent and is probably related to wind turbulence over and around the open spaced trees. The importance of the high mid-tree level of wind scar in the open spaced trees is increased by the fact that this was where the highest density of fruit existed in both grapefruit blocks. Overall, the N-S hedging appeared to reduce the amount and severity of wind scar inside the block compared to the open planting.

Evidence is presented that spring E-W winds cause the wind scar in Florida and that the spring period coincides with the development of wind scar as has been found in other parts of the world (2, 3, 5, 6, 10). It should be expected that N-S windbreaks on the east and particularly the west side of a grove would reduce wind scar. Some evidence is presented that N-S hedging of the grove will provide considerable self-protection against wind scar.

Additional protection would be provided by allowing the outer east and west rows plus every 10th or 12th internal row to grow taller than the rest of the grove. This would create parallel windbreaks that should provide protection to the fruit in the tops of the inner row trees as well as in

Table 6. Comparison of wind scar on mature 'Marsh' grapefruit in a wide-spacing open grove and in a N-S hedged grove. Groves near Dundee, Fla. (1976).

Row	Tree side	Fruit location		Wind scar grade: Moderate	Wind scar grade: Severe	Total fruit sampled
Open grove[z]				%	%	
1	West	Top		57	26	-58-
		Middle		66	15	-59-
		Bottom		63	17	-56-
			Mean[y]	/62	/19	
	East	Top		73	4	-56-
		Middle		47	8	-51-
		Bottom		40	7	-47-
			Mean	/53	/6	
8	West	Top		65	7	-60-
		Middle		32	20	-57-
		Bottom		24	5	-55-
			Mean	/40	/11	
	East	Top		52	2	-64-
		Middle		45	2	-56-
		Bottom		20	0	-54-
			Mean	/39	/1	
N-S hedged grove[z]						
1	West	Top		42	28	-90-
		Middle		56	18	-90-
		Bottom		43	29	-91-
			Mean	/47	/25	
	East	Top		39	2	-89-
		Middle		24	2	-90-
		Bottom		14	6	-90-
			Mean	/26	/3	
8	West	Top		50	20	-92-
		Middle		34	7	-90-
		Bottom		11	0	-87-
			Mean	/32	/9	
	East	Top		26	7	-88-
		Middle		23	1	-90-
		Bottom		13	2	-90-
			Mean	/21	/3	

[z]Avg. of 2 trees in open grove and 3 trees in hedged grove. Trees 17 to 18 ft tall, hedged grove more exposed to West.
[y]Means unweighted for fruit density distribution in the tree.

the lower parts of the trees (8, 11). This system would waste less grove space and would establish windbreaks faster than growing shade tree windbreaks. Taller shade tree windbreaks to the west would probably still be beneficial. These internal citrus tree windbreaks would be inexpensive to create, fit in with present cultural practices in most groves, but would cause some harvesting difficulties.

Studies are now planned to determine the best ht, width, and spacing of the windbreak tree rows for maximum internal grove wind protection. The uniform fruit damage on the hedged outer rows shown in Table 6 suggests that the grapefruit trees were sufficiently permeable to air to avoid creating a static air wall in front of the trees. This permeability will minimize turbulence (8) and help to achieve a 10 to 15 times height downwind reduction in wind speed (4, 8, 11). With the additional benefits of parallel windbreaks (11), sufficient wind reduction 200 to 300 ft downwind might be achieved (10 to 12 rows) thereby creating an effective citrus tree windbreak system. Hopefully, with a resulting reduction below the present 15 to 30% severe wind scar, the packout of fresh Florida citrus could be significantly increased.

Literature Cited

1. Blanchard, F. 1934. Depressing effects of wind on growth and yield of citrus trees. *Calif. Citrogr.* 19:206.
2. Brodrick, H. T. 1970. Investigations into blemishes on citrus fruits. *S. Afr. Citrus J.* 441:7-31.
3. Campbell, M. M. 1967. Windbreaks for citrus trees. *Aust. Citrus News* 43(10):10, 15.
4. Denuyl, D. 1936. The zone of effective windbreak influence. *J. Forestry* 34:689-695.
5. Dodson, P. G. C. 1966. Damage to citrus fruit by wind. *S. Afr. Citrus J.* 393:5-7, 11.
6. Freeman, B. 1974. How artificial windbreaks help citrus growers in Australia. *Citrus Subtrop. Frt. J.* 483:4-6, 8.
7. Metcalf, W. 1936. The influence of windbreaks in protecting citrus orchards. *J. Forestry* 34:571-580.
8. Moen, A. N. 1974. Turbulence and the visualization of wind flow. *Ecology* 55:1420-1424.
9. Newins, H. S. 1937. Windbreaks for prevention of damage to citrus trees. *Proc. Fla. State Hort. Soc.* 50:43-46.
10. Platt, R. G. 1967. Windbreaks for citrus. *Calif. Citrogr.* 51:396-397, 418-421.
11. van Eimern, J., R. Karschon, L. A. Razumova, and G. W. Robertson. 1964. Windbreaks and shelterbelts. *World Meteorol. Org.* No. 147.TP.70, Tech. Note No. 59:1-188.
12. Young, F. D. 1926. Desert winds and windbreak protection. *Calif. Citrogr.* 11:455, 484-487.

Proc. Fla. State Hort. Soc. 89:59-62. 1976.

TWO YEAR SUMMARY OF EXTENSION INTEGRATED PEST MANAGEMENT PROGRAM

K. G. Townsend
University of Florida,
Institute of Food and Agricultural Sciences,
Cooperative Extension Service,
Agricultural Research and Education Center,
P. O. Box 1088, Lake Alfred, FL 33850

Additional index words. Oranges, *Citrus sinenis* Osbeck.

Abstract. **Two years of experience using an integrated pest management program in 26 paired blocks of round oranges (Citrus sinensis, Osbeck) produced for the processing market shows reduction in pest control costs without significantly reducing vigor or yield. In most cases, control of greasy spot disease has been accomplished in a manner compatible with maintaining the fungal pathogen of rust mites.**

To date, round oranges comprise 74% of the total citrus acreage (851,000 acres) in Florida (1). About 90% of the round orange production is utilized in processed products where internal quality of the fruit is more important than external rind blemish except in severe cases (3).

Parasites, predators and pathogens play a major role in pest control on citrus. Various species of parasites are instrumental in keeping soft and armored scales at a generally non-economic level. *Hirsutella thompsonii* (Fisher), a naturally occurring pathogen of citrus rust mite *Phyllocoptruta oleivora* Ashmd., is one example. Its effects are observed during dense populations of rust mites usually occurring in July and August. Conserving natural control factors by careful selection of pesticides and their application on a symptomatic and economic basis offers an opportunity to increase efficiency of production.

The Extension Pest Management program was designed to demonstrate the integrated pest management strategy developed by researchers at Lake Alfred AREC and the ARS at Orlando under a variety of ecological field conditions throughout Florida (2).

Materials and Methods

This project has 26 paired 10-acre grove blocks located in 4 areas of the state (Fig. 1). Eight groves are located on the ridge from Lake Alfred south. Ten groves are in the central and northern sections. Five groves are along the east coast and around Lake Okeechobee, and three are located in the west coast citrus producing area.

The groves were selected for uniformity and are comparable in many aspects such as rootstock, variety, age, etc. The cooperator furnishes and applies pesticides to one half of each paired block, but only as prescribed by this project. This is called the demonstration half. In the other half of each pair the cooperator practices pest control by following the recommendations in the Florida Spray and Dust Schedule. The half receiving the grower's program thus serves as "control" for the demonstration block.

Fertilization and other horticultural practices are identical for each half of the paired block. Each pair is monitored bimonthly for all pests present in sufficient numbers to warrant sampling. To date, greasy spot, citrus rust mites and citrus snow scale have caused the greatest concern.

At the inception of this program the 10-15% infested fruit threshold which was designed and used as an indicator for preventative citrus rust mite control would not allow sufficient latitude for development of the concept of pest management. Therefore, the following threshold was derived to serve in the interim period until research could provide a more definitive threshold.

The demonstration half of each pair received the first miticide application when monitoring data showed 10% of the infested fruit had 35 or more citrus rust mites per lens field (2 cm^2) and less than 50% of the dead mites were infected with *Hirsutella.*

FC 435-66 oil was used for greasy spot control where the