1976 ANNUAL REPORT

VOLUME I

B A N A N A S

UNITED FRUIT COMPANY

DIVISION OF TROPICAL RESEARCH

AND

DIVISION EXPERIMENTAL DEPARTMENTS

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BANANA DISEASES

Leaf spot (black Sigatoka and Sigatoka) and nematode root rot continue to be the most costly of the diseases and pests attacking bananas. Leaf spot control in the four Central American Divisions absorbs nearly 5 million dollars or 52% of the costs of disease and pest control; nematode control costs about 2 million dollars or 22%. Although disease control procedures were improved in 1975, costs of materials and labor continued to rise and it was necessary to greatly increase number of spray cycles to provide good control of the virulent black Sigatoka. As a result, overall costs rose considerably.

SIGATOKA

Sigatoka is present in all of Central and South America, except Honduras and Belice where it has been replaced by black Sigatoka. The Armuelles Division had a record year of good Sigatoka control with only 10.3 cycles of spray. It was the only Division that reduced Sigatoka costs (Table 1). In contrast, control was not as good as in 1975 in Golfito and Almirante, even though the same number of cycles were applied in 1976 as in 1975. Heavy spotting broke out in Coto and Palmar Districts in June and July and there were several heavy spotting outbreaks in Changuinola.

Greater use was made of Benlate and the Benlate-Dithane "cocktail". Armuelles used the cocktail formula extensively (1.5-2 oz Benlate plus 12 oz Dithane). Benlate alone at the low rate of 2 oz per acre provided adequate control during dry weather in the Armuelles and Golfito Divisions. Low-volume applications of oil (1 gal per acre) replaced the former 2.5 gal per acre oil-in-water emulsion in all Divisions. To avoid problems when water contamination of the oil occurred, emulsifier was added to oil for the first tank mix of the day. Blending speed was increased to over 3000 RPM. Towards the end of the year, some oil burning appeared in the Pacific coast divisions when drought conditions prevailed. Low-volume oil-in-water emulsions may be needed under such conditions. (DONALDSON, STOVER, GROVE)

BLACK SIGATOKA - HONDURAS

A record number of cycles was applied in 1976 and costs soared (Table 1). However, control was the best since the first epidemic swept through the division in 1974. A small amount of fruit ripened in localized "hot spots" in November and December when the market was saturated and fruit was left hanging one to two weeks longer than usual. Losses were kept to a minimum in spite of record high rainfall from October through December and a large amount of lost flying time due to breakdown of helicopters.

Figures 1-3 show disease trends. Spotting began to increase sharply in October, reached a peak in November and December, and began the seasonal decline in late January 1977 over most of the Division. In some localized

TABLE 1. Black Sigatoka and Sigatoka Cycles and Costs (in U.S. Dollars) - 1973-1976

	HONDURAS (Black Sigatoka)				ALMIRANTE				GOLFITO				ARMUELLES			
	1976	1975	1974	1973	1976	1975	1974	1973	1976	1975	1974	1973	1976	1975	1974	1973
Average cycles/year	29.5	21.6	17.2	13.8	16.0	16.0	16.9	16.3	17.7	17.0	16.6	14.3	10.3	12.5	13.6	13.1
Cost/acre/ cycle	3.82	2.98	2.25	1.35	3.24	3.00	1.68	1.20	2.99	2.36	1.73	1.31	3.11	2.69	1.58	1.22
Cost/project/ acre	112.54	64.35	38.72	18.63	51.89	48.01	28.38	19.29	52.90	40.23	28.70	18.75	32.09	34.08	22.41	15.96
Change in cost/acre 1976/1975		+48.19				+3.88				+12.67				-1.99		

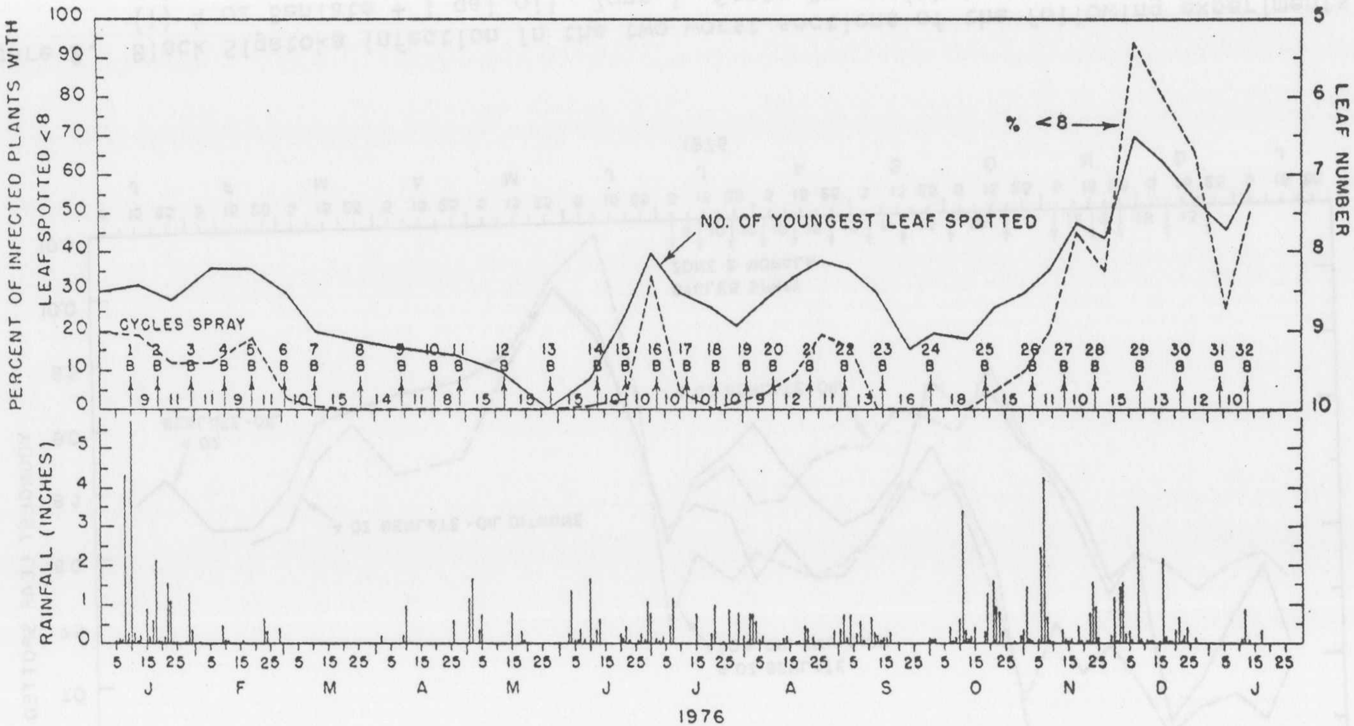


Figure 1. Black Sigatoka infection in the two worst sections of Santa Rosa Farm: Benlate-oil zone.

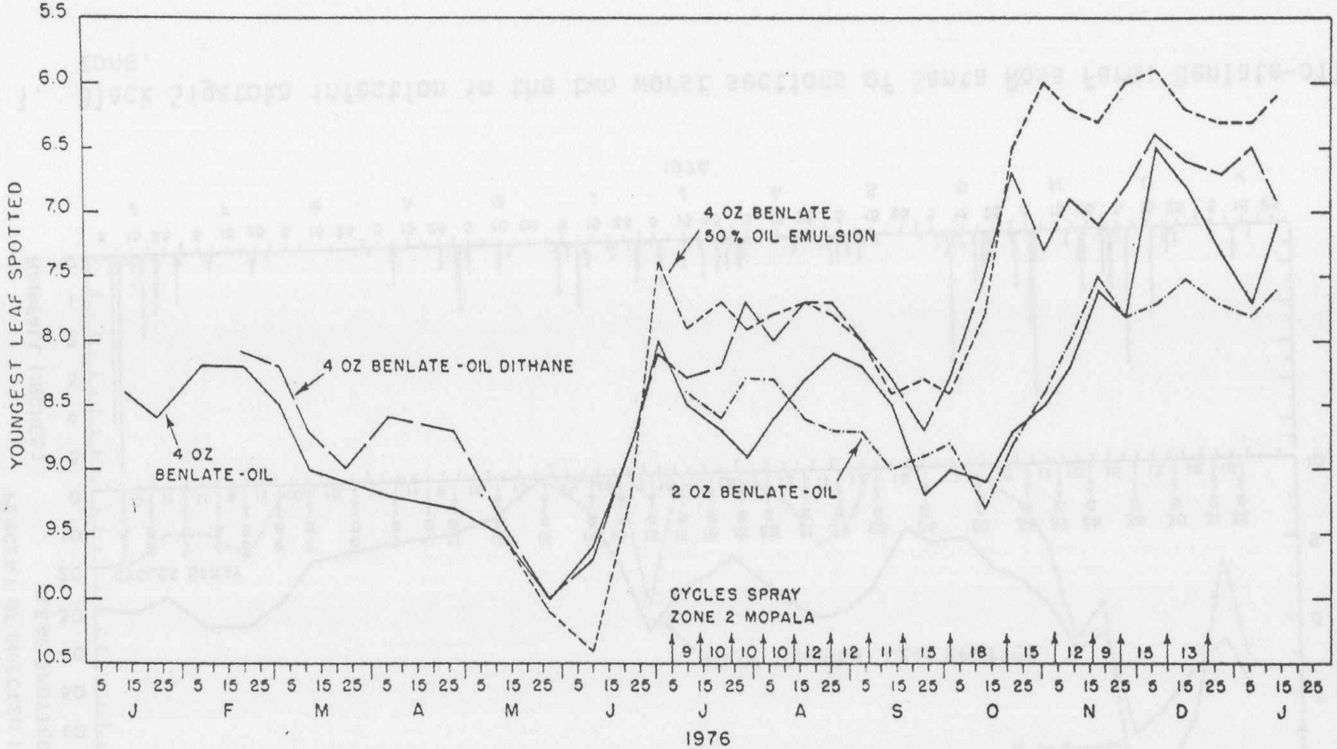


Figure 2. Black Sigatoka infection in the two worst sections of the following experiments: (1) 4 oz Benlate + 1 gal oil, Zone 1, Santa Rosa; (2) 4 oz Benlate + 12 oz Dithane M-45 + 1 gal oil, Zone 2, Santa Rosa; (3) 4 oz Benlate + 0.5 gal water + 0.5 gal oil, Zone 1, Mopala; (4) 2 oz Benlate + 1 gal oil, Zone 2, Mopala. All rates are per acre.

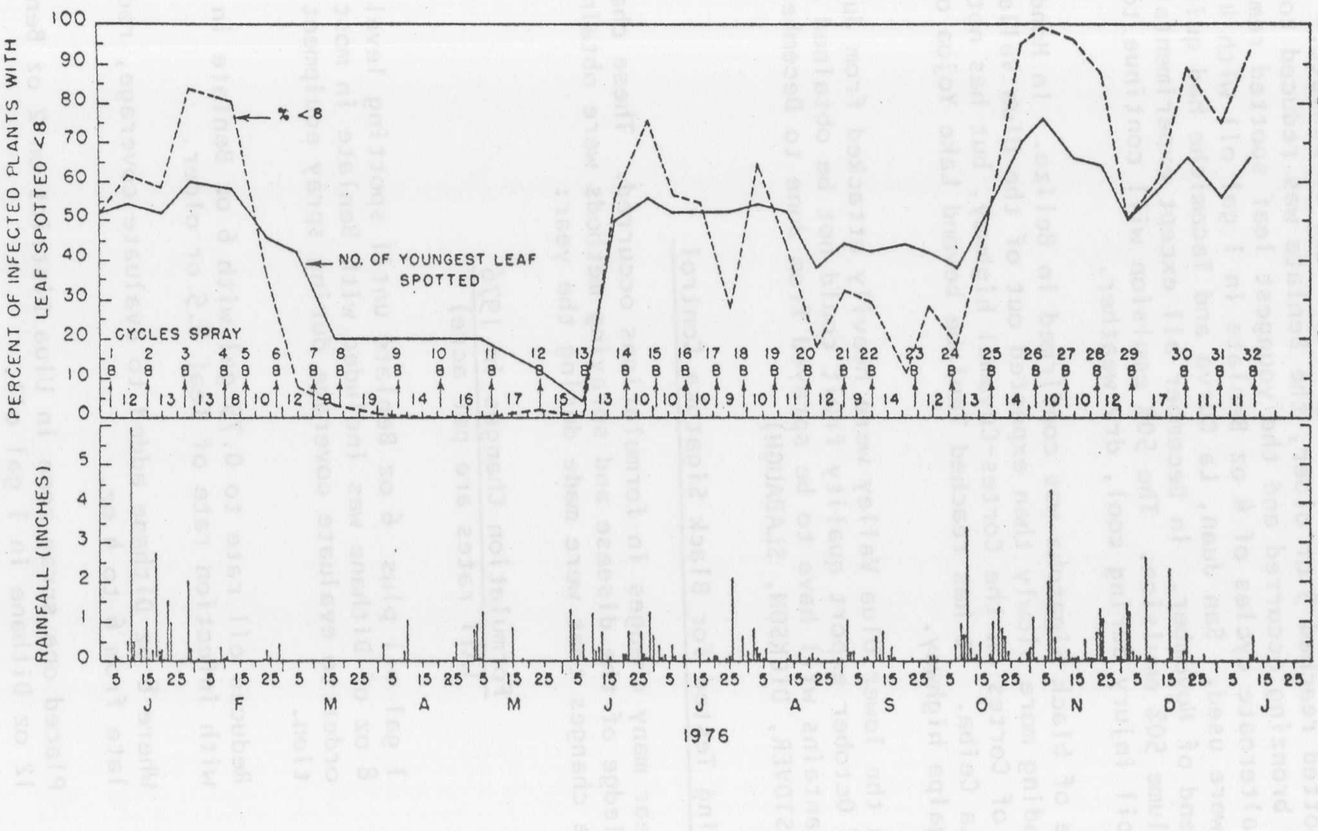


Figure 3. Black Sigatoka infection in the two worst sections of Las Flores Farm.

areas, however, heavy spotting persisted through February.

By the first of August bronzing was showing up in areas such as Omonita, Santa Rosa and Los Limones. At this time the low-volume emulsion (0.5 gal oil in 0.5 gal water) area of Santa Rosa showed less bronzing. It was then recommended to put other areas where the youngest leaf spotted in the two worst sections was 8 or better on low-volume emulsion with 4 oz of Benlate. Where the youngest leaf spotted reached 9 or older, the Benlate was reduced to 2 oz. Where pronounced bronzing occurred and the youngest leaf spotted remained younger than 8, alternate cycles of 4 oz Benlate in 1 gal oil with 4 oz Benlate in 50% emulsion were used. San Juan, La Curva and Tacamiche had quite prominent bronzing by the end of November. In December all except experimental areas were using the low-volume 50% emulsion. The 50% emulsion will continue to June in order to reduce oil injury during cool, dry weather.

The presence of black Sigatoka was confirmed in Belize. In Honduras the disease was spreading more slowly than expected out of the Ulúa Valley. It has moved 25 km west of Cortes on the Cortes-Cuyamel highway, but has not moved east of Tela towards La Ceiba. It has reached Taulabe beyond Lake Yojoa on the main San Pedro-Tegucigalpa highway.

Plantains in the lower Ulua Valley were heavily attacked from July onward and by the end of October export quality fruit could not be obtained and all exports ceased. Plantains will have to be sprayed from June to December for export quality fruit. (STOVER, DICKSON, SLABAUGH)

Formulae and Cycling Tested for Black Sigatoka Control

During the year many changes in formulations occurred. These changes were made as more knowledge of the disease and spraying methods were obtained. Following are listed the changes that were made during the year:

Formulation Changes in 1976
(All rates are per acre)

January 7	1 gal oil plus 6 oz Benlate until spotting levels lowered; 8 oz of Dithane was included with Benlate in most areas in order to evaluate coverage during spray equipment calibration.
February 6	Reduced oil rate to 0.75 gal with 6 oz Benlate in farms with infection rate of leaf 8.5 or older.
February 10	Where 8 oz Dithane added to evaluate coverage, reduce Benlate from 6 to 4 oz.
February 10	Placed one spray zone in Ulua District on 2 oz Benlate plus 12 oz Dithane in 1 gal oil.
February 21	Farms with persistently high rates of infection for last 3 months received 2 cycles of 6 oz of Benlate at 10-12 day intervals.

February 25 — Three standard formulae listed for use depending on amount of disease in two worst sections:

1. 2 oz Benlate, 12 oz Dithane, 1 gal oil where youngest leaf spotted 8.5 or older.
2. 2 oz Benlate, 12 oz Dithane, 0.75 gal oil where youngest leaf spotted 8.5 or older from February-May, or where drought conditions prevail.
3. 4 oz Benlate, 12 oz Dithane, 1 gal oil where youngest leaf spotted 8.5 or younger during June, July and August.

June 1 — 4 oz Benlate, 12 oz Dithane, 1 gal oil used over entire Division. Cycles 10-12 days on all areas where leaf 8.5 or younger infected.

June 7 — Cycles shortened in all areas:

Leaf 8.5 or older spotted - 14 days maximum
Leaf 8.4 or younger - 11 days maximum

June 10 — Lowered flying height to 70 feet from ground.

June 11 — Placed Lima District on Benlate only, except certain areas in San Juan and Tacamiche that received Benlate + Dithane.

July 5 — Placed entire Division on 4 oz Benlate in 1 gal oil, except certain spray zones in La Lima, Ulua, Guanacastal and Higuerito Districts which continued with Benlate plus Dithane.

August 1 — The following formulae were designated:

Formulae	Composition per acre	
1. Standard Benlate Standard Oil	4 oz Benlate 1 gal oil 0.2% Triton X-45, or 0.1% Agral 90	When youngest leaf spotted No. 8.9 or younger
2. Low Benlate Standard Oil	2 oz Benlate 1 gal oil 0.2% Triton X-45, or 0.1% Agral 90	When youngest leaf spotted No. 9.0 or older

August 11 — The following formulae also were put into effect:

3. Standard Benlate Low Oil Emulsion	4 oz Benlate 0.5 gal oil 0.5 gal water 0.75% Triton X-45, or 0.38% Agral 90	On all areas where infection on leaf 8.0 or older and on all areas where pronounced bronzing evident and spotted leaves younger than 8.0 for two consecutive cycles, then alternate with formula 1.

Formulae	Composition per acre	
4. Low Benlate Low Oil Emulsion	2 oz Benlate 0.5 gal oil 0.5 gal water 0.75% Triton X-45, or 0.38% Agral 90	On all areas where infection on leaf 9.0 or older.

August 20 The following formulae and cycle intervals were put into effect to reduce number of mixes:

Youngest leaf spotted	Cycle days	Formula
7.9	9-11	Standard Benlate Standard Oil
8.0	10-12	Standard Benlate Low Oil Emulsion
9.0	13-14	Low Benlate Low Oil Emulsion

Finally on November 16, all formulations were changed to emulsions with the following schedule recommended for the rest of 1976:

SEASON					
December to May			June to November		
	Low Oil Emulsion			Standard Oil Emulsion	
Youngest leaf spotted*	Cycle days	Formula	Youngest leaf spotted*	Cycle days	Formula
7.9	10-12	Standard Benlate	7.9	9-11	Standard Benlate
8.0	12-14	Low Benlate	8.0	10-12	Standard Benlate
9.0	15-17	Low Benlate	9.0	13-14	Low Benlate

* Average of the two worst sections spotted in the zone.

FORMULAE CONTENTS PER ACRE

1. Standard Benlate Standard Oil Emulsion	4 oz Benlate 0.85 gal oil 0.15 gal water 0.10% Agral 90
2. Standard Benlate Low Oil Emulsion	4 oz Benlate 0.5 gal oil 0.5 gal water 0.38% Agral 90

FORMULAE CONTENTS PER ACRE (Cont.)

3. Low Benlate	2 oz Benlate
Low Oil Emulsion	0.5 gal oil
	0.5 gal water
	0.38% Agral 90

The four zones of 4 oz Benlate plus 12 oz Dithane M-45 continued through December. However, toward the end of December, because of heavier disease build-up and the discovery of some tolerance to Benlate, it was decided to spray all heavily diseased areas with 4 oz Benlate plus 12 oz Dithane M-45 in a 50% emulsion per acre for two cycles and then alternate with 4 oz Benlate in 50% emulsion. (STOVER, DICKSON, SLABAUGH)

Oil-in-Water Emulsions

Because more frequent spraying is required for black Sigatoka than Sigatoka control, low-volume emulsions were studied in order to reduce the amount of oil being applied. Excessive oil not only damages the leaves (bronzing), but can reduce yield, especially during cool, dry weather.

In the laboratory it was not possible to make a good stable 85% emulsion using 4 oz Benlate plus 12 oz Dithane and Agral 90 up to 3.5% by oil volume. At 2.3% or above it became very viscous. With a 50% emulsion a good stable emulsion was obtained at 0.5% Agral 90 and a fairly fast-breaking one at 0.38% Agral. In the field 0.38% proved satisfactory. Agral 90 at 0.38% of oil volume is also required for a 75% emulsion. For 4 oz Benlate in an 85% emulsion only 0.1% Agral 90 is required.

The low-volume (1 gal per acre) 50% emulsion has been successfully used in Honduras between December and June. (DICKSON, SLABAUGH, STOVER)

Levels of Spotting with Different Formulations

A number of areas received different formulations for comparison. Levels of Benlate of 1.5 and 2 oz along with Dithane at 8 and 12 oz were tested in 1 and 0.75 gal of oil per acre in Tacamiche Farm. No differences could be detected in disease control in these small-scale tests up to mid-year. Larger tests were then initiated.

In Santa Rosa-Mopala large blocks were sprayed with four different formulae. Spotting data are shown in Figure 2.

Benlate-Oil: This 600-acre block had been sprayed almost continuously since November 1974 with 4 oz of Benlate in 1 gal of oil. In 1976, 30 applications were made. These included five cycles at the beginning of the year at 6 oz of Benlate, one of 4 oz plus 12 oz Dithane, and in the last three cycles of the year beginning November 25 the carrier was changed to an 85% emulsion sprayed at 1 gal per acre. The 30 cycles for the year give an average of 12.2 days between applications.

4 oz Benlate + 12 oz Dithane + 1 gal oil per acre: This treatment consisted of 260 acres lying between the Benlate-oil zone of Santa Rosa 1 and the 50% emulsion zone of Mopala 1. This treatment was begun on February 14 and continued through November 26.

4 oz Benlate + 1/2 gal oil + 1/2 gal water per acre: Beginning May 14, 312 acres of Mopala were sprayed with this formulation. Twenty cycles were applied to November. Some heavy infection on shot plants appeared in September in Sections 4 and 5 along the river and began moving toward the interior of the spray zone. By December considerable infection was occurring in Sections 1 and 2 near the river. By mid-December heavy infection was also occurring in Sections 69 and 70 and ripe and turning fruit appeared.

2 oz Benlate + 1 gal oil per acre: This formula was applied to 294 acres of Zone 2 of Mopala beginning July 5. Fifteen cycles were applied including one cycle on November 4 of 4 oz Benlate, and the last two cycles in December were sprayed with the 50% low-volume emulsion.

Spotting reached high levels in all of the above areas during the last three months of the year (Figure 2). However, control was adequate in all areas except the emulsion block. Control in this treatment did not begin to deteriorate until September and by December severe spotting was present in about 80 of the 312 acres. Tolerance to Benlate was detected in this area in September. Also, the area lies along the Ulua River where "hot spots" frequently develop because of poorer coverage or a more favorable micro-environment for the pathogen. Under these circumstances, it is probable that at least part of the disease outbreak in the emulsion area can be attributed to a location effect. This is one reason why formulations must be tested in several locations over a year's time before they can be fairly evaluated. (STOVER, DICKSON, SLABAUGH, GROVE)

Benlate Tolerance

Tolerance and loss of disease control have been recorded for at least eight pathogens where benomyl alone was sprayed at regular intervals for 2-3 years. For early detection of tolerance and possible loss of control, ascospores from black Sigatoka areas are discharged at regular intervals onto agar plates containing 0.1 mg/ml (0.1 ppm) of benomyl. Up until September these spores have either not germinated or germinated abnormally. Conidia from spots have reacted similarly. However, when isolations were made from hyphae in young lesions, from 25 to 70% of the colonies that developed grew at a much faster rate and could grow on media with 0.1 mg/ml of benomyl (Figure 4). About one-half of these tolerant isolates would also grow (although more slowly) at levels up to 500 mg/ml, but not at 1000 mg/ml of benomyl. These tolerant isolates were of two types - one that grew about six times as fast as the non-tolerant isolates and one that grew about four times as fast (Figure 4). In addition, cultural characteristics were very different from wild type isolates.

Colonies from hyphae isolated from young lesions by removing a piece 1 mm or less in diameter were always either tolerant or non-tolerant and no mixtures occurred. Also, conidia produced in culture were always the same type as the parent. In contrast to the dual nature of hyphal isolates, ascospores and conidia produced in and on spotted areas that yielded tolerant thalli were always non-tolerant. Tolerant isolates were never obtained from areas that had not been sprayed with benomyl.

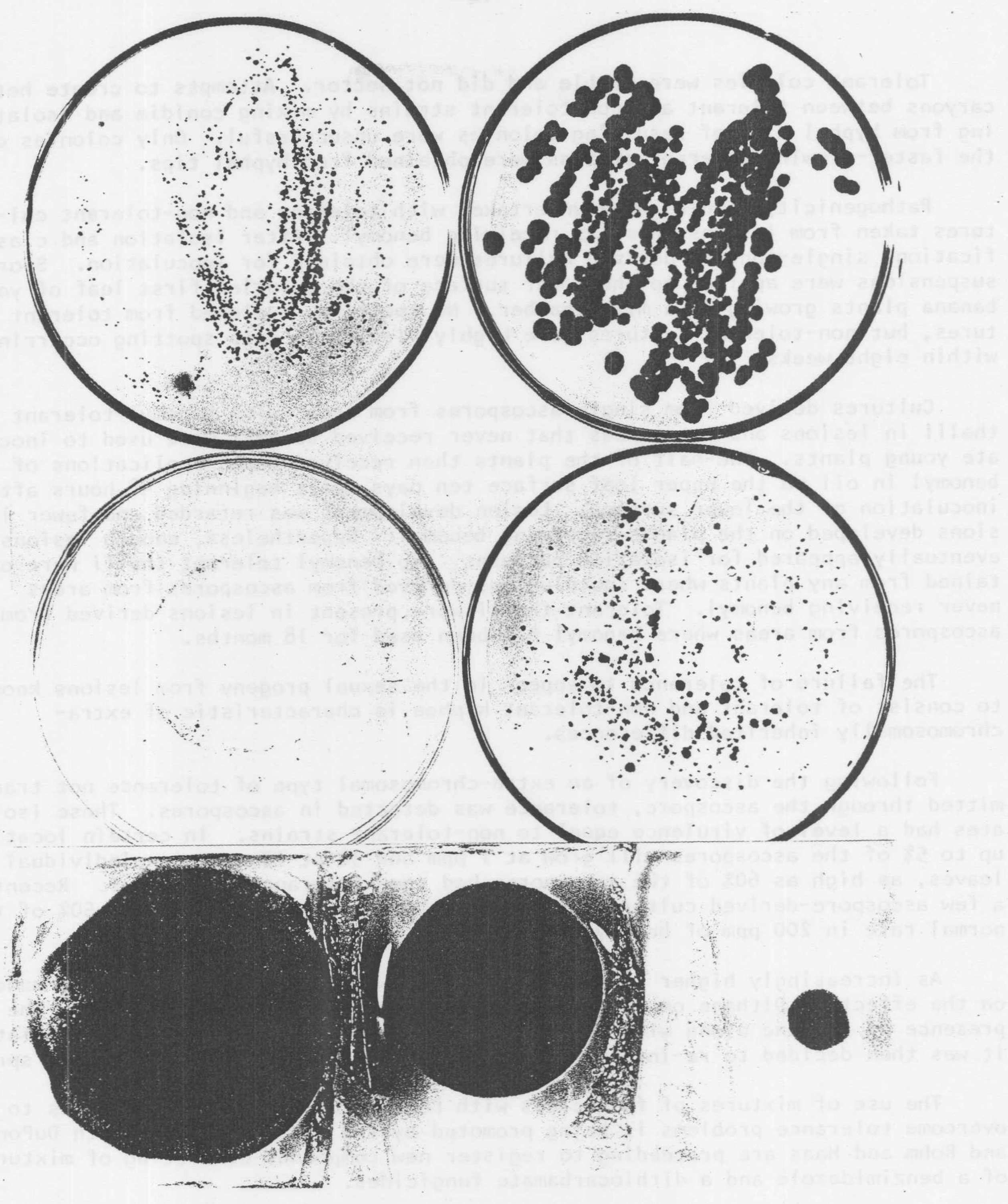


Figure 4. Tolerant and non-tolerant strains of Mycosphaerella fijiensis var. <u>difformis</u> to benomyl. (Upper row) Five-day growth on Mycophyl agar without benomyl and (middle row) with 0.1 μg/ml of benomyl. The two plates on the right contain the tolerant strain; those on the left the non-tolerant. (Lower row) Rate of growth and colony characteristics of two strains tolerant to benomyl (large colonies) and the wild non-tolerant strain after 10 days on Mycophyl agar at room temperature (23-26° C). From left to right colonies are 11, 7 and 2 mm in diameter.

Tolerant colonies were stable and did not sector. Attempts to create hetercaryons between tolerant and non-tolerant strains by mixing conidia and isolating from hyphal tips of resulting colonies were unsuccessful. Only colonies of the faster-growing tolerant strains were obtained from hyphal tips.

Pathogenicity studies were undertaken with tolerant and non-tolerant cultures taken from lesions in areas receiving benomyl. After isolation and classification, single-conidia derived cultures were obtained for inoculation. Spore suspensions were applied to the lower surface of the unfurled first leaf of young banana plants growing in a mist chamber. No spotting developed from tolerant cultures, but non-tolerant cultures were highly virulent - mass spotting occurring within eight weeks.

Cultures derived from single ascospores from areas with benomyl-tolerant thalli in lesions and from areas that never received benomyl were used to inoculate young plants. One-half of the plants then received three applications of benomyl in oil on the upper leaf surface ten days apart beginning 48 hours after inoculation of the lower surface. Lesion development was retarded and fewer lesions developed on the plants receiving benomyl. Nevertheless, enough lesions eventually appeared for isolation purposes. No benomyl tolerant thalli were obtained from any plants where inoculum was derived from ascospores from areas never receiving benomyl. Tolerant thalli were present in lesions derived from ascospores from areas where benomyl had been used for 18 months.

The failure of tolerance to appear in the sexual progeny from lesions known to consist of tolerant and non-tolerant hyphae is characteristic of extra-chromosomally inherited differences.

Following the discovery of an extra-chromosomal type of tolerance not transmitted through the ascospore, tolerance was detected in ascospores. These isolates had a level of virulence equal to non-tolerant strains. In certain locations up to 5% of the ascospores will grow at 1 ppm and 3% at 10 ppm. In individual leaves, as high as 60% of the ascospores had some tolerance to benomyl. Recently, a few ascospore-derived cultures have been obtained that grow at about 50% of the normal rate in 200 ppm of benomyl.

As increasingly higher levels of tolerance were detected, a study was made on the effect of Dithane on the incidence of tolerant isolates (Table 2). The presence of Dithane along with the Benlate reduced the level of tolerant isolates. It was then decided to re-instate Dithane as a component of the Benlate-oil spray.

The use of mixtures of fungicides with Benlate or other benzimidazoles to overcome tolerance problems is being promoted by the manufacturers. Both DuPont and Rohm and Haas are proceeding to register new compounds consisting of mixtures of a benzimidazole and a dithiocarbamate fungicides.

The Effect of Dithane in the Benlate-Oil Formulae

Four areas were kept on 4 oz of Benlate plus 12 oz Dithane M-45 plus 1 gal of oil when the remainder of the Division stopped using Dithane in the mix at the end of June:

Table 2. Effect of Benlate alone and Benlate plus Dithane on tolerance of ascospores of <u>Mycosphaerella</u> <u>fijiensis</u> var. <u>difformis</u> to benomyl in Santa Rosa Farm.

		Tolerance Levels		
		1.0-10 ppm	<1.0 ppm	% Tolerant
Sept. 6-7	Benlate	14*	21	60
	Benlate + Dithane	0	32	0
Sept. 29-30	Benlate	24	51	32
	Benlate + Dithane	3	27	10
Nov. 29-30	Benlate	79	35	69
	Benlate + Dithane	0	84	0

* No. of ascospore-derived colonies growing at levels indicated.

Table 4. Amount of spotting on leaf 7 on plants with fruit being calipered for the first week of harvest in adjacent areas treated with Benlate or Benlate + Dithane in Laurel-Limones Farms.

Adjacent sections south to north	Spotting rating* Benlate + Dithane	Spotting rating* Benlate	% plants in category 3 and 4* Benlate + Dithane	% plants in category 3 and 4* Benlate
52-51, 42-43	1.40	1.29	0	0
45, 44-45	1.20	2.57	0	50.0
46, 33	1.30	1.14	0	0
32, 32	1.20	1.14	0	0
25, 25	1.10	1.13	0	0
Average	1.24	1.45		

* Average of 5-10 plants per section number: 1 = less than 5% of leaf spotted; 2 = 5-15%; 3 = 16-33%; 4 = more than 33%.

Table 5. Amount of spotting on leaf 7 on plants with fruit being calipered for the first week in adjacent areas treated with Benlate or Benlate + Dithane in San Juan-La Curva Farms.

Adjacent sections south to north	Spotting rating * Benlate + Dithane	Spotting rating * Benlate	% plants in category 3 and 4 * Benlate + Dithane	% plants in category 3 and 4 * Benlate
42, 34-35	1.00	1.00	0	0
41, 36	1.00	1.00	0	0
40, 37	1.00	1.00	0	0
39, 38	1.14	1.00	0	0
72, 71	1.14	1.00	0	0
73, 70	1.00	1.00	0	0
74, 15-16	1.00	1.00	0	0
Average	1.04	1.00		

* Average of 5-8 plants per section number: 1 = less than 5% of leaf spotted; 2 = 5-15%; 3 = 16-33%; 4 = more than 33%.

Table 6. Effect of Benlate, Calixin, and Benlate plus Calixin on spotting levels on non-fruited plants in Tacamiche Farm.

Date of Survey	Benlate	Calixin	Calixin + Benlate
	Average age youngest leaf spotted		
Oct. 11, 1976	7.0	8.5	8.6
25	6.4	6.9	6.4
Nov. 8	6.7	6.5	6.5
22	6.8	6.4	6.4
Dec. 6	6.6	6.7	7.3
20	6.4	6.5	6.4
Jan. 4, 1977	6.5	6.4	7.1
18	6.5	6.7	6.5
28	6.0	5.8	5.9
	% leaves in spotting categories 2 and 3*		
Oct. 11, 1976	0	2.2	1.3
25	7.2	1.4	2.5
Nov. 8	2.4	2.2	1.8
22	0.9	1.3	3.1
Dec. 6	2.9	6.6	1.0
20	2.2	4.2	1.4
Jan. 4, 1977	3.4	1.9	0.1
18	5.9	6.6	0.4
28	4.2	7.4	1.0

* Category 2 = 5-15% of leaf spotted; 3 = 16-33%.

increased in the Benlate and Calixin plots. There was much less spotting in the Calixin-Benlate treatment than in either Benlate or Calixin alone.

An examination of spotting data on shot plants (Table 7) indicates that disease levels in the Benlate and Calixin plots were about equal by the end of January. The Calixin-Benlate treatment, however, clearly had less spotting. The data show the Benlate treatment significantly reduced spotting on shot plants nearing harvest from an average index of 3.5 to 2.00. Calixin maintained the average index at around 2.00, and the Calixin plus Benlate reduced the index from 2.0 in December to 1.0-1.4 in January (Table 7). These data confirm studies made elsewhere indicating that Calixin alone is not as effective as Benlate. However, a mixture of the two may be more effective than either one alone. Additional studies are warranted when registration and a tolerance is obtained. (STOVER, DICKSON)

Imazalil

Imazalil is a new systemic fungicide produced by Janssen Pharmaceutica and tested by the French in Africa where it provided good control of Sigatoka. Ascospores are extremely sensitive to concentrations as low as 0.1 ppm. Imazalil acts on the cell wall causing leakage of contents and severe distortion of germ tubes (Figure 5). This material was sprayed in Omonita Farm in a "seedbed" because fruit could not be exported until Imazalil was registered and a tolerance established with the Environmental Protection Agency. The first application was made on April 10 at 200 g a.i. in 1 gal oil per acre followed on April 20 by the second application. On May 5 one-half the area (four swaths wide) was changed to 100 g a.i. per acre. These latter treatments were carried out for a total of six cycles. In addition, it was necessary to make an application on June 5 of 100 g a.i. per acre to the 200 g a.i. zone because of a shortage of material on hand.

On August 31, the 200 g a.i. plot was changed to 0.75 g a.i. per acre. These treatments continued to the end of the year, except that the last two applications were applied as a 50% emulsion. In all, 16 cycles of Imazalil were applied. Fruit for residue work was shipped to the United States on August 19, 1976.

After the first two applications, light pitting was found on many of the leaves, although it did not appear serious. Since that time the pitting had disappeared. No pitting was found on fruit. There appeared to be a relationship between the amount of light intensity at time of spraying and amount of pitting.

Control has been about equal in both the Imazalil plots (16 cycles of spray) and an adjacent control block sprayed with Benlate-oil (22 cycles). Figure 6 shows the rainfall, spray application dates, and leaf spot data.

Imazalil warrants commercial-scale testing when clearance is obtained and a price is established. (DICKSON, SLABAUGH, STOVER)

Methods of Evaluating Spotting Levels

In commercial type surveys to determine the youngest leaf spotted, tall plants are used. A study was made to determine what effect plant height or

Table 7. Effect of Calixin, Benlate, and Calixin + Benlate on spotting levels on leaf No. 7 just prior to harvest.

Date 1976	BENLATE Av. grade	% leaves #7 in category* 1	2	3	4	CALIXIN Av. grade	% leaves #7 in category 1	2	3	4	CALIXIN + BENLATE Av. grade	% leaves #7 in category 1	2	3	4
Nov. 22	3.52	0.0	12.0	24.0	64.0	2.04	8.0	80.0	12.0	0.0	1.76	60.0	12.0	20.0	8.0
Dec. 2	2.40	5.0	50.0	45.0	0.0	1.75	35.0	55.0	10.0	0.0	1.90	15.0	80.0	5.0	0.0
13	2.50	0.0	50.0	50.0	0.0	3.50	0.0	10.0	30.0	60.0	2.00	0.0	100.0	0.0	0.0
23	2.00	30.0	40.0	30.0	0.0	1.80	30.0	60.0	10.0	0.0	1.50	60.0	30.0	10.0	0.0
Jan. 4	2.00	8.0	84.0	8.0	0.0	1.40	64.0	32.0	4.0	0.0	1.04	96.0	4.0	0.0	0.0
14	2.00	16.0	68.0	16.0	0.0	1.60	44.0	52.0	4.0	0.0	1.00	96.0	4.0	0.0	0.0
28	2.00	24.0	52.0	24.0	0.0	1.96	24.0	56.0	20.0	0.0	1.40	60.0	40.0	0.0	0.0

* 1 = less than 5% of leaf spotted; 2 = 5-15%; 3 = 11-33%; 4 = more than 33%.

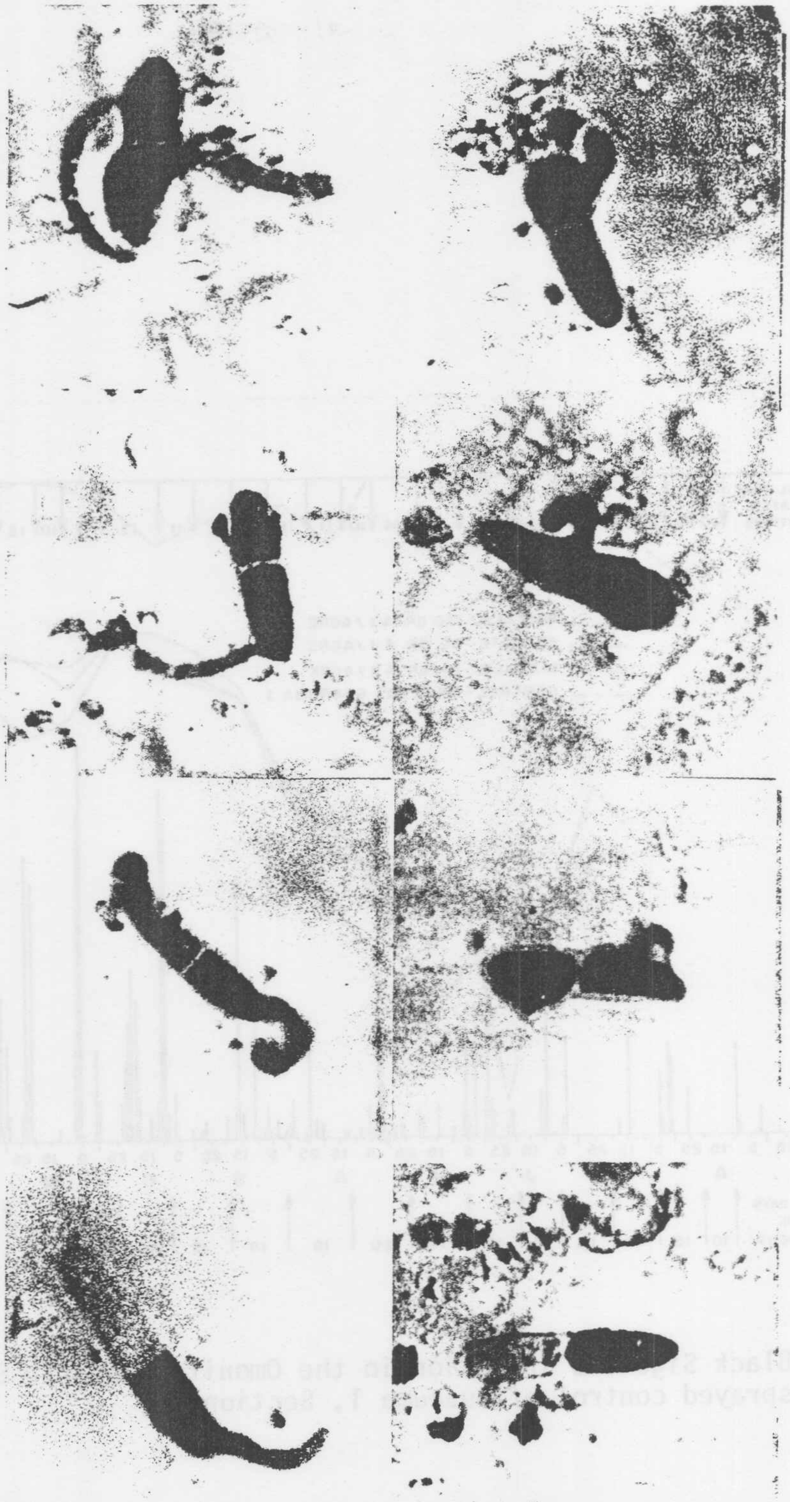


Figure 5. Ascospores of *Mycosphaerella fijiensis* var. *difformis* subjected to 0.1 ppm of Imazalil. Note leakage of contents from side walls, empty cells, and distorted germ tubes.

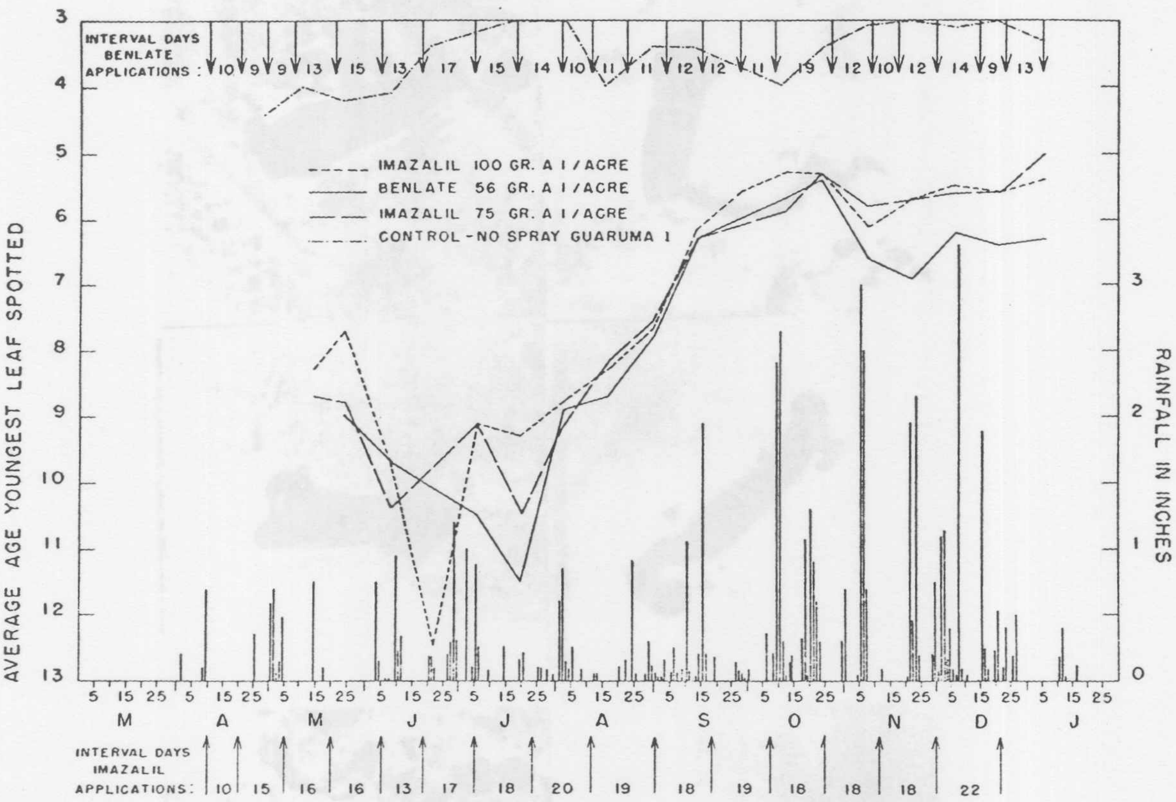


Figure 6. Black Sigatoka infection in the Omonita Imazalil Experiment and unsprayed control of Guaruma I, Section 38.

age had on the survey readings. Also, since most black Sigatoka spotting develops between shooting and harvest, a study was made of evaluating leaf spot just prior to harvest.

To categorize medium and tall plants, 10 plants of the medium and tall height classes were measured as to height and time to shooting (Table 8). The tall plants on May 20 averaged 12.6 (range 12.2-13.1) ft in height to the axil of the first opened leaf and the candela. These shot at an average of 13.3 (range 12.8-14.3) ft. The dates of shooting were between May 26 and June 9 or an average of 11.9 days after marking (June 1). The medium plants on May 20 averaged 10.6 (range 10-11.6) ft in height and shot at an average of 13.8 (range 12.4-14.9) ft in height. The dates of shooting were between June 20 and August 20 with the average being July 31 or 71.5 days after marking.

An evaluation of youngest leaf spotted on tall and medium height plants (Table 9) shows that a much younger leaf is spotted in medium than in tall plants. Whether this is due to a faster rate of leaf production in the younger medium-sized plants or a faster rate of disease development is not known.

For evaluation of spotting intensity just prior to harvest, the seventh leaf of plants with the ribbon color being harvested for the first time (first week) was chosen. Spotting was evaluated using the standard index described in Tropical Agriculture 48: 185, 1971: 0, none up to 10 individual lesions; 1, 5% of leaf area with spotting; 2, 6% to 15%; 3, 16% to 33%, and 4, more than 33% of leaf area spotted. Figure 7 shows the data from March through mid-January. There is a good correlation between spotting intensity on leaf No. 7 on plants near harvesting age and youngest leaf spotted on medium-sized plants. A similar but less close correlation occurs between youngest leaf spotted on tall plants. (DICKSON)

Effect of Black Sigatoka on Carrying Quality of Fruit

Two banana ripening trials of fruit harvested from Sigatoka diseased plants were run. Each trial consisted of 10 boxes of fruit packed from each of 10 racemes from heavily spotted plants.

Blue-ribbon bagged fruit from the week of July 3 (27th week) was harvested on September 20 (approximately 100 days old) in Tacamiche Farm. Plants showed from 1-5 leaves in Category 4 (more than 33% of leaf area diseased), plus 0-4 leaves in Category 3 (16-33% leaf area damaged). The average leaf index was 2.4 and the average caliper grade of the second hand was 13.4 (range 11-15). Shortly after packing, the boxes were placed in a ripening room where the temperature was maintained at 58° F. The first box showing signs of ripening occurred 21 days after packing and consisted of one finger of each of two hands where the fingers had been heavily scarred.

Gold-ribbon bagged fruit from the week of August 7 (32nd week) was harvested on October 22 (approximately 93 days old) in Indiana Farm. Plants showed from 1-6 leaves in Category 4, plus 0-3 leaves in Category 3. The average leaf index was 2.3 and the average caliper grade of the second hand was 14.9 (range 13-19). This time the packed boxes were held at ambient temperature for 24 hours, then 48 hours at 62° F, followed by 48 hours at 60° F,

Table 8. Height and days to shooting for "medium" and "tall" plants marked in San Juan Farm on May 20, 1976.

		Height in feet May 20	Date of shooting	Days to shooting	Height at shooting
Tall plants	1	12.7	May 27	7	13.2
	2	12.7	June 9	20	13.4
	3	12.9	5	16	13.4
	4	12.9	May 29	9	13.2
	5	12.2	June 4	15	12.8
	6	13.1	May 26	6	13.6
	7	12.2	30	10	13.0
	8	12.7	31	11	14.3
	9	12.3	June 1	12	13.0
	10	12.4	2	13	13.0
Average		12.61		11.9	13.29
Medium plants	1	10.9	June 20	31	12.4
	2	11.6	July 6	47	14.2
	3	10.0	Aug. 7	79	13.3
	4	10.3	17	89	14.5
	5	10.0	July 26	67	13.4
	6	11.2	29	70	13.9
	7	10.3	Aug. 20	92	14.9
	8	10.2	8	80	13.8
	9	10.7	July 31	72	13.3
	10	10.5	Aug. 16	88	14.6
Average		10.57		71.5	13.83

Table 9. Evaluation of youngest leaf spotted on "medium" and "tall" plants and leaf spot intensity on leaf No. 7 of plants with ribbon being harvested the first week.

	Medium Plants		Tall Plants		Shot Plants				
Date	No. youngest leaf spotted	% spotted <8	No. youngest leaf spotted	% spotted <8	Av. grade leaf #7	% #7 leaves in grade 1	2	3	4
Mar. 9,10,12	5.9	100	7.6	50	2.2	40	16	28	16
22	6.3	100	7.6	48	2.9	10	32	20	38
Apr. 10	7.0	78	8.3	14	3.0	6	30	22	42
23	6.9	80	8.6	10	3.1	10	24	12	54
May 6	7.0	78	9.0	6	2.8	12	26	30	32
21	7.6	40	10.1	0	1.7	54	24	14	8
June 4	7.4	58	10.3	0	1.7	54	26	14	6
18	7.7	34	11.5	0	1.4	76	12	8	4
July 6	7.7	32	10.5	0	1.1	92	6	2	0
20	7.7	30	10.1	0	0.8	74	2	0	0
Aug. 18	7.7	44	8.8	2	0.9	89	0	0	0
Sept. 2	7.3	58	8.7	2	0.9	98	0	0	0
16	7.5	52	8.8	4	1.0	96	4	0	0
30	7.8	32	9.5	0	1.1	86	14	0	0
Oct. 15	7.9	28	9.7	0	1.0	100	0	0	0
Nov. 1	7.1	80	9.7	4	1.4	66	26	8	0
15	7.4	58	8.7	2	2.1	12	70	18	0
29	6.6	98	8.0	22	2.0	2	96	2	0
Dec. 13	6.3	100	7.7	38	1.9	8	90	2	0
29	7.5	50	9.1	2	1.1	88	12	0	0
Jan. 12	7.0	92	8.2	6	1.1	92	8	0	0

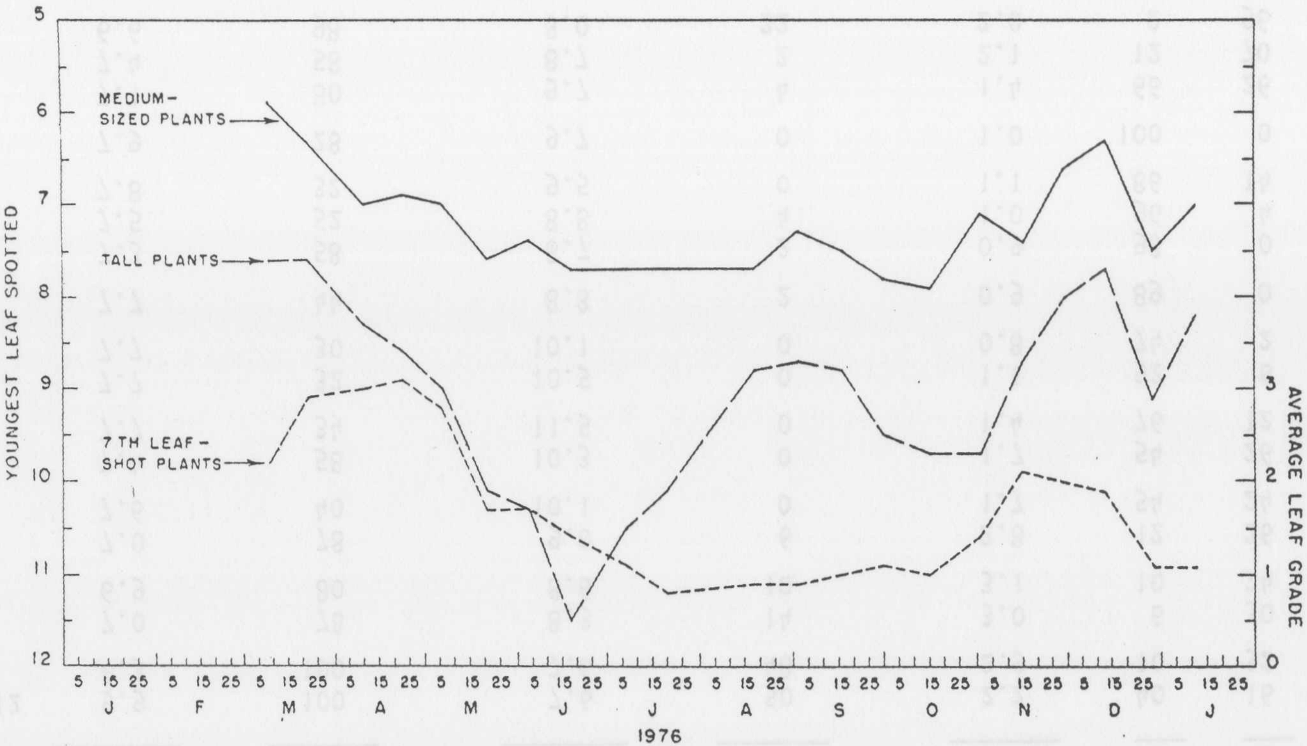


Figure 7. Comparison of Sigatoka grading systems on plants of different size. Commercial type surveys were made on medium and tall plants and compared to spot intensity of the 7th leaf of shot plants nearing harvest age.

then at 58° F. One box had 2, 1 and 3 fingers of 3 hands respectively ripening at 15 days. The plant from which this fruit came had seven leaves at harvest: 4 in Category 4 and 3 in Category 1 with an average index of 2.7. The caliper grade was 14. All other boxes completed 21 days with no ripes and turnings.

These data support previous studies showing that fruit from plants severely diseased will carry at least 2 weeks, provided most of the spotting develops after shooting. (DICKSON, STOVER)

Effect of Deleafing on Black Sigatoka Incidence

Rapid removal of fallen leaves and leaves with more than 25% of the area with spotting should reduce amount of inoculum being produced and improve disease control. In December 1975 an experiment began in Indiana Farm to determine the effect weekly deleafing and deleafing to 9 leaves at shooting would have on black Sigatoka incidence. The two treatments consisted of:

CONTROL: Six randomized blocks (1-2 sections each), hanging leaves removed with a machete once every two weeks, standard deleafing for fruit spot spray and scar prevention.

DELEAFED: Six randomized blocks (1-2 sections each), all hanging leaves, any leaves burnt with leaf spot, and all leaves except nine at shooting removed with a knife on a pole weekly.

Rate of infection (youngest leaf spotted) was evaluated every two weeks on ten non-fruited plants and leaf spotting intensity on ten plants about to be harvested in the center of each section.

The layout of the experiment and rate of infection for the different treatments are shown in Figure 8. Data on rate of infection and spotting levels show no difference between treatments on unshot plants (Table 10). There are slightly fewer leaves with Category 2 (6-15% of leaf area spotted) spotting in the deleafed treatment (Table 11). (STOVER, DICKSON, OYUELA)

Distribution in Southeast Asia and Probable Origin of *Mycosphaerella fijiensis*

Patterns of detection and distribution of *Mycosphaerella musicola* and *M. fijiensis* (including the var. *difformis*) in Southeast Asia and the Pacific Islands were studied (Figure 9). The data indicate a center of origin of *fijiensis* in the New Guinea-Solomon Islands area. From there the pathogen was carried, most likely in scale leaves on sword sucker rhizomes or in leaf trash, to Taiwan, Philippines, some of the adjacent islands in Indonesia, and most of the South Pacific Islands. Movement into Fiji, Hawaii, Philippines, and Southern Malaya has occurred probably within the past 30 years. *M. musicola* still predominates in most of Indonesia including Java and Sumatra, the Island of Borneo, and on the Asian mainland, except in Southern Malaya. Wherever *fijiensis* has invaded areas occupied by *musicola*, it has replaced the latter as the dominant banana leaf spot. (STOVER)

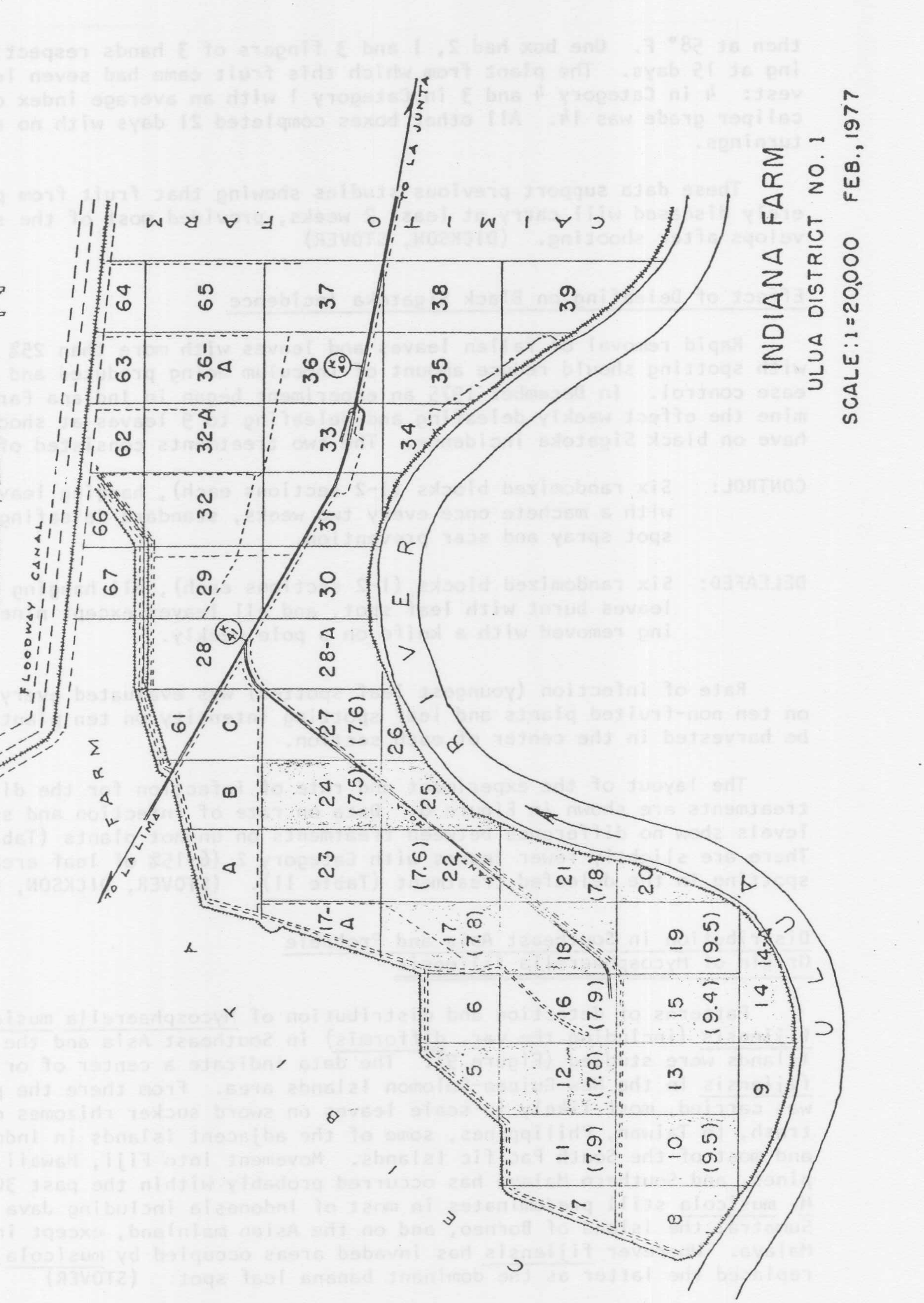


Figure 8. Location of deleafed (dark) and control plots in Indiana Farm and average of youngest leaf spotted between May 10 and September 27,

Table 10. Effect of deleafing on black Sigatoka incidence*

		Average age youngest leaf spotted	% spotted leaves <8	% leaves in spotting category 1**
Control No Deleafing	Sections 7/11	7.9	38	42
	9/13	9.4	6	27
	16	7.9	39	41
	19/14A	9.5	5	26
	22	7.6	52	41
	26/27	7.6	49	42
	Average	8.3	32	37
Deleafed	Sections 8/10	9.5	5	25
	5/12	7.8	46	42
	14/15	9.4	6	26
	17/18	7.8	41	40
	20/21	7.8	42	41
	24/25	7.5	50	43
	Average	8.3	32	36

* Deleafing began in December 1975; data shown is for non-shot plants recorded fortnightly between May 10 and September 27, 1976.

** Up to 5% of leaf area spotted.

Table 11. Effect of deleafing on black Sigatoka incidence at harvesting grade*.

		Average No. of youngest leaf spotted	% spotted leaves 8	% of leaves in spotting category 1**	% of leaves in spotting category 2**
No Deleafing	Sections 7/11	5.0	97	62	0.3
	9/13	5.5	95	56	1.0
	16	4.6	100	62	3.0
	19/14A	6.0	97	51	1.1
	22	5.4	97	48	7.3
	26/27	5.3	95	56	2.4
	Average	5.3	97	56	2.4
Deleafed	Sections 8/10	5.7	95	54	0.8
	5/12	4.9	100	63	0.3
	14/15	6.1	97	50	1.6
	17/18	4.4	100	62	2.3
	20/21	5.6	100	52	4.8
	24/25	4.9	100	58	0.7
	Average	5.3	98	56	1.7

* Deleafing began in December 1975.

** 1 = Up to 5% of leaf area spotted.
2 = 6-15% of leaf area spotted.

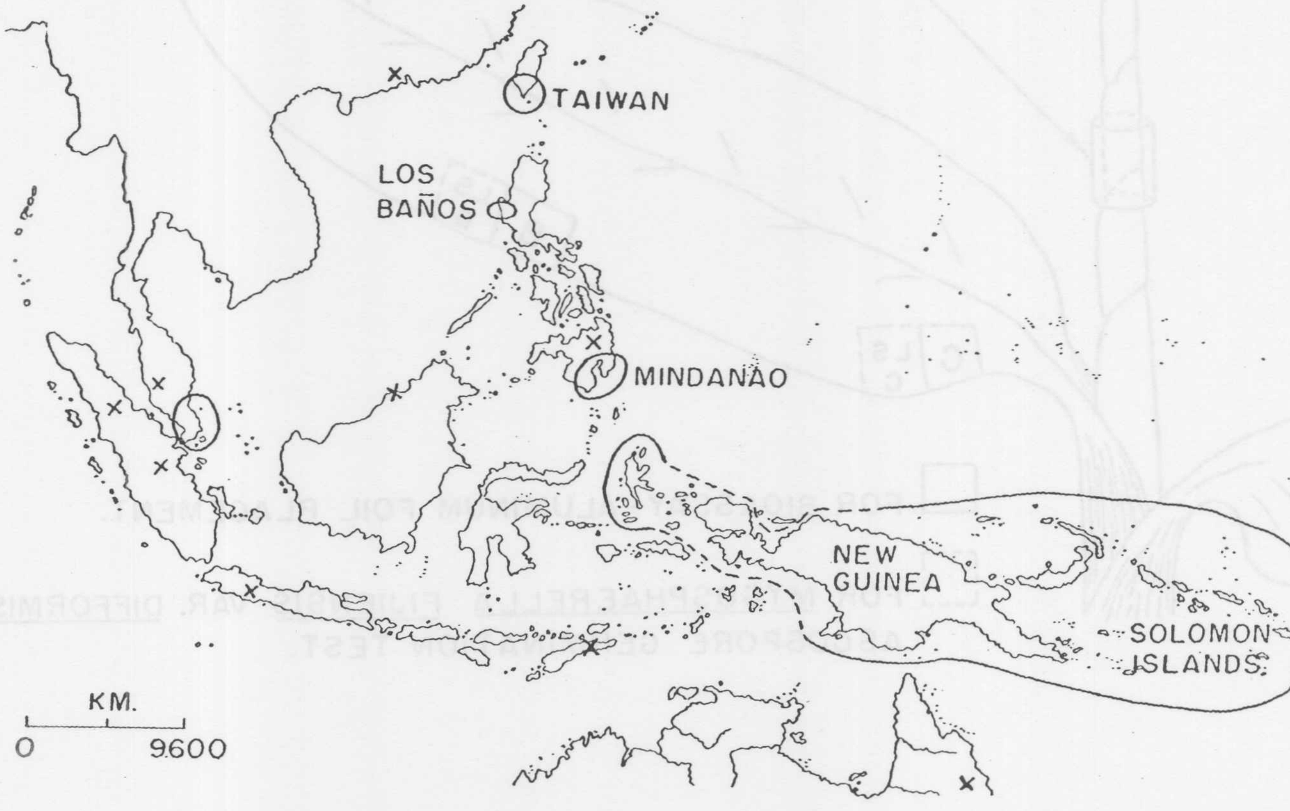


Figure 9. Present known distribution of Mycosphaerella fijiensis and Mycosphaerella musicola in Southeast Asia. M. fijiensis is indicated by solid lines and M. musicola by x.

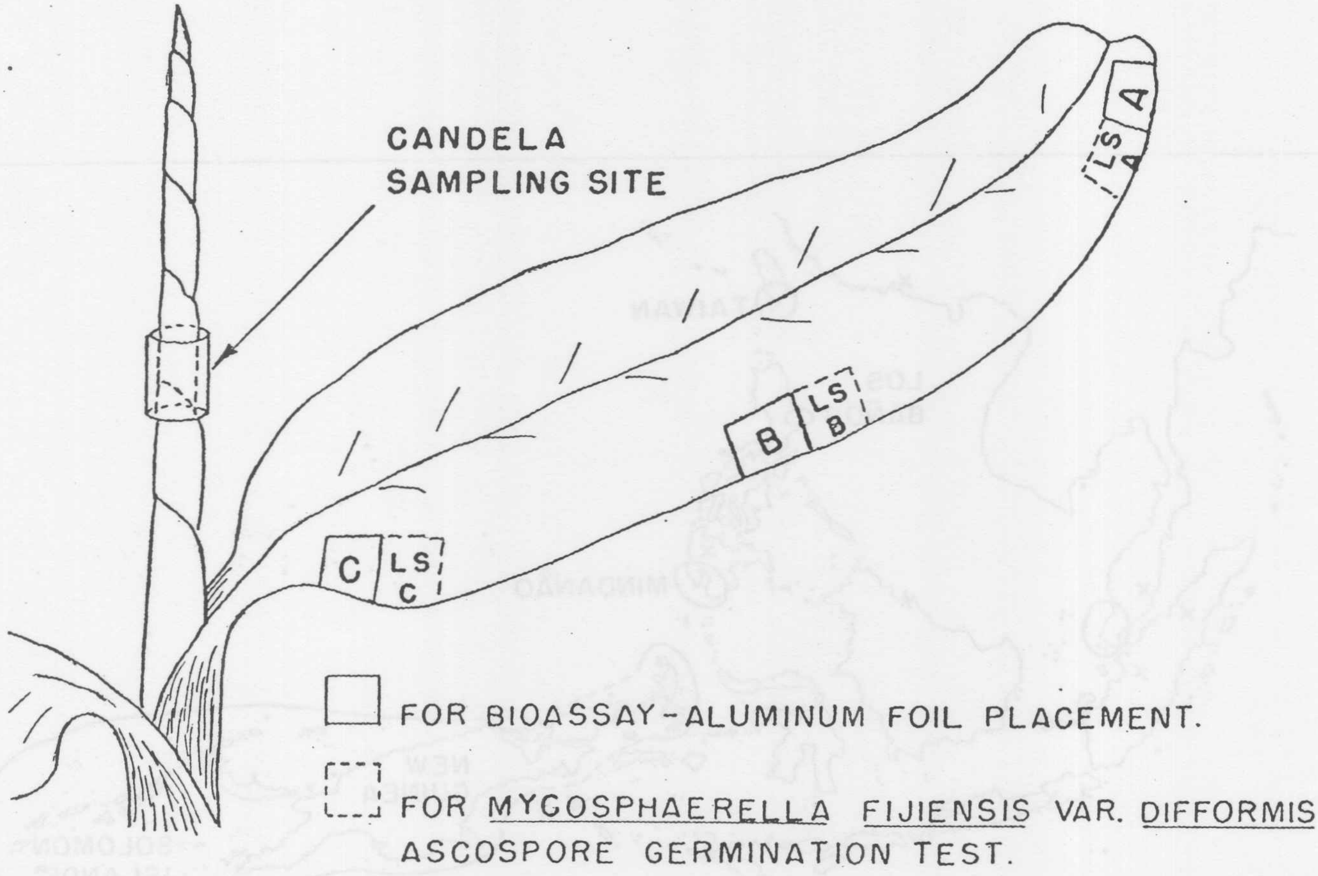


Figure 11. Positions on banana leaves utilized for monitoring Benlate quantities and distribution.

aliquot of the fungicide-ethyl acetate solution was then spotted on paper filter discs (14 mm in diameter) and air-dried with the aid of an Oster Air-jet Dryer. After drying, the discs were placed on PDA (Potato-Dextrose Agar) previously seeded with spores of Penicillium expansum. The cultures were maintained at room temperature for 48 hr before zones of inhibition were measured and recorded. Five evenly spaced plants were selected across each spray swath and the experiment was conducted three times. The formulation used in these applications contained 4 oz Benlate + 0.1% Agral 90 per gal of oil and was applied at the rate of 1 gal per acre.

The micronair system used in this experiment consisted of four units mounted on a Piper Pawnee. Three of the four units were equipped with 30 mesh screen on the cages, whereas the other unit was equipped with 20 mesh screen. These micronair units were equipped with 3.5 in blades (cracked and chipped) which were adjusted to a 40°angle on the inboard units and a 50° angle on the outboard units. These angles permitted a rotating speed of approximately 4,000 RPM for each unit. The inboard units were located 50 in (right side) and 49 in (left side) from the fuselage, providing a total distance of 131 in between the inboard units. The outboard units were located 85 and 86 in from the inboard units on the right and left side, respectively. All units were centered with the lower edge of the wings and level with the plane of the lower wing surfaces. All units were located 6.25 in behind the wing. All micronair applications were made at an airspeed of 90 mph and from an altitude of 65-70 ft above the ground. A pump pressure of approximately 40 psi and an 80 ft swath were used. The nozzle system used in this experiment was mounted on a Bell G2-A helicopter. This equipment conformed the specifications noted in Figure 10 and Table 12, with the exception of altitude. All applications from the nozzle system were made from an altitude of 100 ft above the soil surface.

No significant differences were observed in the quantity of Benlate deposited within the canopy in general when the micronair and nozzle systems were compared (Tables 12 and 13). However, more fungicide was deposited within the canopy when applied with the nozzle system (Figures 12 and 13). In contrast, when slides were brought from Guatemala, sprayed with a Snow aircraft with Micronair AU 3000 units, the results showed that the Bananera application of approximately 3.6 oz Benlate per acre was superior to the Honduras application of 4 oz per acre. The average quantity of Benlate deposited was 24% less in Honduras (2.2×10^{-7} g per 69.4 sq cm) than in Bananera (2.9×10^{-7} g per 69.4 sq cm). These differences are probably related to the much older and poorly maintained Micronair units on the Piper Pawnee.

Variability, in general, in Honduras Division applications was greater within the canopy under micronair application than under nozzle application (Tables 13 and 14). This variability may be attributed, in part, to the lighter coverage obtained in the center of the micronair application swaths (Figure 14).

Adequacy of coverage was statistically the same when both systems of spraying were compared within the canopy. However, a higher average percentage of adequate coverage was generally noted in nozzle system applications (Table 15). Adequacy of coverage is defined as 314 sq mm of inhibition area in the bioassay test.

Table 12. Spray equipment specifications for Bell G2-A helicopters used in the aerial spray application experiments.

Tee Jet 4664 Nozzle (hardened stainless steel orifice) arrangement

	Rate of Application	
	1 g.p.a. oil or 0.5 g.p.a. oil and 0.5 g.p.a. water	3/4 g.p.a. oil
Center boom	6-D2 (orifice) 23 (core)	4-D2-23
Outboard booms	4-D3-23	10-D3-23
	22-D3-25	12-D3-25
	First nozzle 2-1/2 inches from tip of outboard boom, remainder spaced 12 inches apart; center boom 14.8 inch nozzle spacing beginning 6-1/2 inches from tip.	First nozzle 2-1/2 inches from outboard boom tip, then spaced 14 inches apart; center boom 24-inch nozzle spacing beginning 6-1/2 inches from tip.

Flight Specifications

Swath width	100 ft
Speed	60 m.p.h.
Height from ground	70 ft
Spray pressure	100 psi
Gallons per minute	11.5

Table 13. Spray distribution within a banana canopy as applied by aircraft using two different spray systems.

Position of sample within canopy[1]	Area of inhibition zones (mm^2)		Coefficient of variability (%)	
	Nozzle[2]	Micronair	Nozzle	Micronair
Candela	285.2 ef	230.0 f	35.6	26.0
1 A	458.6 abcde	361.2 def	27.3	47.0
B	427.4 bcdef	272.2 ef	23.7	37.6
C	628.0 a	477.6 abcde	16.6	32.3
5 A	521.0 abcd	576.8 abc	23.6	18.2
B	593.0 ab	454.6 abcde	17.2	29.1
C	525.0 abcd	413.4 bcdef	13.5	25.2
L A	411.4 bcdef	282.2 ef	19.8	29.3
B	511.4 abcd	339.6 def	20.2	27.7
C	397.2 cdef	279.8 ef	36.3	19.9
$\bar{x}$	475.8	368.7		

[1] The numbers refer to leaf number on the plant and L represents leaves 7, 8 or 9; the letters A, B and C refer to the sampling sites at the leaf tip, middle and base, respectively.

[2] The nozzle and micronair systems were used on a helicopter and an airplane, respectively; each statistic represents the mean of 15 samples taken from five evenly spaced plants (across each swath) in three tests; numbers followed by similar letters are not significantly different at the 0.01 level (Duncan's Multiple Range Test); the inhibition zones were determined by bioassay with *Penicillium expansum*.

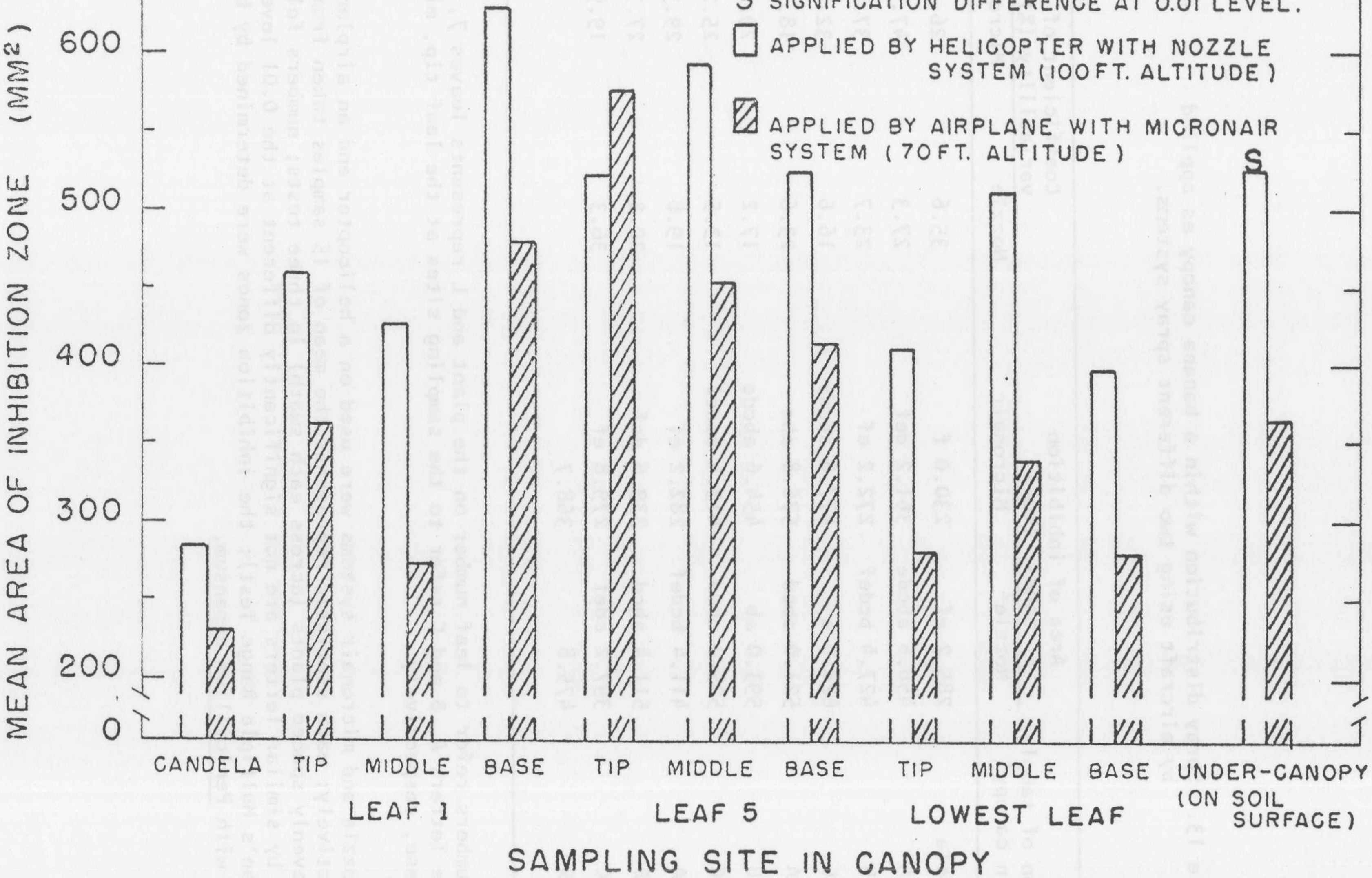


Figure 12. Comparison of micronair and nozzle spray systems for Benlate distribution within the banana canopy. A bioassay method of detection was used with Penicillium expansum as the test organism.

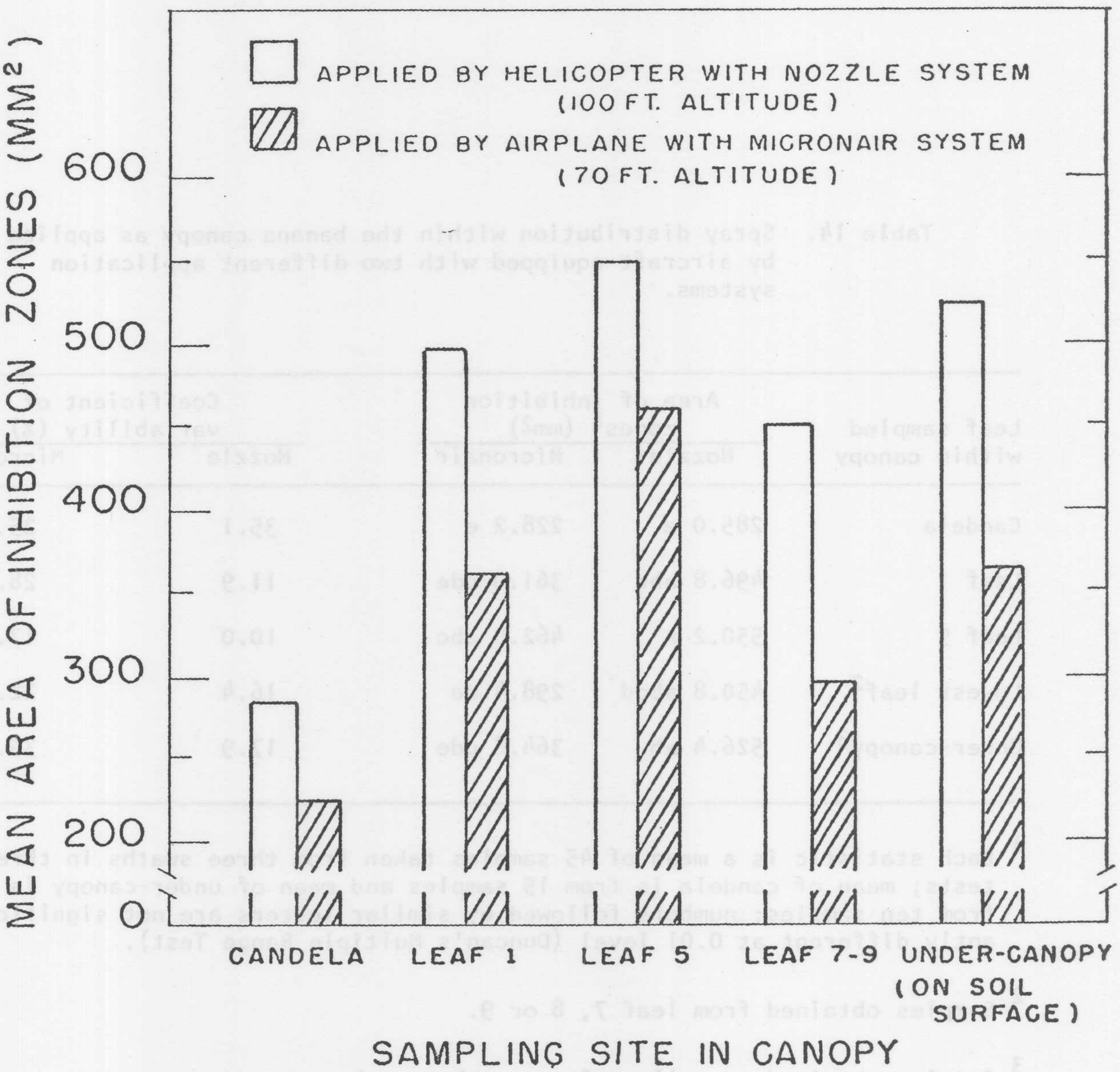


Figure 13 Comparison of micronair and nozzle spray systems in terms of Benlate spray distribution within the banana canopy. A bio-assay method of detection was used with Penicillium expansum as the test organism.

Table 14. Spray distribution within the banana canopy as applied by aircraft equipped with two different application systems.

Leaf sampled within canopy	Area of inhibition zones[4] (mm2)		Coefficient of variability (%)	
	Nozzle[1]	Micronair	Nozzle	Micronair
Candela	285.0 e	228.2 e	35.1	25.8
Leaf 1	496.8 abc	361.0 cde	11.9	28.0
Leaf 5	550.2 a	462.0 abc	10.0	17.5
Lowest leaf[2]	450.8 abcd	298.4 de	16.4	22.7
Under-canopy[3]	526.4 ab	364.8 cde	17.9	35.0

[1] Each statistic is a mean of 45 samples taken from three swaths in three tests; mean of candela is from 15 samples and mean of under-canopy is from ten samples; numbers followed by similar letters are not significantly different at 0.01 level (Duncan's Multiple Range Test).

[2] Samples obtained from leaf 7, 8 or 9.

[3] Samples obtained at soil surface at the mat base.

[4] Inhibition zones were determined via bioassay with Penicillium expansum.

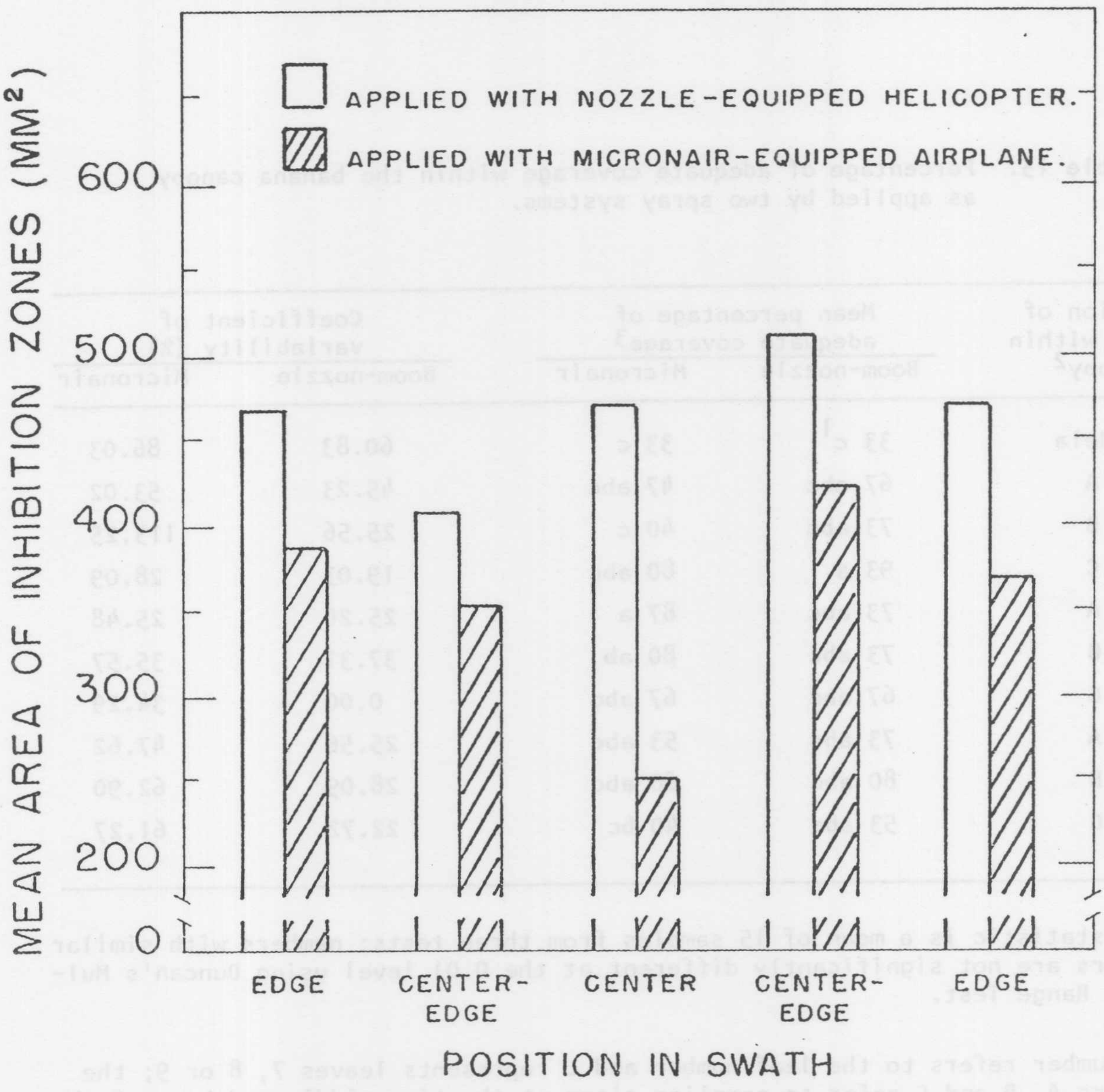


Figure 14. Spray distribution across the swath as applied by two different spray systems. The spraying altitudes were 100 ft and 70 ft for helicopter and airplane, respectively. A bioassay test was used for Benlate detection with Penicillium expansum as the test organism.

Table 15. Percentage of adequate coverage within the banana canopy as applied by two spray systems.

Position of sample within canopy[2]	Mean percentage of adequate coverage[3]		Coefficient of variability (%)	
	Boom-nozzle	Micronair	Boom-nozzle	Micronair
Candela	33 c[1]	33 c	60.83	86.03
1 A	67 abc	47 abc	45.23	53.02
B	73 abc	40 c	25.56	113.25
C	93 a	80 abc	19.03	28.09
5 A	73 abc	87 a	25.26	25.48
B	73 abc	80 ab	37.31	35.57
C	67 abc	67 abc	0.00	34.29
L A	73 abc	53 abc	25.56	47.62
B	80 abc	60 abc	28.09	62.90
C	53 abc	40 bc	22.72	61.27

[1] Each statistic is a mean of 15 samples from three tests; numbers with similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

[2] The number refers to the leaf number and L represents leaves 7, 8 or 9; the letters A, B and C refer to sampling sites at the tip, middle and base of the leaf lamina, respectively.

[3] Adequate coverage was determined by bioassay and was defined as samples having 314 sq mm or more of area in the inhibition zone (determined by bioassay with Penicillium expansum).

Weather conditions during these experiments were noted and recorded. The data showed more Benlate was deposited within the canopy at 68-74° F than at 78° F (Table 16). This may be the result of oil evaporation from small droplets at the higher air temperature, or the result of an increase in air turbulence which can cause virtual suspension of the small droplets (less than 100 μ in diameter) in the air, thus being more subject to increased desiccation and drift.

Relative humidity plays a role in droplet loss, particularly in emulsion sprays and should be included in later studies. Also, more accurate temperature and wind velocity measurements must be developed in order to acquire meaningful data on the effect of atmospheric conditions on spray efficiency.

In the ascospore germination tests, normal germination occurred on 7.7% of the leaf samples. Over 50% of these sampling sites had inhibition zone areas of less than 314 sq mm according to the bioassay tests. Normal germination on leaf samples taken at random prior to spray application in each area averaged 41% and occurred on 93% of the samples. Unsprayed control from Guaruma II, Section 38 had a normal germination rate of 86% with 100% of the leaf samples displaying normal germination.

As noted earlier, the nozzle system in Honduras and the micronair system in Guatemala were superior to the micronair-equipped Pawnee used in Honduras. These studies show that good maintenance of spray equipment is necessary for optimum spray application efficiency. Additional studies will be made with new Micronair-equipped aircraft now in service in Honduras.

<u>A Comparison of Two Ultra-Low Application Rates.</u> As a result of more foliar bronzing, an experiment was initiated to determine differences, if any, between rates of 0.75 and 1 gal of oil per acre.

The equipment utilized and all specifications were as noted (Figure 10 and Table 12), except spraying was done from an altitude of 100 ft. The spray contained 4 oz Benlate (or 2 oz Benlate) + 12 oz Dithane M-45 + 0.1% Agral 90 per unit volume of oil per acre. The rate of Benlate application (4 or 2 oz per acre) was the same within each experiment. Spray samples were collected at 4-6 ft intervals at the soil surface across each swath on aluminum foil (110 x 110 mm) along the flag-lines. Large glass slides (100 x 100 mm) were also placed at the foil sampling sites. The aluminum foil samples were processed and bioassayed as described earlier in this section on aerial spray application experiments. The slides were examined under a microscope for droplet density and size. Droplet density and size were determined from three randomly selected portions of each slide. Leaf samples were taken from unobstructed foliage across each swath for ascospore germination tests. The weather conditions were as follows:

Table 16. Effect of weather conditions on Benlate spray distribution within the banana canopy.

Position of sample within canopy[1]	Weather conditions[2] A	B	C
	Mean area of inhibition zones[3] (mm^2)		
Candela	246	287	222
1 A	423	564	246
B	272	324	437
C	531	607	531
5 A	603	633	423
B	487	702	380
C	598	423	370
L A	398	394	238
B	531	503	308
C	445	437	174
$\bar{x}$	453.4	487.4	332.9

1 The numbers refer to the leaf number and L represents leaves 7, 8 or 9; the letters A, B and C refer to the sampling sites of each leaf lamina at the tip, middle and base respectively.

2 A = 68° F, overcast, wind velocity - 0 at canopy level, time of application was 5:30-5:45 a.m.

B = 74° F, clear, wind velocity - 0 at canopy level, time of application was 5:50-6:00 a.m.

C = 78° F, clear, wind velocity - 0 at canopy level, time of application was 6:05-6:27 a.m.

3 A bioassay was used with Penicillium expansum as the test organism; each statistic is the mean of 10 samples taken from two swaths; no significant differences were detected with an Analysis of Variance test.

Trial	Farm	Gal/ acre	Time of application	Temperature	Wind velocity	Misc.
1	Ceibita	0.75	5:32 AM (3/6)[a]	70° F	0[b]	Overcast
	Caimito	1.00	5:50 AM (3/6)	70° F	0.6 mph (short gusts)	Overcast
2	Tibombo	0.75	6:25 AM (3/29)	68° F	0	Clear
	Omonita	1.00	6:05 AM (3/30)	70° F	0	Clear
3	Tacamiche	0.75	6:00 AM (5/5)	73° F	0	Partly overcast
		1.00	6:15 AM (5/5)	73° F	0	Partly overcast

[a] Date of application.

[b] These figures represent measurements at sampling sites at approximately 4 ft above the ground.

Actual gallonage rates per acre deviated from the proposed rates in some cases. All measurements of Benlate quantity and droplet density were adjusted to correct for this error.

No significant differences in Benlate quantity delivered per unit area were detected in two of three trials, but Benlate quantities were generally larger in the 1 gal treatment (Table 17), and more variation was observed at 0.75 gal per acre. No significant differences in droplet density were noted and the variability was similar for the rates within each trial (Table 18). In two of the three trials, a significantly higher percentage of small droplets (less than 100 μ in diameter) was observed in the 0.75 gal treatment. Also, the percentages of droplets less than 200 μ in diameter were higher in the 0.75 gal treatment (Table 19). This increase in the percentage of small droplets was possibly the result of a greater concentration of suspended materials in the spray. Presumably, the greater concentration of suspended materials in the spray would also reduce the rate of droplet desiccation, hence higher percentages of small droplets and no significant differences in droplet density between the two rates. The higher percentages of small droplets increase susceptibility to spray drift, suspension in convective currents, and droplet desiccation. Thus, the 0.75 gal rate is less desirable because of the weather conditions normally encountered in Honduras. An increase in droplet size probably would not be desirable because of possible reduced coverage quality (distance between droplets too great). A 1 gal rate appears to be the minimum for good disease control.

Ascospore germination tests indicated an adequate quantity of chemical was reaching all unobstructed foliage. Normal spore germination was observed in only one trial (Trial 3) and occurred on only 6% of the samples.

Table 17. Areas of fungal inhibition zones produced by Benlate spray samples taken from two application rates as monitored at the soil surface.

Trial:	Application rate (gal/a)	Mean area of inhibition zones (mm^2)[1]	Coefficient of variability (%)
1 :	0.75	491 b	13.1
	1.00	866 a	7.7
2 :	0.75	723 m	13.1
	1.00	648 m	7.7
3 :	0.75	546 x	17.7
	1.00	646 x	9.0

[1] Trial 1 and 2 received 4 oz Benlate + 12 oz Dithane M-45 + 0.1% Agral 90 per acre and Trial 3 received 2 oz Benlate + 12 oz Dithane M-45 + 0.1% Agral 90 per acre; each statistic is the adjusted mean of 34 or more samples from two swaths; numbers followed by similar letters are not significantly different at the 0.01 level.

Table 18. Droplet densities observed on glass slides exposed to two application rates from nozzle-equipped helicopters as monitored at the soil surface.

Trial:	Application rate (gal/a)	Mean area of inhibition zones (mm^2)[1]	Coefficient of variability (%)
1 :	0.75	274.8 a	11.1
	1.00	265.3 a	11.4
2 :	0.75	222.9 m	32.8
	1.00	228.6 m	28.4
3 :	0.75	144.8 x	20.5
	1.00	129.7 x	24.9

[1] Trials 1 and 2 received 4 oz Benlate (Trial 3 = 2 oz Benlate) + 12 oz Dithane M-45 + 0.1% Agral 90 per acre; each statistic is the mean of 34 or more samples from two swaths; numbers followed by similar letters are not significantly different at the 0.01 level.

Table 19. Percent of droplets in five size ranges observed in Benlate spray with two different application rates.

Range of droplet size (μ)	Mean percent of droplet density*					
	Trial 1		Trial 2		Trial 3	
	Application rate (gal/a)					
	0.75	1.00	0.75	1.00	0.75	1.00
0-100	59 a (11.7)	38 b (17.3)	39 g (18.6)	25 h (32.1)	21 op (29.4)	30 n (21.8)
101-200	20 c (21.8)	30 b (23.2)	26 h (21.9)	20 hi (23.3)	40 m (15.2)	27 no (19.2)
201-300	7 e (43.8)	13 cd (19.0)	9 jk (42.3)	14 ij (20.7)	17 p (14.5)	13 pq (26.1)
301-400	5 e (52.0)	9 de (37.3)	6 k (47.7)	13 ij (36.9)	9 (64.9)	9 q (34.7)
401+	8 e (49.0)	10 de (46.0)	20 hi (20.5)	27 h (27.9)	14 pq (32.0)	20 op (35.4)

* Trials 1 and 2 received 4 oz Benlate (Trial 3 = 2 oz Benlate) + 12 oz Dithane M-45 + 0.1% Agral 90 per acre; each statistic is the mean of 48, 34 and 40 samples from trials 1, 2 and 3, respectively; the percents were rounded-off to the nearest percent; numbers followed by the same letters are not significantly different at the 0.01 level (Duncan's Multiple Range Test).

( ) Coefficient of variability.

<u>A Comparison of Emulsion and Oil As Carriers of Benlate</u>. An experiment was designed to determine whether any differences exist between emulsion and oil formulations on the basis of Benlate quantities delivered, droplet density, and percentages of droplets within various size ranges.

The equipment used for application is outlined in Figure 10 and Table 12. The oil and emulsion formulations contained 4 oz of Benlate + 1 gal of oil + 0.1% Agral 90 and 4 oz of Benlate + 0.5 gal of oil + 0.5 gal of water + 0.38% Agral 90. The rate of application was 1 gal per acre. Spray samples were collected at 5 ft intervals across each swath on aluminum foil and adjacent glass slides. The methods of sample processing were the same as noted earlier in this section on aerial application experiments. This experiment was conducted three times and samples were taken across two swaths in each treatment. Leaf samples were taken from unobstructed foliage and subjected to the ascospore germination tests. Weather conditions were as follows:

Trial	Date	Time of application	Formulation	Temperature ° F	Wind velocity[1]	Other
1	5/14	6:00 AM	Emulsion	73	0-SG	Clear
		6:20 AM	Oil	78	0-SB	Clear
2	6/13	7:35 AM	Emulsion	78	0-SG	Partly overcast
		8:00 AM	Oil	80	0-SG	Partly overcast
3	6/23	5:45 AM	Emulsion	74	0-SG	Overcast
		6:05 AM	Oil	74	0-SG	Overcast

[1] SG, short gusts of wind occurring above the canopy; SB, constant breeze occurring above the canopy; zero indicates no measurable wind velocity in the canopy.

Significantly more Benlate was delivered in the oil than in the emulsion formulation. However, there was no significant difference in the amount of Benlate delivered in two of three trials; the emulsion application was more variable and 14% less active ingredient was detected (Table 20).

The droplet density was significantly higher in oil than emulsion. However, droplet density was significantly higher in only one of three trials. Variability in droplet counts was greater in emulsion samples with an average of 14% fewer droplets (Table 21). No significant differences in percentages of droplets in various size ranges could be detected. More variability was noted in the emulsion treatment (Table 22).

According to Amsden (Agricultural Aviation 4: 88-93, 1962), a water droplet, 100 microns in diameter, will have a lifetime of 50 seconds and

Table 20. Mean areas of fungal inhibition zones detected in Benlate spray samples taken at the soil surface from one gal per acre applications of oil and emulsion formulations with nozzle-equipped helicopters.

Trial :	Formulation[1]	Mean area of inhibition zones (mm^2)	Coefficient of variability (%)
1 :	Emulsion	949.1 a [2]	17.5
	Oil	891.5 a	15.0
2 :	Emulsion	857.3 m	12.9
	Oil	895.7 m	13.0
3 :	Emulsion	682.0 s	24.7
	Oil	860.4 r	24.1
$\bar{x}_{1-3}$:	Emulsion	830.3 z (-14%)	9.3
	Oil	884.4 y	8.6

[1] The oil formulation contained 4 oz Benlate + 1 gal oil + 0.1% Agral 90 and the emulsion formulation contained 4 oz Benlate in 0.5 gal oil + 0.5 gal water + 0.38% Agral 90.

[2] Each statistic is the mean of 40 samples from two swaths with the exception of $\bar{x}$ 1-3 which is the mean of 120 samples; numbers followed by similar letters are not significantly different at the 0.01 level; number in brackets indicates difference in the quantity of active ingredient delivered.

Table 21. Mean droplet densities detected in Benlate spray samples at the soil surface from one gal per acre applications of oil and emulsion formulations with nozzle-equipped helicopters.

Trial	:	Formulation[1]	Mean droplet density (No./cm^2)	Coefficient of variability (%)
1	:	Emulsion	196.8 a[2]	29.6
		Oil	166.6 a	18.7
2	:	Emulsion	107.9 n	30.6
		Oil	179.5 m	23.9
3	:	Emulsion	90.9 w	45.6
		Oil	110.8 w	33.3
$\bar{x}$ 1-3	:	Emulsion	131.9 z (-14%)	18.3
		Oil	153.6 y	12.0

[1] Same formulations as those noted in Table 20.

[2] Each statistic is the mean of 40 samples from two swaths with the exception of $\bar{x}$ 1-3 (=120 samples); number in brackets indicates difference in droplet density; numbers followed by similar letters are not significantly different at the 0.01 level.

Table 22. Mean percents of droplets in various size ranges detected in 1 gal per acre applications of oil and emulsion formulations[1] with nozzle-equipped helicopters.

Trial	:	Size of droplet (μ in diameter)	Percent of droplets: Emulsion	Percent of droplets: Oil	Coefficient of variability (%): Emulsion	Coefficient of variability (%): Oil
1	:	100	20.5 b[2]	20.5 b	22.7	26.9
		101-200	38.6 a	36.5 a	12.7	15.6
		201-300	14.1 bc	20.4 b	35.8	14.2
		301-400	5.4 d	9.0 cd	65.5	43.3
		400	21.4 b	13.6 bc	32.2	34.4
2	:	100	11.9 hi	14.1 hi	29.1	39.0
		101-200	44.1 f	37.4 f	12.7	15.0
		201-300	20.8 g	17.1 gh	21.2	11.4
		301-400	9.9 i	11.0 i	42.6	30.8
		400	13.4 hi	20.4 g	26.8	15.8
3	:	100	11.4 r	11.3 r	31.8	22.8
		101-200	42.4 p	44.1 p	17.7	14.8
		201-300	19.5 q	20.1 q	19.4	13.9
		301-400	11.4 r	11.9 r	22.8	21.6
		400	15.3 qr	12.6 r	25.7	32.3
$\bar{x}$ 1-3	:	100	14.6 y	15.3 y	15.8	11.7
		101-200	41.7 w	39.3 w	8.3	5.9
		201-300	18.1 xy	19.2 x	15.6	6.5
		301-400	8.9 z	10.6 z	21.8	16.5
		400	16.7 xy	15.6 y	18.4	15.3

[1] Same formulations as noted in Table 20.

[2] Each statistic is the mean of 40 samples taken from two swaths except those of $\bar{x}$ 1-3 (120 samples); numbers followed by similar letters are not significantly different at the 0.01 level (Duncan's Multiple Range Test).

fall 22 ft at 68° F and 80% relative humidity without the influence of aircraft "downwash". Since the emulsion is 50% water, evaporation is increased and could result in lower quantities of Benlate and droplet densities. This is supported by the higher variability in the emulsion.

No normal germination was observed in the ascospore germination tests in either the emulsion or oil treatment. Apparently, both treatments delivered sufficient quantities of Benlate to provide adequate control on unobstructed foliage.

An Evaluation of Flying Altitudes. The equipment used was as noted in Figure 10 and Table 12. The formulations used were as follows:

Trial	Farm	Formulations
1	Ceibita	2 oz Benlate + 12 oz Dithane M-45 + 0.1% Agral 90 per gal oil per acre.
2	San Juan	Same as Trial 1.
3	Los Limones	4 oz Benlate + 12 oz Dithane M-45 + 0.1% Agral 90 per gal oil per acre.
4	Caimito	4 oz Benlate + 0.1% Agral 90 per gal oil per acre.
5	Caimito	Same as Trial 4.

Samples were collected at 5 ft intervals across two swaths in each treatment at the soil surface on aluminum foil (110 x 110 mm) and adjacent glass slides (100 x 100 mm). Sampling sites were located along flag-lines dissecting the spray areas to ensure continuous application over the sampling sites. Processing of these samples was as noted earlier, except acetone was substituted for ethyl acetate as a solvent for Benlate residues on the foil samples. In three trials, five plants across each swath were selected for analysis of spray distribution within the canopy. Only the tallest unshot plants were selected and all were selected to achieve approximate equal spacing across each swath. Spray distribution in the canopy was monitored attaching aluminum foil (110 x 110 mm) at each sampling site. Leaf samples for ascospore germination tests were taken from areas immediately adjacent to the foil (Figure 11). The foil spray samples were processed as noted above. Weather conditions for each trial were as follows:

Trial	Date	Time of application	Temperature ° F	Wind velocity (mph)*	Misc.
1	5/19	6:20 AM (70 ft)	76	0	Overcast
		6:25 AM (100 ft)	76	0	Overcast
2	5/28	6:05 AM (70 ft)	75	0-1,2	Overcast
		6:10 AM (100 ft)	75	0-1,2	Overcast

Cont'd.

Trial	Date	Time of application	Temperature ° F	Wind velocity (mph)*	Misc.
3	6/19	5:45 AM (70 ft)	74	0	Partly overcast
		6:00 AM (100 ft)	74	0	Partly overcast
4	7/6	7:03 AM (70 ft)	78	0-1,2	Overcast
		7:11 AM (100 ft)	78	0-1,2	Overcast
5	7/15	6:55 AM (70 ft)	78	1.25	Overcast
		7:08 AM (100 ft)	78	1.25	Overcast

( ) Altitude of spray application.

* Numbers 1,2 represent spray drift of 1-2 swaths resulting from above canopy winds.

Significantly more Benlate was delivered at the soil surface from an altitude of 70 ft than 100 ft. In individual trials, a significantly larger quantity of Benlate was delivered from the lower altitude in two of four trials. However, variability was greater at the lower altitude (Table 23). Significantly higher droplet densities were observed in samples receiving spray from 70 ft. In one of four trials, the difference in density was not significant. Again, more variability was noted in spray samples from the lower altitude (Table 24).

Significantly higher percentages of small droplets (less than 200 μ in diameter) were delivered to the soil surface from the lower altitude.

When trials were considered separately, three of four trials had higher percentages of small droplets (less than 200 μ in diameter) delivered from the lower altitude. Patterns in variability were not consistent when droplet size ranges were compared between the treatments. However, variability was consistently lower in the droplet size range (101-200 μ) which had the highest percentage of droplets (Table 25). A close examination of the data indicated that a number of weather factors may be responsible for the lower efficiency of application from the higher altitude. The same helicopter and tank mix was used within each trial which eliminates the possible variables created by differences in aircraft and mix.

Chemical distribution was also monitored within the canopy with aluminum foil and subsequent bioassays. The leaves monitored included leaf 1, 3, 5 and 7 at three positions on each lamina. In general, all sampling sites received larger quantities of Benlate when the spray was applied from an altitude of 70 ft. (Figure 15). These differences were significant only at the tip of leaf 3, the base of leaf 5, the middle of leaf 7, and the base of leaf 7. More spray penetration within the canopy resulted from application at the lower altitude. If the average areas of fungal inhibition of the entire leaves are considered, leaf 7 received significantly more Benlate at the lower altitude (Figure 16). These data show better spray penetration is obtained within the canopy at the

Table 23. Mean areas of fungal inhibition zones detected in Benlate spray samples[1] applied from two different altitudes with nozzle-equipped helicopters.

Trial	: Altitude of application (ft above soil surface)	Areas of inhibition zones (mm^2)	Coefficient of variability (%)
1	: 70	864 a[2]	28.5
	100	585 b	20.2
2	: 70	626 d	45.4
	100	477 d	59.7
3	: 70	873 m	24.8
	100	763 m	17.2
5	: 70	634 w	19.7
	100	460 x	19.3
$\bar{x}_{1,2,3,5}$	: 70	749.4 y	17.8
	100	571.1 z (-44.6%)	12.9

[1] A description of the formulations used in these trials is presented earlier in the text.

[2] Each statistic is the mean of 40 samples taken from two swaths except for those in $\bar{x}$ 1,2,3,5 (160 samples); numbers followed by similar letters are not significantly different at the 0.01 level; the number in brackets represents the average difference in the quantity of Benlate delivered.

Table 24. Droplet densities detected in Benlate spray samples[1] applied from two different altitudes with nozzle-equipped helicopters.

Trial : Altitude of application (ft above soil surface)		Droplet density (No./cm^2)	Coefficient of variability (%)
1 :	70	155 a[2]	37.1
	100	112 b	30.8
2 :	70	171 d	41.9
	100	99 e	42.0
3 :	70	188 m	24.3
	100	183 m	23.4
5 :	70	213 r	35.5
	100	134 s	21.9
$\bar{x}_{1,2,3,5}$:	70	182 y	14.1
	100	132 z (-27.3%)	12.4

[1] The formulations used in each trial were as described earlier in the text.

[2] Each statistic is the mean of 40 samples taken from two swaths except for those in $\bar{x}$ 1,2,3,5 (160 samples); numbers followed by similar letters are not significantly different at the 0.01 level; the number in brackets represents the average difference in droplet density.

Table 25. Mean percents of droplets within various size ranges as obtained from nozzle-equipped helicopters applying Benlate sprays[1] from two different altitudes.

Trial	: Droplet size (μ in diameter)	Percent of droplets 70 ft	Percent of droplets 100 ft	Coefficient of variability (%) 70 ft	Coefficient of variability (%) 100 ft
1 :	<100	14.5 de[2]	25.0 bc	26.0	18.7
	101-200	32.9 a	29.3 ab	13.8	18.3
	201-300	19.1 cd	14.1 de	23.3	36.7
	301-400	9.9 e	8.9 e	28.7	33.6
	>400	23.6 bc	22.7 bc	22.2	21.6
2 :	<100	22.4 g	12.1 ij	12.9	26.3
	101-200	34.5 f	31.8 f	11.9	18.5
	201-300	16.0 hi	17.8 ghi	28.0	19.4
	301-400	10.1 j	15.8 hi	38.7	22.0
	>400	17.0 ghi	22.5 gh	21.9	30.4
3 :	<100	16.8 mno	12.0 o	33.7	36.9
	101-200	41.6 k	33.6 l	14.5	14.2
	201-300	15.4 mno	17.6 mn	19.1	21.3
	301-400	13.4 no	16.1 mno	27.3	28.5
	>400	12.8 no	20.7 m	27.2	21.8
5 :	<100	20.3 q	10.9 r	25.8	40.7
	101-200	42.5 p	35.6 p	9.3	16.2
	201-300	15.4 qr	18.9 q	29.5	21.2
	301-400	11.4 r	17.5 q	47.3	22.0
	>400	10.4 r	17.1 q	24.1	18.0
$\bar{x}_{1,2,3,5}$:	<100	18.5 uv	15.0 xy	9.7	8.4
	101-200	37.8 s	32.6 t	6.7	9.8
	201-300	16.5 vw	17.2 vw	13.8	11.3
	301-400	11.2 y	14.6 wx	11.8	12.6
	>400	16.0 vw	20.6 u	13.8	11.1

[1] The formulations used in the trials were as described earlier in the text.

[2] Each statistic is the mean of 40 samples taken from two swaths except for those in $\bar{x}$ 1,2,3,5 (160 samples); numbers followed by similar letters are not significantly different at the 0.01 level (Duncan's Multiple Range Test).

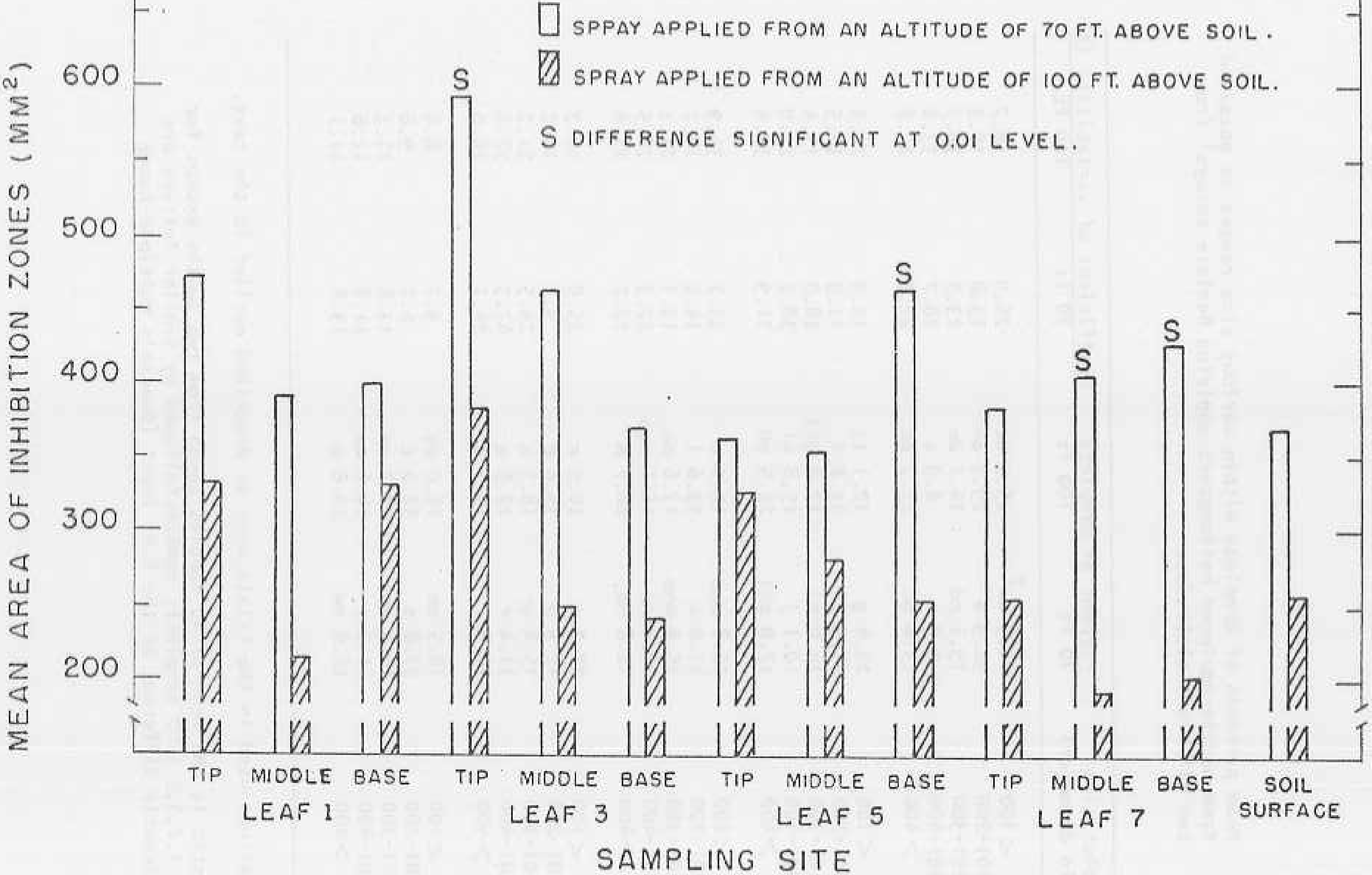


Figure 15. Benlate spray distribution within the banana canopy as detected by bioassay. All applications were by a helicopter equipped with a nozzle system.

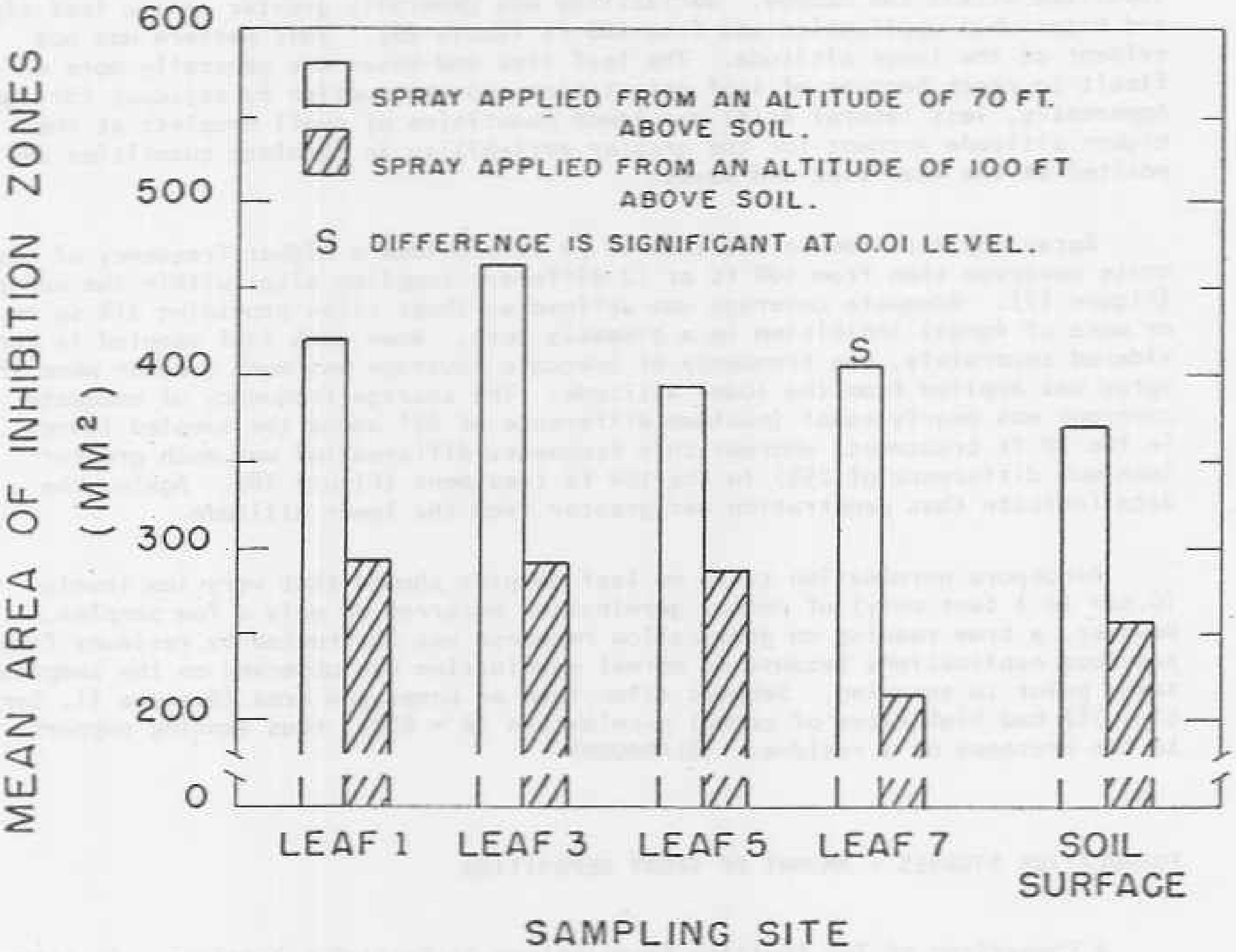


Figure 16. Benlate distribution within the banana canopy as detected by bioassay. All applications were made with a nozzle-equipped helicopter.

lower altitude. Also, more spray reached the soil surface under the canopy at the lower altitude. The quantity of Benlate reaching the soil was similar to the average quantity on each leaf (Figure 16). From these data, it appears that the amount of Benlate reaching the soil is indicative of the average quantity deposited within the canopy. Variability was generally greater at the leaf tips and bases when application was from 100 ft (Table 26). This pattern was not evident at the lower altitude. The leaf tips and bases are generally more difficult to reach because of leaf orientation and obstruction by adjacent foliage. Apparently, less lateral drift and lower quantities of small droplets at the higher altitude account for the greater variability in Benlate quantities deposited at the leaf tips and bases.

Spray applied from an altitude of 70 ft provided a higher frequency of adequate coverage than from 100 ft at 12 different sampling sites within the canopy (Figure 17). Adequate coverage was defined as those sites providing 314 sq mm or more of fungal inhibition in a bioassay test. When each leaf sampled is considered separately, the frequency of adequate coverage was much greater when the spray was applied from the lower altitude. The average frequency of adequate coverage was nearly equal (maximum difference of 6%) among the sampled leaves in the 70 ft treatment, whereas this frequency differential was much greater (maximum difference of 25%) in the 100 ft treatment (Figure 18). Again, the data indicate that penetration was greater from the lower altitude.

Ascospore germination tests on leaf samples showed that very low levels (0.6%= in 1 test only) of normal germination occurred on only a few samples. However, a true reading on germination response was obstructed by residues from previous applications because no normal germination was observed on the samples taken prior to spraying. Samples taken from an unsprayed area (Guaruma II, Section 38) had high rates of normal germination ($\bar{x}$ = 80%), thus lending support to the presence of a residue. (SLABAUGH)

FORMULATION STUDIES - AMOUNT OF SPRAY DEPOSITION

A Comparison of Two Emulsion Formulations As Fungicide Carriers. An experiment was initiated to compare the application efficiencies of an 85:15 oil-water formulation and a 50:50 oil-water formulation.

The equipment used for application was as outlined previously (Figure 10 and Table 12). The emulsion formulations contained 4 oz Benlate in 0.85 gal oil + 0.15 gal water + 0.1% Agral 90 (or in 0.5 gal oil + 0.5 gal water + 0.38% Agral 90). The application rate was 1 gal per acre and all figures were adjusted for application rate error. Spray samples were collected at 5 ft intervals across each swath on aluminum foil and adjacent glass slides. The methods of sample processing were the same as those noted earlier in the section on aerial application experiments. This experiment was conducted two times and samples were taken across two swaths in each treatment. Weather conditions were as follows:

Table 26. Areas of inhibition zones obtained by bioassay from various sampling sites in the banana canopy from Benlate sprays applied from two different altitudes[1].

Sampling site[2]	Area of inhibition zone (mm2)			Coefficient of variability %	
	Altitude (ft above soil)				
	70	100	Percent difference in area of zone	70	100
1 A	471.6 ab*	332.0 bcdefg	-29.6	12.4	38.1
B	390.6 bcdefg	216.0 efg	-44.5	38.9	21.8
C	400.0 bcdef	331.2 bcdefg	-17.2	26.9	40.9
3 A	593.0 a	383.2 bcdefg	-35.4	22.9	43.9
B	463.2 abcd	249.6 defg	-42.8	37.5	23.9
C	370.4 bcdefg	243.2 defg	-34.3	40.6	34.7
5 A	361.4 bcdefg	327.6 bcdefg	- 9.4	15.3	41.1
B	355.6 bcdefg	281.0 cdefg	-20.9	40.7	15.3
C	465.2 abc	255.8 defg	-45.0	24.4	14.9
7 A	385.2 bcdefg	256.8 defg	-33.3	38.1	34.2
B	407.2 bcde	190.8 g	-53.1	26.4	16.4
C	429.2 abcd	203.0 fg	-52.7	21.1	30.0
G	338.0 bcdefg	229.4 efg	-32.1	7.6	11.0
G	402.0 bcdef	287.8 bcdefg	-28.4	40.9	19.1

[1] Application was with a helicopter equipped with a nozzle system.

[2] The numbers refer to the leaf numbers of the plant; the letters A, B and C refer to tip, mid-section and base of the leaf lamina.

* Each statistic is the mean of 15 samples taken from three swaths; numbers followed by similar letters are not significantly different at the 0.01 level as determined with Duncan's Multiple Range Test; percent figures are rounded-off to the nearest 0.1 percent.

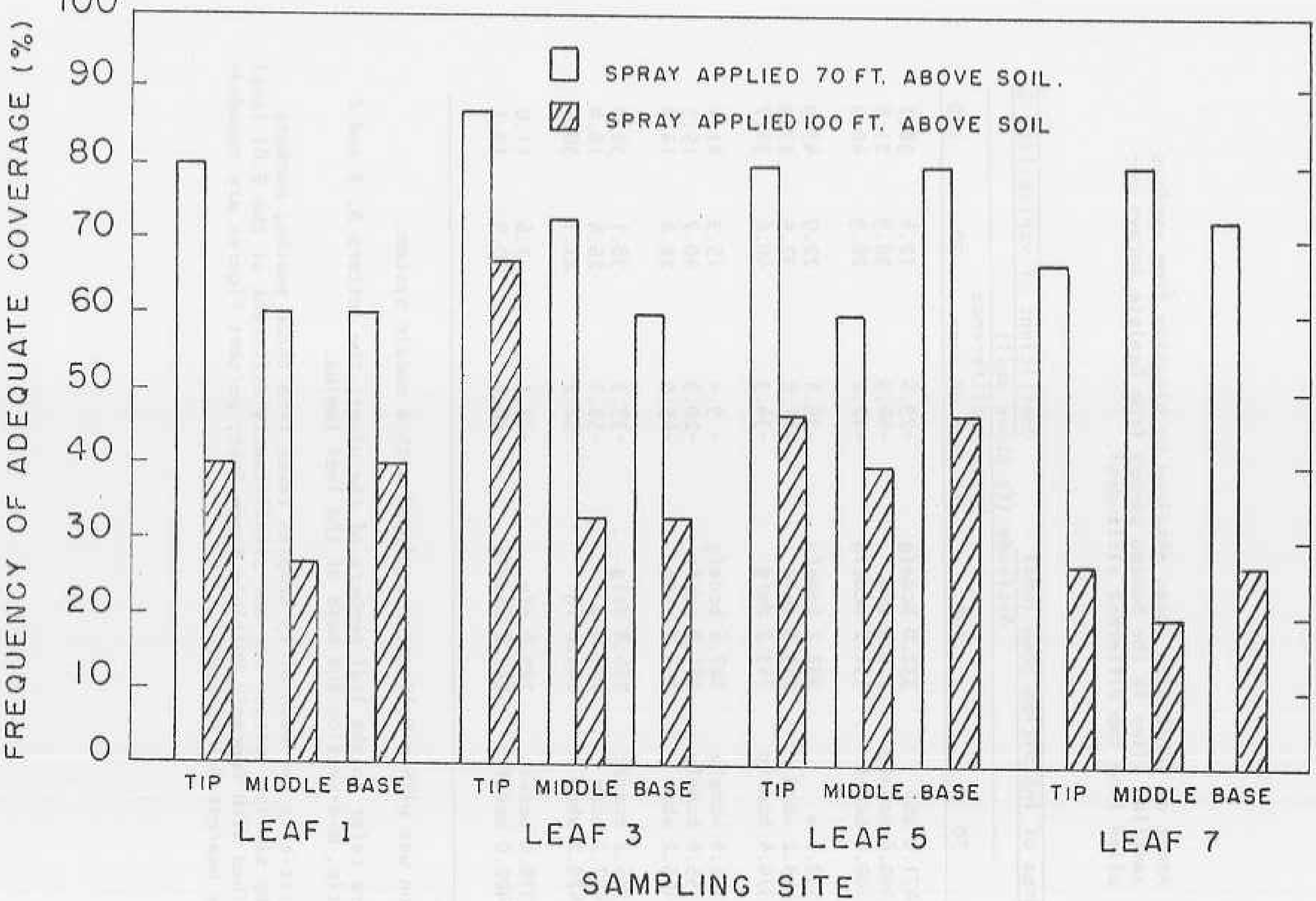


Figure 17 Frequency of adequate Benlate spray coverage at twelve sampling sites within the banana canopy. Adequate coverage was defined as 314 sq mm or more of fungal inhibition area in a bioassay test using *Penicillium expansum*.

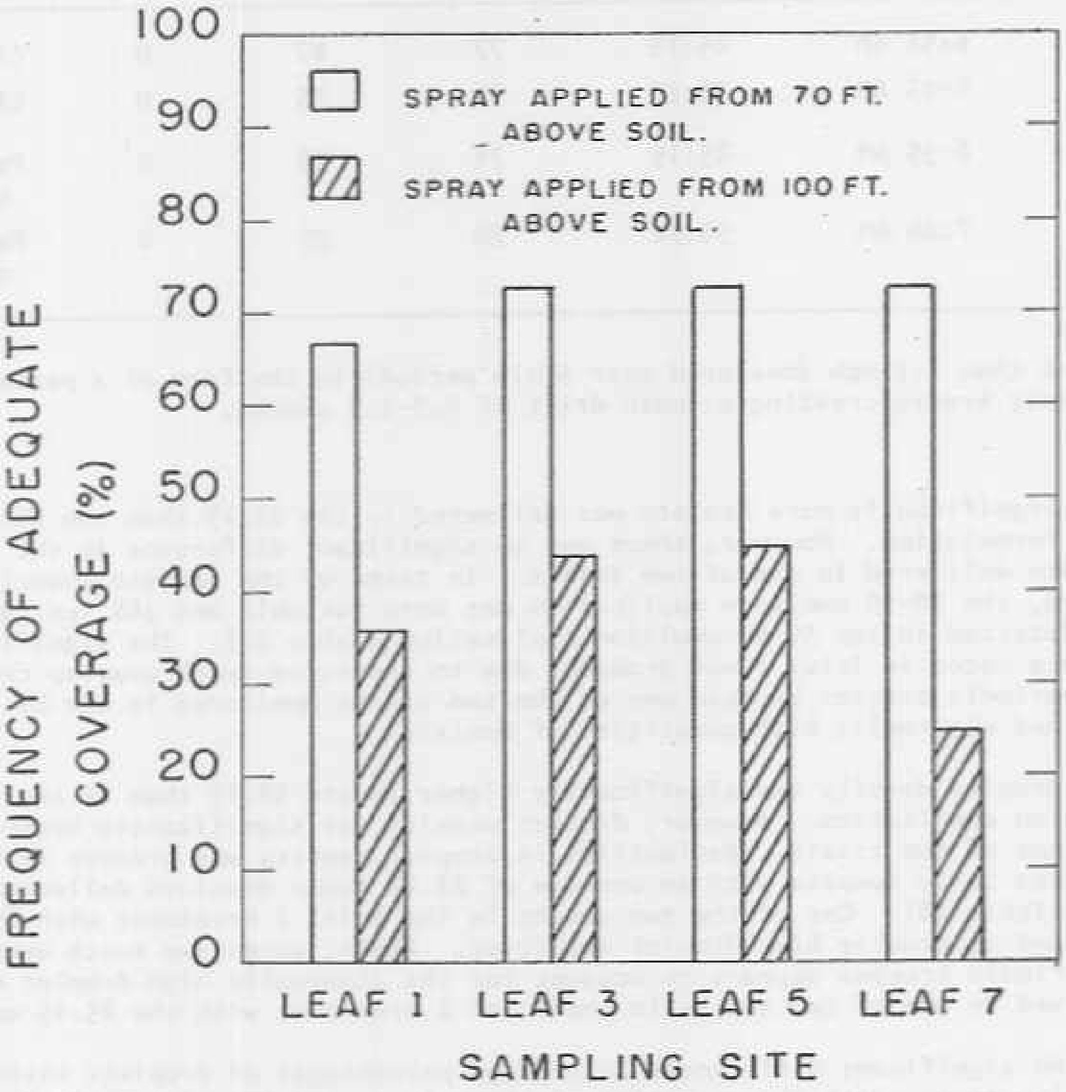


Figure 18. Frequency of adequate Benlate spray coverage on leaves in the banana canopy. Adequate coverage was defined as 314 sq mm or more of fungal inhibition area in a bioassay test using *Penicillium expansum*.

Trial	Time of application	Formulation	Temperature ° F	Relative humidity (%)	Wind velocity	Other
1	6:53 AM	85:15	77	87	0	Clear
	6:15 AM	50:50	72	95	0	Clear
2	6:35 AM	85:15	74	95	0[1]	Partly overcast
	7:20 AM	50:50	70	95	0	Partly overcast

[1] Less than 1.7 mph (measured over 5 min period) in the form of a periodic steady breeze creating a swath drift of 0.5-1.5 swaths.

Significantly more Benlate was delivered in the 85:15 than the 50:50 emulsion formulation. However, there was no significant difference in the amount of Benlate delivered in one of two trials. In terms of the Benlate quantities delivered, the 50-50 emulsion application was more variable and 36% less Benlate was detected in the 50-50 emulsion application (Table 27). The significant difference noted in Trial 2 was probably due to excessive swath overlap caused by the periodic breezes because one of the two swaths monitored in the 85:15 treatment had abnormally high quantities of Benlate.

Droplet density was significantly higher in the 85:15 than in the 50:50 emulsion application. However, droplet density was significantly higher in only one of two trials. Variability in droplet density was greater in the 50:50 emulsion spray samples with an average of 23.8% fewer droplets delivered per unit area (Table 28). One of the two swaths in the Trial 2 treatment with 85:15 emulsion had abnormally high droplet densities. Again, excessive swath overlap due to periodic breezes appears to account for the abnormally high droplet densities observed in one of two swaths in the Trial 2 treatment with the 85:15 emulsion.

No significant differences in average percentages of droplets within various size ranges with the exception of those less than 100 microns in Trial 1 could be detected. However, higher percentages of droplets less than 300 μ in diameter were detected in the 85:15 emulsion application in one of two trials (Table 29). Variability, in terms of droplet size percentages, was generally greater in the 85:15 application (Table 29).

The results from this experiment agree closely with the results from the oil alone versus 50% emulsion where the quantity of Benlate delivered and the droplet density in general were higher in Benlate-oil alone than in the 50% emulsion. In any case, it appears that the 85% emulsion application is probably more efficient in terms of Benlate quantities delivered and droplet density, than the 50% emulsion, particularly during the warmer and drier seasons of the year. (SLABAUGH)

Table 27. Mean areas of fungal inhibition zones detected in field sampling of Benlate applied in two formulations with nozzle-equipped helicopters.

Trial :	Formulation[1]	Mean area of inhibition zones (mm^2)	Coefficient of variability (%)
1 :	85:15	845.5 a[2]	28.0
	50:50	853.4 a	32.6
2 :	85:15	1073.8 m**	12.8
	50:50	824.7 n	13.3
$\bar{x}$ 1,2 :	85:15	959.9 x*	11.1
	50:50	830.4 y (-36.4%)	17.7

[1] All formulations contained 4 oz Benlate blended into 0.85 gal oil + 0.15 gal water + 0.1% Agral 90 or 0.5 gal oil + 0.5 gal water + 0.38% Agral 90.

[2] Each statistic is the mean of 40 samples from two swaths except those in $\bar{x}$ 1,2 (mean = 80 samples); numbers followed by similar letters are not significantly different at the 0.05 level (*) or the 0.01 level (**); the number in brackets represents the difference in the quantity of Benlate delivered.

Table 28. Mean droplet densities of Benlate spray samples detected on glass slides at the soil surface from 1 gal applications with nozzle-equipped helicopters.

Trial	:	Formulation[1]	Droplet density (No./cm²)	Coefficient of variability (%)
1	:	85:15	191.5 a[2]	18.7
		50:50	180.2 a	18.7
2	:	85:15	228.6 m	15.1
		50:50	141.9 n	16.8
$\bar{x}$ 1,2	:	85:15	207.8 x	12.0
		50:50	158.3 y (-23.8%)	16.9

[1] The formulations are the same as those noted on Table 27.

[2] Each statistic is the mean of 40 samples from two swaths except those in $\bar{x}$ 1,2 (mean = 80 samples); numbers followed by similar letters are not significantly different at the 0.01 level; the number in brackets represents the average difference in droplet density.

Table 29. Mean percentages of droplets within various size ranges detected in 1 gal emulsion applications as applied with nozzle equipped helicopters.

Trial	:	Droplet size (μ in diameter)	Percent of droplets 85:15[1]	50:50	Coefficient of variability (%) 85:15	50:50
1	:	100	15.6 def[2]	26.4 bc	24.6	17.1
		101-200	39.6 a	36.2 ab	19.2	17.1
		201-300	24.2 cd	19.9 cde	26.0	18.1
		301-400	9.6 f	8.0 f	31.2	40.6
		400	11.0 ef	9.5 f	24.4	24.1
2	:	100	21.3 q	19.5 q	19.5	19.5
		101-200	41.7 p	35.1 p	8.4	9.9
		201-300	16.0 qr	15.5 qr	20.5	17.6
		301-400	8.4 s	9.6 rs	23.6	18.7
		400	12.6 qr	20.3 q	15.5	23.3
$\bar{x}$ 1,2	:	100	18.5 wxy	22.7 w	12.2	11.8
		101-200	40.7 v	35.7 v	10.1	10.5
		201-300	20.1 wx	17.7 wxy	17.8	14.0
		301-400	9.0 z	8.8 z	20.6	15.1
		400	11.7 yz	15.1 xy	14.2	11.9

[1] These formulations are the same as those noted on Table 27.

[2] Each statistic is the mean of 40 samples from two swaths except those in $\bar{x}$ 1,2 (mean = 80 samples); numbers followed by similar letters are not significantly different at the 0.01 level (Duncan's Multiple Range Test).

BENLATE STUDIES

The systemic activity of Benlate in banana foliage is limited primarily to movement into very localized areas with virtually no lateral movement in the leaf (1975 Annual Report, pp. 19-26). The active ingredient of Benlate is released slowly in oil and water moving laterally presumably in the frequent leaf wettings of dews, irrigation and rains. Hence persistence of Benlate on the foliage becomes important to good control.

Atplus 300-F for Suspension and Persistence of Benlate

Atplus 300-F has been promoted as a partial replacement for oil for Sigatoka control. An experiment was initiated to test suspension and persistence qualities in Atplus before utilizing it in a large-scale field trial.

Benlate suspension quality was tested in the equivalents of the following formulations:

A - 4 oz Benlate + 1 gal oil + 0.1% Agral 90

B - 4 oz Benlate + 0.5 gal oil + 0.5 gal water + 0.38% Agral 90

C - 4 oz Benlate + 0.204 gal oil + 0.046 gal Atplus 300-F + 0.75 gal water

D - 4 oz Benlate + 0.204 gal oil + 0.046 gal Atplus 300-F + 0.75 gal water + 0.38% Agral 90.

All formulations were mixed in a low-speed (2700 RPM) and a high-speed (6000 RPM) blender for 2 min and 30 sec, respectively. When Atplus was added to the mix, the oil and Atplus were blended before adding Benlate which was mixed into the water. Immediately after blending, the samples were passed through a 30-mesh sieve and observed for precipitation rates. The experiment was repeated twice.

All emulsion formulations passed through the sieve with a minimum of Benlate residue retained after either low or high-speed blending. The oil formulation passed through the sieve easily after high-speed but not low-speed blending (Table 30). All formulations showed good suspension qualities when mixed in a high-speed blender. Under conditions of slow-speed blending, the Atplus formulations suspended better than the emulsion formulation being used currently. When Agral 90 was omitted from the Atplus formulation, suspension quality was significantly better in the Atplus formulation than in the current emulsion formulation (Table 30). Benlate suspension in the oil formulation was approximately equal to that observed in the Atplus emulsions after slow-speed blending. However, it should be noted that 73% of the Benlate was removed by the sieve tests which may influence precipitation rates (Table 30).

Table 30. Benlate suspension and mixing qualities in Atplus 300-F formulations after slow-speed blending (2700 RPM)

Formulation[1]	Percent Precipitation[2] 5 min	10 min	15 min	129 min	Percent passing 30-mesh sieve
A	3.7 a **	4.7 de *	5.0 mn *	7.0 yz **	27 (100)
B	4.7 a	7.3 d	11.0 m	25.3 x	100 (100)
C	0.0 b	1.0 e	2.3 n	5.3 z	100 (100)
D	1.0 ab	2.3 de	3.0 n	10.7 y	100 (100)

[1] See listing of formulations in above text.

[2] Numbers followed by similar letters are not significantly at the 0.01 (**) or 0.05 (*) level using Duncan's Multiple Range Test.

( ) Amount of Benlate passing through sieve after high-speed blending (6000 RPM).

The persistence quality of Benlate was determined by discharging ascospores on sprayed leaf samples subjected to various amounts of simulated rain. All spray samples were vigorously agitated in the field just prior to application. The formulations were applied with a Paasche air-brush in amounts equivalent to those expected from an aircraft application rate of 1 gal per acre. A spray tower (9 x 9 x 32 in) with air-brush nozzle attached to a lid was used to achieve an evenly distributed spray pattern on the leaves. Sprayed samples were left in the field 24 hr before removing them for simulated rain application in a rain tower and subsequent spore discharge in the laboratory. Each treatment was replicated three times and the experiment was repeated. The treatments used in this experiment were:

- 4 oz Benlate + 1 gal oil/acre
- 4 oz Benlate + 1 gal oil + 0.1% Agral 90/acre
- 4 oz Benlate + 0.5 gal oil + 0.5 gal water + 0.38% Agral 90/acre
- 4 oz Benlate + 0.204 gal oil + 0.046 gal Atplus 300-F + 0.75 gal water/acre
- 4 oz Benlate + 0.204 gal oil + 0.046 gal Atplus 300-F + 0.75 gal water + 0.38% Agral 90/acre
- 1 gal oil/acre
- 1 gal oil + 0.1% Agral 90/acre
- 0.5 gal oil + 0.5 gal water + 0.38% Agral 90/acre
- 0.204 gal oil + 0.046 gal Atplus 300-F + 0.75 gal water /acre
- 0.204 gal oil + 0.046 gal Atplus 300-F + 0.75 gal water + 0.38% Agral 90/acre

The persistence qualities of Benlate were the same in all Benlate formulations when using ascospore germination as the control parameter. This was true for all quantities of simulated rain applied (0.4-1.9 inches) (Table 31). All oil and emulsion formulations without Benlate decreased normal germination significantly. Decreases in normal germination were statistically equal with the exception of pure oil in combination with Agral 90. The later mix reduced the percent of normal germination significantly more than the other treatments without Benlate (Table 31). However, the addition of Agral 90 to the oil formulation with Benlate did not significantly increase Benlate persistence on leaves subjected to 1.9 inches of simulated rain. There was no difference between Atplus and Agral emulsions with regard to Benlate persistence under the test conditions. It remains to be seen whether the Atplus formulation in a large-scale field trial can provide an equal or higher level of control than Benlate in oil alone. If the control is equal, a savings of $0.30 per acre per cycle can be realized.

Triton XS-75 for Suspension and Persistence of Benlate

An experiment to test the suspension and persistence qualities of Benlate in oil and emulsion formulations with Triton XS-75 was initiated. All oil only formulations contained 4 oz of Benlate (Lots No. F 906121) per gallon of oil with 0.00, 0.05, 0.10, 0.25 and 0.50 percent of Triton XS-75 or Agral 90 added. All emulsion formulations contained 4 oz of Benlate in 0.5 gal of oil + 0.5 gal of water with 0.00, 0.05, 0.10, 0.25 and 0.50 percent of either adjuvant added. The addition of these adjuvants was based on the quantity of oil in the mix. All formulations were mixed in a low-speed (2700 RPM) and a high-speed (6000 RPM) blender for 2 min and 30 sec, respectively. Immediately after blending, the samples were passed through a 30-mesh sieve and observed for precipitation rates. Each treatment had 4 replicates and the experiment was repeated.

All formulations passed through the sieve with a minimum of residue retained after slow- or high-speed blending. In the oil formulations, there was no significant difference in Benlate suspension between mixes containing Triton XS-75 and Agral 90 when blended at a slow-speed (Table 32). The addition of 0.05-0.50 percent of either adjuvant did not increase the suspension quality of Benlate in mixes blended at a slow-speed but actually decreased suspension quality significantly when the precipitation rate was evaluated 1 hr after blending (Table 32). High-speed blending of the oil formulations increased suspension quality considerably when the precipitation rates at both blending speeds were compared (Tables 32 and 33). Under high-speed blending, the addition of either adjuvant decreased suspension quality when evaluated 30 min or longer after blending. These decreases were not significant until 1 hr after mixing (Table 33).

In general, the Benlate suspended equally well after slow-speed blending in the emulsion formulations containing either adjuvant. This was true even when Triton XS-75 was used at twice the concentration of Agral 90 (Table 34). Benlate suspension in the emulsion formulation without adjuvant added was equal or slightly worse than that observed in the formulations containing 0.05-0.10% of either adjuvant, but rapid oil and water phase separation was observed in the formulation without adjuvant (Table 34). No oil and water phase separation or Benlate precipitation was observed in the emulsion formulations with or without adjuvant after high-speed blending when observed 24 hours later. In general, more foaming was observed in the Agral than in the Triton mixes. Evidently, there is no real

Table 31. Normal *Mycosphaerella fijiensis* var. *difformis* ascospore germination after simulated rains on banana leaves sprayed with various Benlate formulations.

Formulations[1]	Mean percent normal germination[2] Simulated rain (inches) 0.4	0.8	1.2	1.5	1.9	$\bar{x}$
Benlate-Oil	0.0	2.8	5.0	0.0	0.0	1.56 d
Benlate-Oil-Agral	0.0	0.0	0.0	0.0	0.0	0.00 d
Oil-Agral	46.8	57.0	45.8	62.2	61.5	54.66 c
Oil	63.0	67.8	67.6	74.0	71.2	68.72 b
Benlate-Agral Emulsion	0.0	0.0	0.0	0.0	0.0	0.00 d
Benlate-Atplus Emulsion	0.0	0.0	0.0	0.0	0.0	0.00 d
Benlate-Atplus-Agral Emulsion	0.0	0.0	0.0	0.0	0.0	0.00 d
Agral Emulsion	69.3	69.8	77.8	83.0	76.3	75.24 b
Atplus Emulsion	59.7	65.0	71.0	69.3	74.7	67.94 b
Atplus-Agral Emulsion	59.2	62.0	62.2	67.8	79.8	66.20 b
Control	93.0	80.3	82.8	89.2	87.2	86.5 a

[1] See listing of formulations noted earlier in the text.

[2] Each statistic is the mean of 6 replicates; numbers followed by the same letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

Table 32. Suspension quality of Benlate in oil formulations with Agral 90 and Triton XS-75 after slow-speed blending.

Formulation[1]		Precipitation Rate (%) 1 min[2]	10 min	30 min	1 hr
Agral 90	0.05	44.9 a[3]	61.9 c	72.9 fg	100.0 n
	0.10	44.1 a	50.8 c	63.2 g	100.0 n
	0.25	43.4 a	55.0 c	75.0 efg	100.0 n
	0.50	45.0 a	56.8 c	89.0 e	100.0 n
Triton XS-75	0.05	36.0 a	47.4 c	62.3 g	100.0 n
	0.10	38.3 a	55.0 c	66.7 g	100.0 n
	0.25	41.0 a	57.7 c	79.8 efg	100.0 n
	0.50	43.5 a	60.3 c	90.5 ef	100.0 n
Control		39.7 a	46.2 c	54.4 g	67.7 m

[1] All informations contained 4 oz Benlate in 1 gal of oil; the adjuvants, Triton and Agral were added as a percent of oil volume.

[2] Time interval after blending.

[3] Each statistic is the mean of eight samples; numbers followed by similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

Table 33. Suspension quality of Benlate in oil formulations with Agral 90 and Triton XS-75 after high-speed blending.

Formulation[1]		Precipitation rate (%)			
		1 min[2]	10 min	30 min	1 hr
Agral 90	0.05	0.0 a[3]	0.0 e	5.0 q	14.5 y
	0.10	0.0 a	4.0 d	11.8 no	25.8 vw
	0.25	0.0 a	3.0 d	9.8 no	31.8 v
	0.50	0.0 a	9.0 c	26.3 m	51.0 u
Triton XS-75	0.05	0.0 a	2.3 d	12.8 n	20.5 wxy
	0.10	0.0 a	4.3 cd	6.3 pq	18.8 xy
	0.25	0.0 a	5.5 cd	8.8 op	15.0 y
	0.50	0.0 a	4.5 cd	11.3 no	21.5 wx
Control		0.0 a	0.0 e	3.8 q	8.5 z

[1] All formulations contained 4 oz Benlate in 1 gal oil; the adjuvants were added as a percent of oil volume.

[2] Time interval after blending.

[3] Each statistic is the mean of eight samples; numbers followed by similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

Table 34. Suspension quality of Benlate in emulsion formulations with Agral 90 and Triton XS-75 after slow-speed blending.

Formulations[1]		Precipitation rate (%) 30 min[2]	1 hr	4 hrs	24 hrs
Agral 90	0.05	10.1 b[3]	13.6 gh	21.9 n	26.5 wx
	0.10	11.9 a	15.0 f	21.6 no	26.9 wx
	0.25	10.0 b	12.9 ghi	20.0 p	25.4 y
	0.50	8.8 c	11.1 j	17.8 q	24.1 z
Triton XS-75	0.05	9.0 bc	12.0 ij	20.5 op	26.3 xy
	0.10	12.5 a	18.0 e	23.6 m	27.4 w
	0.25	10.0 b	12.9 ghi	21.0 nop	26.5 wx
	0.50	9.6 bc	12.6 h	19.9 p	26.4 xy
Control[4]		12.5 a	14.0 fg	21.6 no	26.5 wx

[1] All formulations contained 4 oz Benlate in 0.5 gal oil + 0.5 gal water; the adjuvants were added as a percent of oil volume.

[2] Time interval after blending.

[3] Each statistic is the mean of eight samples; numbers followed by similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

[4] Rapid separation of oil and water phase observed.

difference between the two adjuvants in terms of Benlate suspension under these test conditions.

The persistence quality of Benlate was determined by a leaf disc bioassay by discharging ascospores on sprayed leaf samples subjected to various amounts of simulated rain. The formulations were mixed in the slow-speed blender (2700 RPM) for 2 min before taking the samples to the field. The formulations were applied with a Paasche air-brush in amounts equivalent to those expected from an aircraft application of 1 gal per acre. A spray tower (9 x 9 x 32 in) with the air-brush nozzle attached to a lid was used to achieve an evenly distributed spray pattern on the leaves. The plants utilized in this experiment were selected in Guaruma 1, Section 38, an unsprayed area. Sprayed leaf samples were left in the field for 24 hr before removing them for simulated rain application in a rain tower and subsequent spore discharge in the laboratory. Each treatment was replicated three times and the experiment was repeated. The treatments used in this experiment were as follows:

A - 4 oz Benlate in 1 gal oil/acre

B - 4 oz Benlate in 1 gal oil + 0.05% Triton XS-75/acre

C - 4 oz Benlate in 1 gal oil + 0.05% Agral 90/acre

D - 4 oz Benlate in 0.5 gal oil + 0.5 gal water + 0.75% Triton XS-75/acre

E - 4 oz Benlate in 0.5 gal oil + 0.5 gal water + 0.75% Agral 90/acre

F - 4 oz Benlate in 0.5 gal oil + 0.5 gal water + 0.38% Agral 90/acre

G - 1 gal oil/acre

H - 1 gal oil + 0.05% Triton XS-75/acre

I - 1 gal oil + 0.05% Agral 90/acre

J - 0.5 gal oil + 0.5 gal water + 0.75% Triton XS-75/acre

K - 0.5 gal oil + 0.5 gal water + 0.75% Agral 90/acre

L - 0.5 gal oil + 0.5 gal water + 0.38% Agral 90/acre

The persistence qualities of Benlate were the same in all Benlate formulations when using normal ascospore germination as the control parameter. This was true for all quantities of simulated rain applied (0.4-1.9 in) to the Benlate-treated leaves (Table 35). None of the oil or emulsion formulations without Benlate decreased normal ascospore germination significantly. The later results do not agree with the results reported in the section "Atplus 300-F for Suspension and Persistence of Benlate". This discrepancy may have resulted from chemical differences among oil lots because this laboratory has observed suspension quality differences among different spray oil lots. As the data indicated, there was no real difference between the Triton and Agral-treated formulations with regard to Benlate persistence on the foliage.

Suspension and Persistence of Benlate in 85% Emulsion

Field experiments testing oil alone and a 50% emulsion showed less Benlate was delivered in the emulsion in one of three trials. In addition,

Table 35. Percent normal germination of Mycosphaerella fijiensis var. difformis ascospores on sprayed leaves subjected to various quantities of simulated rain.

Amount of simulated rain (in)	Mean rate of normal germination (%)					
	A-F[1]	G	H	I	J	K
0.0	0.0 b[2]	68.3 c	82.7 d	73.3 e	77.3 i	76.7 n
0.4	0.0 b	77.3 c	77.0 d	78.0 e	79.3 i	74.3 n
0.8	0.0 b	83.7 c	74.7 d	84.7 e	94.3 fghi	81.3 n
1.2	0.0 b	81.0 c	82.3 d	87.3 e	90.3 fghi	94.7 m
1.5	0.0 b	73.7 c	88.7 d	87.0 e	96.0 fgh	93.3 m
1.9	0.0 b	75.3 c	79.0 d	84.7 e	98.7 fg	96.0 m
Control BW[3]	82.3 a	82.3 c	82.3 d	82.3 e	82.3 hi	82.3 n
Control AW[4]	81.0 a	81.0 c	81.0 d	81.0 e	81.0 hi	81.0 n

[1] Formulations; see text for formulation content.

[2] Each statistic is the mean of three replicates; numbers followed by similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

[3] Control (no spray applied) without simulated rain applied.

[4] Control (no spray applied) with 1.9 inches of simulated rain applied.

difficulties of mixing have occurred when Benlate was blended into oil alone because of moisture contamination and differences in the wettable powder carriers. A high oil-to-water ratio emulsion may alleviate the application efficiency and blending problems. Benlate (Lot No. F 40215E) was tested in an 85% emulsion. The quantity of Agral 90 needed to achieve good suspension and persistence was studied before initiating field trials. The suspension qualities were tested in the following formulations, all containing ¼ oz of Benlate:

	Gal Oil	Gal Water	% Agral 90
A.	0.85	0.15	0.75
B.	0.85	0.15	0.35
C.	0.85	0.15	0.30
D.	0.85	0.15	0.17
E.	0.85	0.15	0.12
F.	0.85	0.15	0.06
G.	0.85	0.15	
H.	0.5	0.5	0.38

The percent of Agral 90 added was based on the quantity of oil. All formulations were mixed in a low-speed (2700 RPM) and a high-speed (6000 RPM) blender. The oil and Agral 90 were blended before adding Benlate which was mixed into the water previously. All formulations were mixed for 2 min in the low-speed blender and for 30 sec in the high-speed blender. Immediately after blending, the samples were passed through a 35-mesh sieve and observed for precipitation rates. The experiment was repeated.

All formulations passed through the sieve with a minimum of Benlate residue retained after either high- or slow-speed blending. However, the formulations mixed in the low-speed blender were somewhat viscous and slow in passing through the sieve. The flow rate of the formulation blended at a slow-speed decreased as the quantity of Agral 90 was increased (Table 36). The 50/50 oil-water formulation was also slightly viscous when blended at slow speed and approximately equal to the 85/15 oil-water mixture with 0.12% Agral 90 in terms of flow rate. All formulations, after slow-speed blending, remained in complete suspension for at least 120 min. After high-speed blending, the formulations showed various rates of precipitation. The most rapid rates of precipitation occurred in the mixes containing the highest percentages of Agral 90 (Table 36). No foaming was observed in any of the mixes, except in the 50/50 oil-water formulation.

The formulation with 0.12% Agral 90 was selected for a field trial based on the relative mixing qualities in a slow-speed blender which more nearly approximates field conditions. This formulation was tested in the low-pressure, high-volume hydraulic mixing system and the field blender. The mixes from both systems were good.

The persistence quality of Benlate was determined by discharging ascospores on sprayed leaf samples subjected to various amounts of simulated rain.

Table 36. Benlate suspension qualities in a high oil to water ratio formulation after high-speed blending.

Formulations[1]	Precipitation rate (%)[2] 1 min	5 min	10 min	Flow rate through a 35-mesh sieve[3]
A	0.0 a	22.0 c	23.5 w	good (very poor)
B	0.0 a	20.5 cd	22.5 wx	good (very poor)
C	0.0 a	13.5 cd	14.5 xy	good (poor)
D	3.5 a	11.5 de	12.5 y	good (poor)
E	0.0 a	10.0 e	14.0 xy	good (average)
F	0.0 a	2.5 f	11.5 y	good (average)
G	0.0 a	1.0 fg	9.0 y	good (average)
H	0.0 a	0.0 g	0.0 z	good (average)

1 See listing of formulations in the above text.

2 Numbers followed by similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

3 Good = flow rate through the sieve equals pouring rate.
Average = flow rate through the sieve is approximately 10% slower than pouring rate.
Poor = flow rate through the sieve is approximately 33% slower than pouring rate.
Very poor + flow rate through the sieve is over 50% slower than pouring rate.

( ) = Flow rate after slow-speed blending; non-bracketed flow rate indications are after high-speed blending.

All formulations were mixed in the slow-speed blender (2700 RPM) for 2 min in the laboratory before going to the field. All spray samples were agitated vigorously just prior to application. All applications were made with a Paasche air-brush in amounts equivalent to those expected from an aircraft application rate of 1 gal per acre. A spray tower (9 x 9 x 32 in) with the air-brush nozzle attached to the lid was used to achieve an evenly distributed spray pattern on the leaves. Sprayed leaves were left intact in the field for 24 hr before removal for simulated rain application in a rain tower. Each treatment was replicated four times and the experiment was repeated. The formulae used (per acre rate) in this experiment were as follows:

A - 4 oz Benlate + 0.85 gal oil + 0.15 gal water + 0.3% Agral 90/acre

B - 4 oz Benlate + 0.85 gal oil + 0.15 gal water + 0.1% Agral 90/acre

C - 4 oz Benlate + 0.85 gal oil + 0.15 gal water/acre

D - 4 oz Benlate + 0.5 gal oil + 0.5 gal water + 0.38% Agral 90/acre

E - 0.85 gal oil + 0.15 gal water + 0.3% Agral 90/acre

F - 0.85 gal oil + 0.15 gal water + 0.1% Agral 90/acre

G - 0.5 gal oil + 0.5 gal water + 0.38% Agral 90/acre.

The persistence qualities of Benlate were equal statistically in all formulations using ascospore germination as the control parameter. However, an average of up to 5% normal germination was observed on leaf samples treated with the Benlate 85% emulsion when Agral 90 was included in the mix (Table 37). This occurred in only one of the experiments and is probably due to experimental error. All formulations without Benlate reduced normal ascospore germination up to 28% (Table 37). This suggests that oil in combination with Agral 90 reduces normal germination.

Benlate Residue Retention on Banana Foliage Under Field Conditions During May and June

Ultra-low volume emulsion applications (4 oz Benlate in 0.5 gal oil + 0.5 gal water + 0.1% Agral 90/acre) were compared to ULV oil applications (4 oz Benlate in 1.0 gal oil + 0.1% Agral 90/acre) for Benlate residue retention on (or in) the foliage. Both application types were made with Bell G2A helicopters equipped with a boom and nozzle system (See section on Application Efficiency). Detection of residue on the foliage was accomplished by discharging ascospores on leaf samples taken from the field at various time intervals after spray application and recording germination rates. Twenty leaves were selected across a swath in each application area for sampling. The leaves selected for analysis were lower leaves which were horizontal in position and not obstructed from spray application by adjacent foliage. The experiment was repeated. Leaf samples from an unsprayed area were used as controls.

Under field conditions, no statistically significant differences in Benlate residue retention on the banana foliage could be detected when the emulsion and oil were compared (Tables 38 and 39). However, significant differences in the retention of Benlate residue were noted when rainfall and irrigation occurred which suggested the loss of chemical by erosion from the leaf

Table 37. Percent normal germination of Mycosphaerella fijiensis var. difformis ascospores on sprayed leaves subjected to various quantities of simulated rain.

Amount of simulated rain (in)	Mean rate of normal germination (%)						
	A[1]	B	C	D	E	F	G
0.0	0.0 b*	0.0 e	0.0 h	0.0 k	66.6 o	82.5 rst	89.3 xy
0.4	0.0 b	2.5 e	0.0 h	0.0 k	69.1 no	65.8 u	78.3 z
0.8	0.0 b	0.0 e	0.0 h	0.0 k	72.1 no	77.5 tu	80.5 yz
1.2	2.5 b	3.0 e	0.0 h	0.0 k	70.8 n	76.9 tu	79.0 z
1.5	5.1 b	5.1 e	0.0 h	0.0 k	77.3 n	79.5 stu	78.9 z
1.9	3.3 b	2.5 e	0.0 h	0.0 k	78.9 n	78.8 stu	74.5 z
Control BW[2]	91.8 a	91.8 d	91.8 g	91.8 j	91.8 m	91.8 r	91.8 x
Control AW[3]	89.6 a	89.6 d	89.6 g	89.6 j	89.6 m	89.6 rs	89.6 xz

[1] Formulations used in this experiment; see listing in text.

[2] Control (no spray applied) without simulated rain applied.

[3] Control (no spray applied) after a simulated rain application equal to 1.5 inches.

* Each statistic is the mean of eight samples taken in two tests; numbers followed by similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

Table 38. Spore germination of *Mycosphaerella fijiensis* var. *difformis* on banana leaves sprayed with Benlate in oil and emulsion.

	DAYS AFTER APPLICATION						
	0	3	5	7	9	11	
Carrier	Spore germination (%)						$\bar{x}$
Emulsion	7.5*(0.77)	13.5 (1.06)	17.8	30.9	46.8	38.5	25.83 a
Oil	7.3 (0.61)	9.5 (1.04)	20.2	40.6	53.6	49.1	30.05 a
$\bar{x}$**	7.4 c	11.5 c	19.0 bc	35.7 ab	50.2 a	44.2 a	

* Each statistic represents 40 samples (two tests).

** Means having identical letters are not significantly different at the 0.01 level as determined by Duncan's New Multiple Range Test.

( ) Average rainfall in inches occurring before day 3 and 5; irrigation occurred on day 5 (during first experiment; none during second experiment).

Table 39. Normal spore germination of *Mycosphaerella fijiensis* var. *difformis* on banana leaves sprayed with Benlate in oil and emulsion.

	DAYS AFTER APPLICATION						
	0	3	5	7	9	11	
Carrier	Normal spore germination (%)						$\bar{x}$
Emulsion	0.0*(0.77)	2.5 (1.06)	6.3	4.4	2.5	11.8	4.58 a
Oil	0.0 (0.61)	0.0 (1.04)	5.6	3.5	5.3	13.8	4.70 a
$\bar{x}$**	0.0 c	1.25 c	5.95 b	3.95 b	3.90 b	12.8 a	

* Each statistic represents 40 samples.

** Means having identical letters are not significantly different at the 0.05 level as determined by Duncan's New Multiple Range Test.

( ) Average rainfall in inches occurring before days 3 and 5; irrigation occurred after day 5 of first experiment (none during second experiment).

(Table 38). This erosion is undoubtedly the result of physical removal, dilution of active ingredient, and degradation. Total spore germination (abnormal and normal) increased an average 55 and 65% after average rainfalls of 0.69 and 1.05 in, respectively. Another 133% increase in total spore germination was observed after an irrigation cycle. The controls for this experiment had a germination rate of 85%. The percentages of normal spore germination were much lower than those of total spore germination (Tables 38 and 39). Increases in normal spore germination were not significant until an average of over 1.5 in of rainfall occurred. No significant increase in normal spore germination was observed between days 5 and 9, but significant increases occurred between days 9 and 11 (Table 39).

The amount of spore germination inhibition in this experiment was considerably lower than that noted in an earlier experiment (1975 Annual Report, p. 22) where approximately 30% inhibition after irrigation occurred over the same period of time. The amount of chemical used was the same but the use of Agral 90 was not indicated. This may account for the difference in Benlate retention. The data suggest that an emulsion spray is equal to an oil spray in terms of disease control if a 10-day cycle is maintained. However, if fungicide quantities in the mixture are reduced to less than 4 oz/gal/acre, normal spore germination rates may increase because significantly less fungicide reached the canopy in one of three emulsion application trials (page 49).

Stability of Benlate in Spray Formulations

Spray mixtures are prepared 12-24 hr in advance of application. Sometimes unfavorable weather conditions delay application of the mixes for one or more days. When such conditions exist, the mixes are retained until conditions are favorable for application. An experiment was designed to determine whether Benlate deteriorates significantly in oil, emulsion, and water over various time periods, and the quantity of Benlate to be incorporated into the original mixes to maintain active ingredient level.

Benlate stability was tested in oil, emulsion (50% oil + 50% water), and water. All tests contained sufficient Benlate to equal 4 oz per gal of carrier. The oil and emulsion formulations received 0.05 and 0.38% Agral 90, respectively, as is recommended for field use. All formulations were mixed in a Waring Blendor for 30 sec at approximately 6000 RPM to assure good suspension, and incubated at room temperature (72-80° F). One ml aliquots were removed from each original mix for bioassay tests at 0, 24, 48, 72, 96 and 120 hr after blending. The original mix was agitated sufficiently prior to each aliquot removal to ensure complete suspension of Benlate particles which adhere to the glassware during incubation. The 1 ml aliquots of the oil and emulsion formulations were diluted in 100 ml of oil. After vigorous agitation, 1 ml of diluted suspension was dissolved in 10 ml of ethyl acetate. A 0.1 ml sample of the resultant solution was spotted on filter paper discs (14 mm in diameter) and placed on *Penicillium expansum*-seeded PDA. The discs were dried before placement on the PDA with the aid of an Oster Air-jet Dryer. A 1 ml aliquot of the original Benlate in water suspension was diluted in 50 ml of water. One ml of the dilute solution was diluted in another 10 ml of water. Five-hundredths of an ml of the final dilution was spotted on the filter paper discs and placed on *P. expansum*-seeded PDA.

Benlate was not stable in any of the three carriers when incubated in a closed system, i.e. in a tightly capped bottle (Table 40). A significant decrease in active ingredient levels occurred within 24 hr in all the carriers tested. The rate of active ingredient loss in the formulations declined rapidly following the initial 24 hr incubation period (Table 40).

A significant increase in active ingredient levels was observed in the oil and emulsion formulations after 96 hr of incubation (Table 40). This increase in fungicidal activity may be the result of increases in Benlate degradation by products which are fungitoxic to the test organism, Penicillium expansum, or the result of a Benlate-oil-Agral 90 interaction to form another fungicide. All tests gave similar results under the closed system. However, similar increases in the water formulation were not statistically significant (Table 40). Oil alone and oil-Agral 90 mixtures did not show fungicidal activity under these test conditions.

Benlate stability in oil, emulsion, and water also was tested in an open system (incubation in glass containers without caps) which more closely approximates field conditions. The methods of dilution and spotting were the same as those described earlier in this report. Benlate was unstable in this system also (Table 41). However, the percent of active ingredient loss was not statistically significant until 72 hr after blending in the oil and emulsion formulations. The concentration of active ingredient in the water formulation actually increased during the first 48 hr of incubation. Since no such increase was noted in the closed system, it may be assumed that this increase in concentration was the result of water vapor loss (Tables 40 and 41). However, the level of active ingredient apparently decreases during incubation but is masked during the initial 48 hr of incubation by high rates of water evaporation.

After 120 hr of incubation, large increases in active ingredient were observed. This is similar to the observations on the experiment under the closed system (Tables 40 and 41). Apparently, the same process responsible for increased fungicidal activity after 120 hr of incubation in the closed system is also working in the open system. No tests have been conducted to determine if similar responses would occur in the presence of the black Sigatoka pathogen.

A third experiment was designed to determine the Benlate quantities which should be added to the original mix if it is not applied within 72 hr. Various amounts of Benlate were added to the original formulations after 72 hr of incubation and were blended in a Waring Blendor for 30 sec to achieve good suspensions. The addition of 10% more Benlate to the original suspension increased the active ingredient concentration to a point statistically equal to the active ingredient concentrations of the new blends without incubation (Table 42). Evidently, 10% more Benlate must be added in order to maintain original concentrations of Benlate active ingredient if the original mix is not applied within 72 hr.

Acetone and Ethyl Acetate As Solvents for Use in Bioassays of Benlate

Ethyl acetate is used as a solvent to remove Benlate from aluminum foil samples of Benlate spray collected in the field. Anticipating the need of using another solvent for laboratory safety and availability reasons, acetone was tested as a substitute solvent for ethyl acetate.

Table 40. Stability of Benlate in three carriers in a closed system.

Hours after blending	Mean zone of inhibition area (mm^2)					
	Carrier					
	Oil		Emulsion		Water	
0	1470.6 a*		1642.2 m		1161.4 v	
24	1232.6 bcd	(-35.7)	1406.4 no	(-31.4)	1035.4 wx	(-33.9)
48	1260.0 bc	(-31.6)	1314.8 o	(-41.9)	981.6 xy	(-48.4)
72	1154.4 cd	(-47.3)	1288.4 o	(-44.9)	909.8 z	(-65.0)
96	1130.0 d	(-55.8)	1106.6 p	(-64.7)	856.4 z	(-76.6)
120	1321.4 b	(-22.3)	1529.2 mn	(-16.9)	925.4 yz	(-61.6)

* Each statistic represents the average area of ten zones of inhibition in two tests; numbers having similar letters are not significantly different at the 0.01 level as determined using Duncan's Multiple Range Test.

( ) Percent of loss of active ingredient.

Table 41. Stability of Benlate in three carriers in an open system

Hours after blending	Mean zone of inhibition areas (mm^2)		
	Carrier		
	Oil	Emulsion	Water
0	1291.0 b*	1327.5 mn	800.4 y
24	1260.0 b (- 6.4)	1257.8 n (-13.3)	846.2 y (+34.1)
48	1217.0 b (-15.2)	1308.8 n (- 3.6)	1047.8 w (+355.4)
72	1075.8 c (-41.7)	951.8 o (-68.1)	785.2 yz (- 8.3)
96	1041.4 c (-48.8)	962.4 o (-67.3)	726.8 z (-16.6)
120	1471.0 a (+36.9)	1360.2 m (+ 6.2)	935.2 x (+165.7)

* Each statistic represents the average of ten samples from two tests; numbers having similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

( ) Percent increase or decrease in the concentration of active ingredient.

Table 42. Addition of Benlate to formulations after 72 hours of incubation

Amount of Benlate added to original blend (%)	Mean zone of inhibition areas (mm^2)	
	Formulations	
	Oil	Emulsion
0	1412.0 c*	1290.0 z
10	1627.4 b	1406.2 yz
20	1619.2 b	1446.4 xy
30	1626.0 b	1562.6 wx
40	1669.0 ab	1633.4 w
50	1757.8 a	1765.0 v
New blend**	1619.0 b	1493.6 xy

* Each statistic represents ten replicates from two tests; numbers having similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

** This blend was identical to the original blend without incubation.

Solutions of 0, 1, 5, 7.5, 10, 20, 25, 40, 50, 75 and 100 ppm a.i. of Benlate were prepared using 10 ml of ethyl acetate and acetone as solvents. A 0.1 ml aliquot of the solution was spotted on a paper filter disc (14 mm in diameter) and evaporated to dryness using an Oster Air-jet Dryer. The treated paper filter discs were placed in Petri dishes on Potato-dextrose agar (40 gm per lt) seeded with the conidiospores of Penicillium expansum. The quantity of PDA dispensed into each Petri dish (20 ml/plate) was kept constant to eliminate the possible influence of dilution. The samples were incubated at room temperature for 48 hr. Each treatment was replicated three times and the experiment was repeated.

All the Benlate at all concentrations dissolved readily in both solvents. In addition, the inhibition zones were almost equal and provided similar standard curves (Figure 19). These standard curves were very similar to the standard curve previously obtained with ethyl acetate as the solvent (1975 Annual Report, p. 24). Acetone may be substituted for ethyl acetate as a solvent in future bioassay tests.

A New Bioassay Method for Detecting Benlate on Foliage

The method previously used in detecting Benlate distribution throughout the banana canopy included the attachment of aluminum foil at various sampling sites on the leaves and a subsequent bioassay of the Benlate rinsed from the foil using filter paper discs and Penicillium expansum-seeded PDA. The disadvantages were time-consuming experimental site preparation (2 hr per site) and the limited quantity of samples which could be processed after an experiment within a reasonable time period. As a result, a new method was sought which would permit the bioassay of larger quantities of samples. Earlier experiments with bioassays of sprayed leaf discs (14 mm in diameter) using Penicillium expansum-seeded PDA were unsuccessful because of contamination from the leaf discs (1975 Annual Report, p. 18). Aspergillus terreus (provided by Dr. R. H. Fulton of Rohm and Haas) was tested in a leaf disc bioassay for Benlate sensitivity in a salt-PDA medium.

Various concentrations of Benlate in 0.5 gal oil + 0.5 gal water + 0.38% Agral 90 (added as percent of oil) were applied to unsprayed leaf areas (9 x 9 in). The various formulations were initially mixed in the laboratory in a slow-speed blender (2700 RPM) for 2 min before being taken to the field for application. All mixes were vigorously agitated just prior to application to ensure good Benlate suspension and distribution in the carrier. The sprays were applied with a Paasche air-brush in an amount equivalent to that expected from an aircraft application of 1 gal per acre. A spray tower with the air-brush nozzle attached to a lid was used to achieve an even distribution of spray on the leaf sample areas. Sprayed leaf areas were left on the plant for 4 hr before removal for processing. Thirty leaf discs (14 mm in diameter) were removed from each sprayed sample area and placed sprayed-surface down on a salt-agar medium seeded with the conidiospores of Aspergillus terreus in petri dishes (2 discs per plate). The medium contained 40 g of Potato-dextrose agar and 5 g of NaCl per liter of distilled water. Zones of inhibition were recorded after 48 hr of incubation at room temperature. Each treatment had three replicates and the experiment was repeated.

STANDARD CURVE BENLATE VS. PENICILLIUM EXPANSUM.

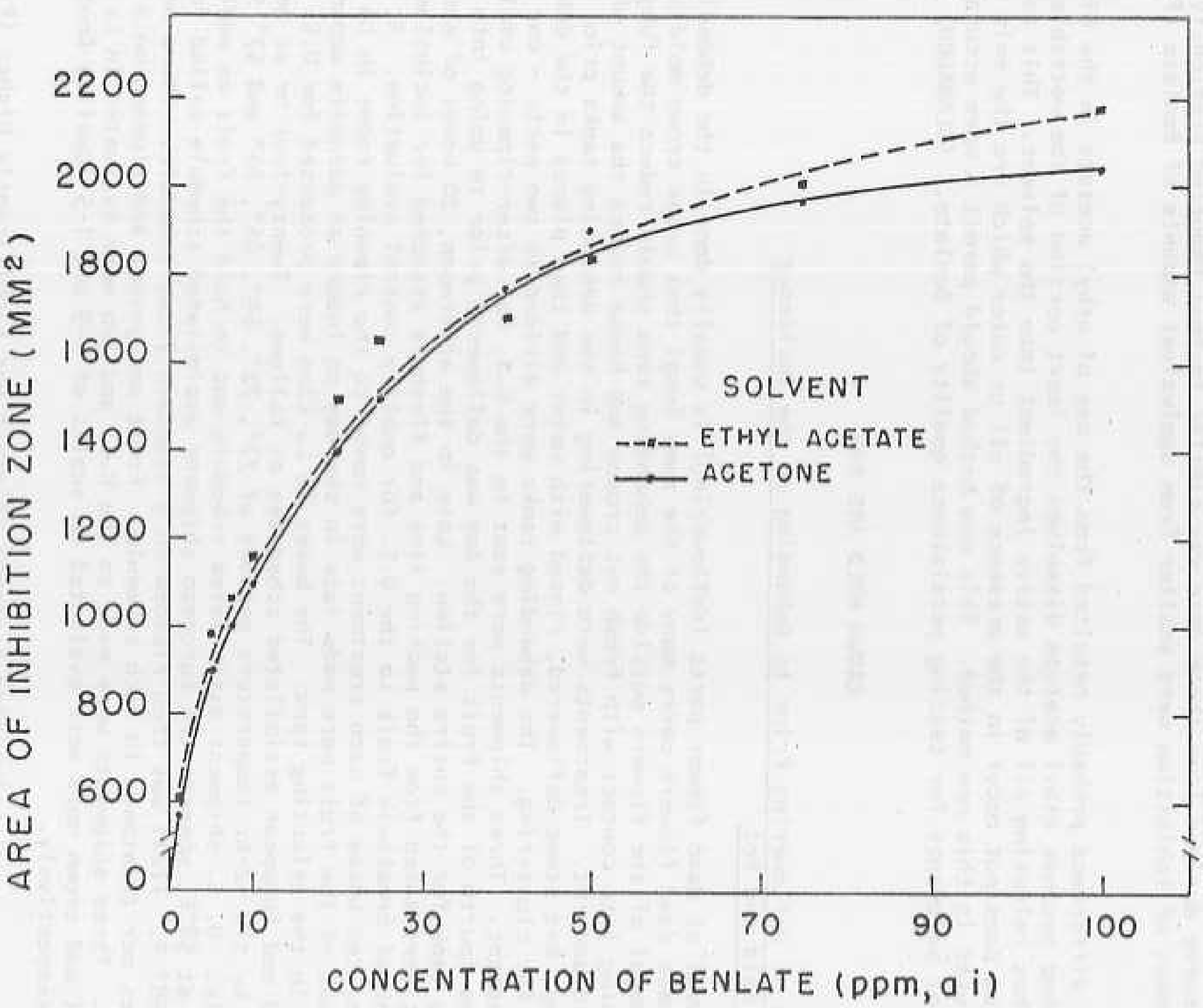


Figure 19. The effect of Benlate against *Penicillium expansum* in a bioassay test.

Concentrations of Benlate equaling less than 0.25 oz a.i. per acre could not be detected using this method of bioassay (Table 43). All other concentrations of Benlate (0.25-5.0 oz a.i./acre) applied to the leaf samples provided zones of inhibition with significant differences between treatments. Variability within each treatment was low as indicated by the coefficient of variability (Table 43). No contamination problem was encountered using this method of bioassay. The standard curve derived from these data was similar to that reported previously, but the zones of inhibition were smaller from equivalent amounts of Benlate (Figure 20).

This difference probably resulted from the use of ethyl acetate in the bioassay method because ethyl acetate dissolves the inert portion of the wettable powder, thus releasing all of the active ingredient into the solvent. This total release does not occur in the presence of oil or water which are the only solvents used in this new method. This new method should permit a more accurate analysis of adjuvants for testing persistence quality of Benlate. (SLABAUGH)

CROWN MOLD AND ROT

Influence of Deflowering Prior to Dehanding on the Incidence of Crown Mold and Rot

Removal of dead flower parts (deflowering) is usually done in the dehanding tank. These dead flowers carry many of the same fungi that cause crown mold and rot. Removal of the flowers outside the dehanding tank should reduce the fungus flora coming into contact with fresh cut crowns and hence reduce the amount of crown mold and rot. Treatments were deflowering in the dehanding tanks prior to clustering, and stems deflowered, rinsed with water and then placed in the dehanding tank for clustering. The dehanding tanks were divided in two parts - one for each treatment. Three shipments were sent to the U.S. for after-ripening evaluation. One fourth of the fruit for the day was deflowered prior to going into the selecting tank for the entire station. Late in the afternoon, 20 boxes of each treatment were taken from the packing line and flashers attached for inclusion in a shipment of breakbulk fruit to the U.S. for quality control evaluation. At the same time, ten boxes of each treatment were moved to the ripening rooms in La Lima. Collections of the fruit were made late in the day to insure an adequate amount of inoculum in the selecting tank. The boxes in La Lima were processed for U.S. assimilated and European assimilated schedules as follows: Twenty-four hr at ambient followed by six 12-hr temperature periods of 77°, 72°, 69°, 66°, 64° and 57° F, respectively. U. S. shipment assimilated schedule was to hold the fruit an additional ten days at 58°F, whereas the European shipment assimilated schedule called for 21 days at 58° F. Fruit was then ripened on a standard 7-day schedule. There were five boxes per treatment in each schedule. Fruit was gassed and ripened on a 7-day schedule. Three shipments were made to the U.S. and two were evaluated in La Lima. Crown rot and crown mold were evaluated on scales of 1-9 and 1-5 (Quality Control scale), respectively.

Crown rot in the simulated European shipment was significantly higher (P = .01) in the deflowering in the dehanding tank treatment (Table 44). For the U.S. simulated shipment, no difference in crown rot was noted. Crown mold in both treatments was an average of medium severity. Crown rot was more severe in the European simulated shipment than in the U.S. simulated shipment with the pre-dehanding deflowering significantly lower than the standard treatment of deflowering in the dehanding tank.

Table 43. Zones of inhibition produced by various Benlate concentrations sprayed on leaves.

Amount of Benlate applied (g x 10-6)[1]	Areas of fungal inhibition zones (mm^2)						
	1	2	3	4	5	$\bar{x}$	cv
0.00[3]	154[2]	154	154	154	154	154.0 k	0.0
0.18 (0.1)	154	154	154	154	154	154.0 k	0.0
0.35 (0.2)	154	154	154	154	154	154.0 k	0.0
0.53 (0.3)	154	154	154	154	154	154.0 k	0.0
0.88 (0.5)	172	190	194	193	188	187.4 jk	4.7
1.23 (0.7)	252	240	229	236	228	237.0 i	4.1
1.76 (1.0)	293	308	323	304	284	302.4 h	4.9
2.64 (1.5)	396	397	423	406	411	406.6 g	2.7
3.53 (2.0)	505	469	491	533	550	509.6 f	6.4
4.41 (2.5)	566	570	580	557	574	569.4 e	1.5
5.29 (3.0)	633	642	631	644	643	638.6 d	1.0
7.05 (4.0)	730	756	785	766	758	759.0 c	2.6
10.58 (6.0)	866	858	787	806	814	826.2 b	4.1
17.63 (10.0)	946	985	925	949	979	956.8 a	2.6

[1] Quantity of Benlate applied to each leaf disc (14 mm in diameter); numbers in brackets equal ounces of Benlate per acre.

[2] Each statistic is the mean of 18 samples; numbers followed by similar letters are not significantly different at the 0.01 level using Duncan's Multiple Range Test.

[3] Control; includes samples receiving no spray and spray without Benlate.

Figure 20. Standard curve for zones of fungal inhibition produced by various amounts of Benlate on leaf discs (14 mm in diameter).

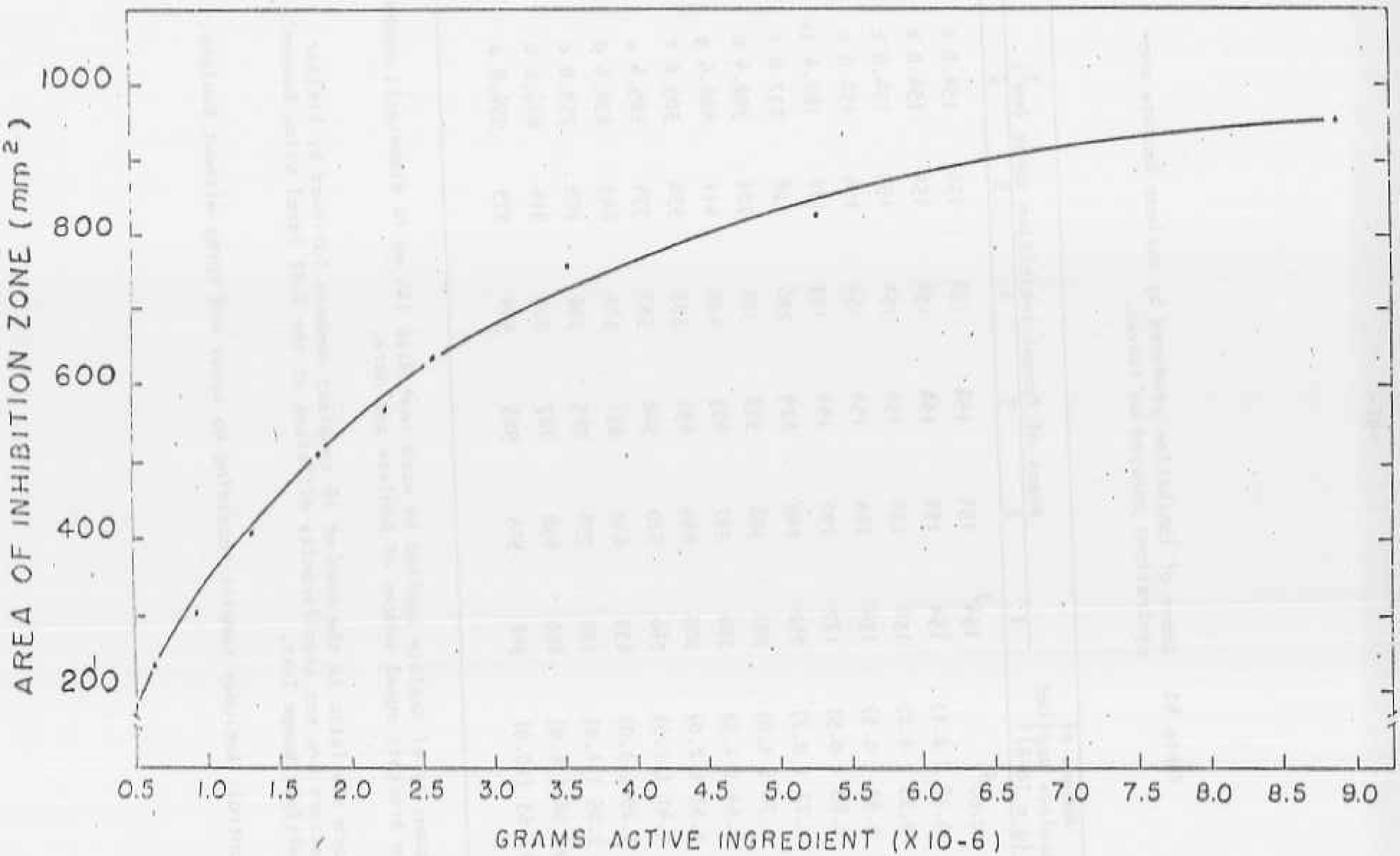


Table 44. Crown rot and crown mold determinations for European and U.S. simulated shipments of deflowered before dehanding and deflowered in the dehanding tank.

	Crown rot		Crown mold	
Treatment	European	U.S.	European	U.S.
Deflower-dehand	6.01	3.70	4.91	3.70
Dehand-deflower	7.05	3.84	4.86	3.84
F Test				
Treatments	13.68**	0.78 NS	0.85 NS	0.03 NS
Blocks	3.40*	0.84 NS	0.79 NS	0.70 NS

F Test = Level of significance

* 5%
** 1%

The three shipments to the U.S. had crown rot readings of 0.0, 2.0 and 0.0 for pre-dehanding deflowering compared to 0.0, 0.0 and 0.0 for deflowering in the selecting tank. Crown mold for the same shipments was reported as 4.2, 74 and 6% of the clusters for deflowering prior to dehanding, and 0.4, 76 and 7% for deflowering in the selecting tank. No conclusions can be drawn from these data because of the great variability among shipments. There is no indication that deflowering prior to dehanding consistently reduces crown mold and rot.

Screening of Chemical for Crown Rot and Crown Mold Control

Benlate and TBZ (Mertect) are recommended for control of crown rot and crown mold. Chemicals that were tested at 200 and 400 ppm a.i. and compared to Benlate and TBZ were Mycoban, Vanodine, Proprionic Acid, Agrimycin 100 and Gibberellic Acid; the latter was combined with Benlate. Fruit was processed through the packing station up to the point where the standard post-harvest spray was applied. The test chemicals were then applied by spraying the crown in three passes to run-off using Carpi knapsack sprayer equipped with 8001 SS nozzle. All chemical solutions and the water control were prepared in a 1% alum solution. Each treatment was five boxes with 12 clusters per box. Treatments were made on three different dates with all chemicals included for each date. The fruit treated at the 200 ppm rate was held under conditions to assimilate a U.S. breakbulk shipment, whereas the 400 ppm rate was held to assimilate a European shipment. The standard schedule which was devised from actual ship measurements is as follows: Twenty-four hr at ambient followed by six 12-hour temperature periods of 77°, 72°, 69°, 66°, 64° and 57° F, respectively. U.S. shipment assimilated schedule was to hold the fruit an additional ten days at 58° F, whereas the European shipment assimilated schedule called for 21 days at 58° F. Fruit was then ripened on a standard 7-day schedule. Fruit held on the assimilated European shipment schedule resulted in ripe and turning in the boxes so this schedule will have to be modified. After ripening readings of crown rot (scale 1-9) and crown mold (scale 1-5) were read as per Quality Control systems.

None of the chemicals were superior or equal to Benlate and TBZ for crown rot and crown mold control (Table 45). There was no advantage of adding Gibberellic Acid to Benlate solutions. There was no apparent difference in the incidence in crown rot or crown mold between the U.S. and European assimilated schedules.

Evaluation of Crown Rot-Crown Mold Isolates for Tolerance to Benzimidazole Fungicides

Benlate, which is used as a post-harvest fungicide for control of crown rot and crown mold, is currently being used for control of black Sigatoka and Sigatoka. Historically, tolerance to this fungicide has been reported through repeated field use. Therefore, isolates from crown rot and crown mold were evaluated for tolerance to Benlate and Mertect (TBZ), both benzimidazole fungicides.

Four collections of fruit were made from randomly selected boxing stations for isolation of crown rot and crown mold fungi in Honduras. Ten boxes of fruit from each packing station were collected at a sampling and the boxes held ambient one day, 58° F for 14 days and ripened on a four-day schedule. Crown rot clusters which had a 4+ reading on a 1 to 9 scale were selected for isolations. Two

Table 45. Effect of various chemicals at 200 and 400 ppm on crown rot (CR) and crown mold (CM) control.

	Concentration ppm a.i.			
	200[3]		400	
Treatment	CR	CM	CR	CM
Alum 1% Control	4.73 x	4.41 v	4.51 x	4.28 x
Mycoban	3.74 y	4.13 vw	3.37 y	3.38 yz
Proprionic acid	3.74 y	3.96 vw	3.64 y	3.75 y
Agrimycin 100	3.75 y	3.88 wx	3.73 y	3.56 y
Vanodine	3.54 y	3.83 wx	3.52 y	3.72 y
Benlate + 5 ppm G.A.[1]	2.78 z	3.56 yz	2.82 y	3.03 z
Benlate	2.67 z	3.26 yz	2.69 z	2.95 z
Tecto	2.56 z	3.00 z	2.58 z	2.95 z
Benlate + 10 ppm G.A.[2]	2.67 z	2.81 z	2.56 z	2.86 z

[1] + 5 ppm Gibberellic Acid A_4/A_7

[2] + 10 ppm Gibberellic Acid A_4/A_7

[3] Means followed by the same letter are not significantly different at the 1% level as determined by Duncan's Multiple Range Test.

isolations per crown were made by cutting out tissue at the advanced edge of the rot from two locations and plating the pieces on acidified PDA. Crown mold isolates were made of mycelium on the same crown and plated on acidified PDA. Transfers from resulting fungal colonies were based upon growth characteristics of the fungus. The transfers were grown on PDA in test tubes. Also, isolates were made from 20 boxes of ripened fruit in Charleston, S. C., and one week later the isolates were brought back to Honduras.

A listing of the fungal isolations from Honduras and Charleston are presented in Table 46. Fourteen genera of fungi were isolated plus bacteria and yeast. The genus Fusarium was most common and isolates were keyed to species of which six were identified. Acremonium strictum was also identified to species.

A disc bioassay technique was used to screen the isolates at 100, 200, 500, and 1000 ppm a.i. of Benlate and TBZ. This technique involves three steps: 1) 0.1 ml of fungicide solution is spotted on 12.7 mm filter paper discs and allowed to air dry; 2) 1 ml of fungus spore suspensions is pipetted into the bottom of a petri dish and 10 ml of tempered PDA pipetted on top of this - the solution is swirled to give a uniform mix; 3) after the PDA has set, the four filter paper discs, one of each concentration, are placed fungicide-side up on the media. Plates were incubated at room temperature and read after growth of the fungi had occurred, generally in two days.

No difference in response between the Honduras and Charleston isolates were noted so the findings are combined. Table 47 is a summary of the findings. Data are reported as percent of the isolates showing tolerance. Of the isolates listed in the table, F. semitectum and A. strictum are considered the most aggressive crown rotting organisms. A. strictum was about 50% tolerant at the 100 ppm level of both Benlate and TBZ and 25% tolerant at the 1000 ppm level of both fungicides. For F. semitectum, the relationships were 25% at 100 ppm and 15% at 1000 ppm. In the case of F. semitectum some isolates were tolerant to TBZ at various or all levels and not tolerant to Benlate as well as the reverse. The indication is that tolerance is present. This condition should be monitored and other postharvest fungicides tested. (DARLINGTON)

PEEL ROT OR ANTHRACNOSE - CHANGUINOLA

Anthracnose, called peel rot by Quality Control, is often a seasonal problem in Changuinola. The fungus (Colletotrichum musae) grows in transit and during ripening on any wounded tissue. An outbreak was studied in October-November.

Observations on Certain Types of Fruit Blemishes in Regard to Peel Rot (Anthracnose) Development During Storage in Changuinola

Green fingers from fruit held 21 days at 58° F were randomly selected for the following defects: point scarring (PS), scarring between fingers (SBF), pitting disease (JS), anthracnose lesion on finger (AF), anthracnose on tip (AT), and neck injury (NI). Blemishes were marked and fingers placed in a humidity chamber at laboratory room temperatures. After an incubation period, readings were taken on the development of Colletotrichum sporulation (Table 48).

Table 46. The number of isolates (from Charleston, S.C. and La Lima, Honduras) isolated from the crowns of bananas with a 4+ crown rot rating on a scale 1-9.

	CHARLESTON	LA LIMA
Acremonium strictum	17	24
Fusarium semitectum	80	230
F. moniliforme	17	5
F. solani	6	2
F. episphaeria	1	3
F. "nivale" (type)	5	0
F. oxysporum	5	0
Curvularia	11	67
Alternaria	1	25
Cladosporium	2	50
Verticillium	5	1
Penicillium	18	11
Nigrospora	3	23
Mucor	0	38
No spore (unknown)	4 a	17 a
Other	61 ab	8 ab

a - Isolates were not tolerance tested.

b - Other included bacteria, yeast and fungi mixed.

Table 47. Percent of fungal isolates showing various levels of tolerance to Benlate (B) and TBZ (T).

Identification	Number of isolates		Concentration of fungicide in ppm a.i. 100	200	500	1000
Acremonium strictum	(41)	B	48.8	43.9	29.3	22.0
		T	48.8	36.6	31.7	29.3
Fusarium semitectum	(310)	B	29.4	22.9	16.8	13.9
		T	24.2	19.0	15.8	13.9
F. moniliforme	(22)	B	27.3	18.2	9.1	9.1
		T	27.3	22.7	4.6	4.6
F. solani	(8)	B	25.0	12.5	12.5	12.5
		T	50.0	37.5	12.5	0.0
F. episphaeria	(4)	B	0.0	0.0	0.0	0.0
		T	25.0	25.0	0.0	0.0
F. nivale	(5)	B	20.0	20.0	20.0	20.0
		T	20.0	20.0	20.0	20.0
F. oxysporum	(5)	B	0.0	0.0	0.0	0.0
		T	20.0	0.0	0.0	0.0
Curvularia	(78)	B	64.1	60.0	51.3	41.0
		T	62.8	60.3	48.7	46.2
Alternaria	(26)	B	57.7	57.7	53.9	50.0
		T	57.7	50.0	50.0	50.0
Cladosporium	(52)	B	73.1	71.2	69.2	69.2
		T	82.7	75.0	71.2	71.2
Verticillium	(6)	B	16.7	16.7	0.0	0.0
		T	33.3	33.3	0.0	0.0
Penicillium	(29)	B	75.9	75.9	72.4	72.4
		T	75.9	75.9	72.4	72.4
Nigrospora	(26)	B	46.2	46.2	46.2	42.3
		T	50.0	50.0	50.0	46.2
Mucor	(38)	B	89.5	81.6	71.1	60.5
		T	92.1	84.2	73.7	63.2

Table 48. Appearance of Colletotrichum musae sporulation in fingers with blemishes of anthracnose (peel rot) on finger (AF), anthracnose on tips (AT), neck injury (NI), pitting disease (JS), scarring between fingers (SBF) and point scarring (PS).

Number of fingers with	Blemish					
	1 AF	2 AT	3 NI	4 JS	5 SBF	6 PS
Colletotrichum	8	6[1]	4	4	3	2
Clean	0	3	6	5	14	8
Total number of fingers	8	14	10	9	17	10

[1] Five other fingers had Botryodiplodia sporulation which would have masked Colletotrichum.

Anthracnose lesions that developed in cold storage sporulated. Care must be taken at the time of boxing that any scarred fingers be removed. Neck injury is also a possible site of development of the anthracnose pathogen. Peel rot which can develop in damaged tissue caused by scarring can be controlled by drenching fruit with 400 ppm Mertect. Mist-type spray booths used at some boxing stations left dry fingers which are possible sites of infection.

The Evaluation of Post-Harvest Fungicide Treatment for Control of Peel Rot on Stems Being Rejected

Ten stems which had been rejected at the boxing station were studied. The hands were removed and obvious defects discarded. Scarring from rough handling was common but not removed as a defect. The hands were split in half and notes taken on each cluster. One-half of the hand was dipped in 400 ppm a.i. Mertect plus 1% alum and the other half dipped in tap water plus 1% alum. Fruit was held 36 hr ambient, moved to ripening room at 58° F and held for 10 days. Fruit was gassed and evaluated four days later at color grade 6.

Clusters were evaluated for peel rot, crown rot and neck rot using a 1-5 disease indexing system. Results from this experiment are represented in Table 49. Analysis of these data using t test comparison of means indicates that 400 ppm Mertect, if applied to cover the entire finger or clusters will control peel rot, crown rot and neck rot. This study supports the recommendation to raise the treatment level to 400 ppm Mertect applied as a dip or drench.

Evaluation of Concentrations of Mertect for Control of Peel Rot

Boxes of fruit were randomly selected on three different dates when the concentration of Mertect (Thiabendazole) being used was 125, 200 and 400 ppm. Five boxes from Farm 15 were included for each treatment date. Boxes had been processed through the normal spray booth and were held at ambient temperature. Evaluations for peel rot, crown rot and crown mold on a 1-5 severity scale were made when the first cluster began to turn. The mean rating per box was used as a replicate. Results of this experiment are presented in Table 50. The 400 ppm Mertect is superior to 200 and 125 ppm rates for the control of crown rot and crown mold. The 400 ppm rate was superior to the 125 ppm rate but not the 200 ppm rate. Therefore, due to the combined levels of control of the three post-harvest problems, it is recommended that 400 ppm Mertect be used on a commercial basis throughout the year for shipments to Europe. (DARLINGTON)

FRUIT SPOTS - HONDURAS

Comparison of the Incidence of Fruit Spot on Honduras Container and Breakbulk Fruit

Quality control reports for fruit spot after ripening in the U.S.A. show a higher incidence in fruit shipped by container compared to non-container. The relationship is graphically illustrated in Figures 21 and 22 and summarized in Table 51. As most spotted fingers are rejected at the boxing station, spotting results from latent infections which develop in transit.

Table 49. Evaluation of 400 ppm dip treatment for peel rot (PR), crown rot (CR) and neck rot (NR).

Defect	Treatment		
	400 ppm Mertect	Water	t value
PR	1.05	3.50	15.51**
CR	1.10	3.30	12.63**
NR	1.00	2.02	8.80**

** Values are significantly different at the 1% level of probability.

Table 50. The effect of increasing post-harvest fungicide treatment on the incidence of peel rot (PR), crown rot (CR) and crown mold (CM) on fruit collected at Farm 15 in Changuinola.

Concentration ppm a.i. Mertect	Evaluation [1]		
	PR	CR	CM
125	3.88 a	2.67 x	2.65 x
200	2.73 ab	2.72 x	2.85 x
400	1.55 b	1.00 y	1.16 y

[1] Means listed are for five boxes, means followed by the same letter are not significantly different at the 5% (a,b) or 1% (x,y) level of probability as determined by Duncan's Multiple Range Test.

Figure 21

FRUIT SPOT 1975 U.S. Q.C. WEEKLY REPORT AFTER RIPENING.

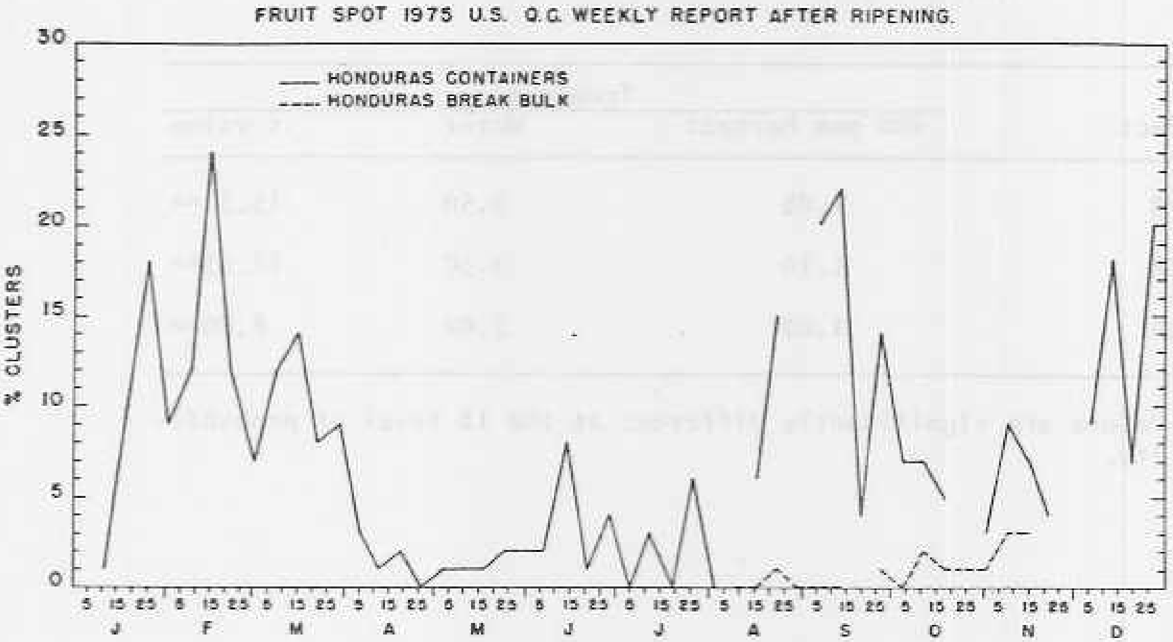


Figure 22

FRUIT SPOT 1976 U.S. Q.C. WEEKLY REPORT AFTER RIPENING.

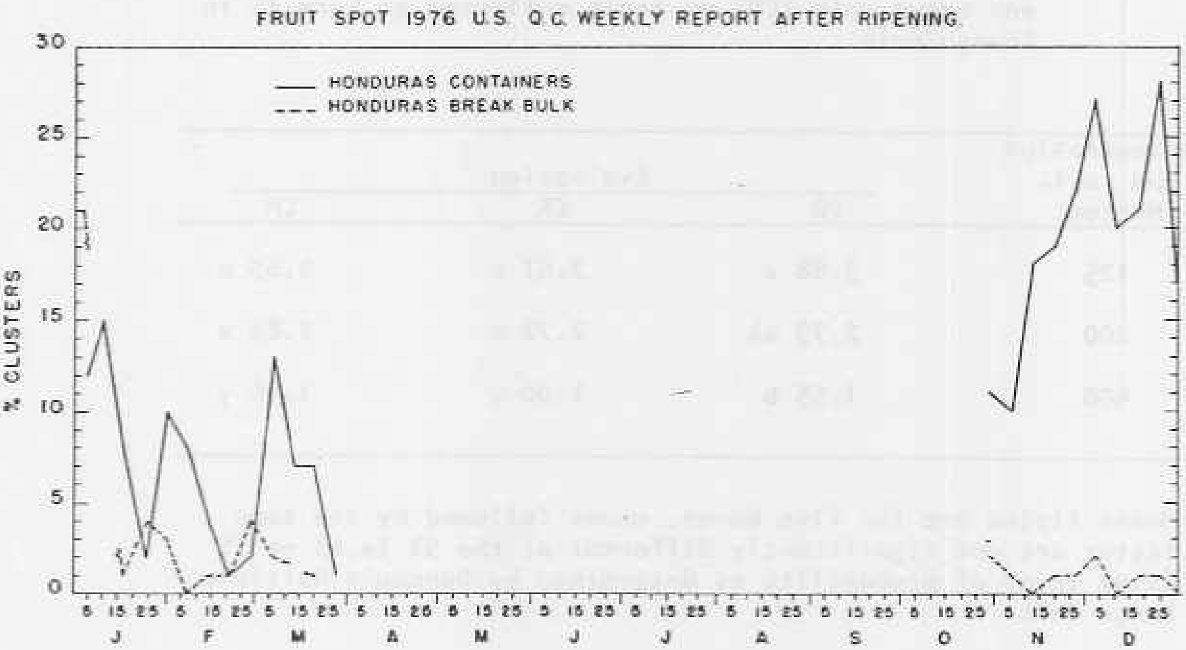


Table 51. Summary of percent clusters showing fruit spot in 1975 and 1976 for containers (C) and breakbulk (BB) fruit.

	# of report		Mean % clusters		Range % clusters			
	C	BB	C	BB	C	BB	C	BB
1975	45	14	7.3	0.9	0-24	0-3	6.49	1.07
1976	23	20	12.2	4.6	1-28	0-21	8.05	4.55

To simulate handling of breakbulk fruit, boxes were held 24 hr at ambient temperature followed by six 12 hr temperature periods of 77°, 72°, 69°, 66°, 64° and 57° F, respectively. U.S. shipment assimilated schedule was to hold the fruit an additional ten days at 58° F, whereas the European shipment assimilated schedule called for 21 days at 58° F. Fruit was then ripened on a standard 7-day schedule. The fruit simulating container conditions was moved to 58° F directly from the packing station. Clusters of fruit were selected on the basis of having at least one spot. Fruit was 12 weeks old with caliper grade 14-18. Treatments consisted of ten boxes with 14 clusters per box. Green fruit was evaluated at 7, 11, 15 and 21 days for the number of new spots. No new spots appeared by the 11th day. By the fifteenth day, the majority of the new spots had developed with no great increase on the 21st day. In the total of both treatments, there were only 38 clusters out of 280 clusters (13.6%) on which new spots developed. This would represent loss of a single quality point due to spotting (13.6 x 0.08 = 1.0 points off). Due to the low incidence of new spotting, no conclusions can be drawn from the experiment. There was no difference between the treatments under the conditions of this experiment.

Effect of Fruit Age on Pitting Disease Development

Banana fingers aged 2 to 14 weeks were inoculated with a spore suspension of *Pyricularia grisea* of 22 x 10^3 spores/ml and placed in a humidity chamber. Fingers were evaluated 18 days later. As indicated in Table 52 and Figure 23, 12- and 14-week old fruit (caliper grade 14-18) had significantly more spots than other fruit. The youngest, or 2-week old fruit, had a higher mean number of spots than the 4- to 10-week old fruit, but this difference was not statistically significant. These data indicate that 12- to 14-week old fruit would be the most likely to have the latent infection phase of *P. grisea*.

Incidence of Fruit Spot in an Unsprayed Area

In Indiana Farm, Honduras, during July and August, Sections 25 (VALERY) and 14 (Grand Nain) were not sprayed for fruit spot. Sections 22 (VALERY) and 9 (Grand Nain) were sprayed for fruit spot using the normal farm practice of a single spray of Dithane at 19.2 g a.i./lt when all hands were exposed. Other practices included deleafing to the average of 9 leaves at shooting, weed control by machete chopping, and an average of 10 (range 9-12 for seven cycles) day spray cycles for Sigatoka using 4 oz of Benlate per acre. Two of the sprays were emulsions and five were in oil.

Starting September 27, weekly evaluation of fruit spots was made for a total of eleven evaluations. Data were collected from 25 stems from each section at each reading. Data included the total number of pitting disease spots, diamond spots, brown spots, infected hands and total number of hands. For the last three weeks, weight loss data were collected by removing the fingers infected with either pitting or diamond spot. Weight loss was determined by weighing the stem, weighing the peduncle and dividing the weight of the discarded fingers by the weight of the total hands, and converting to percent.

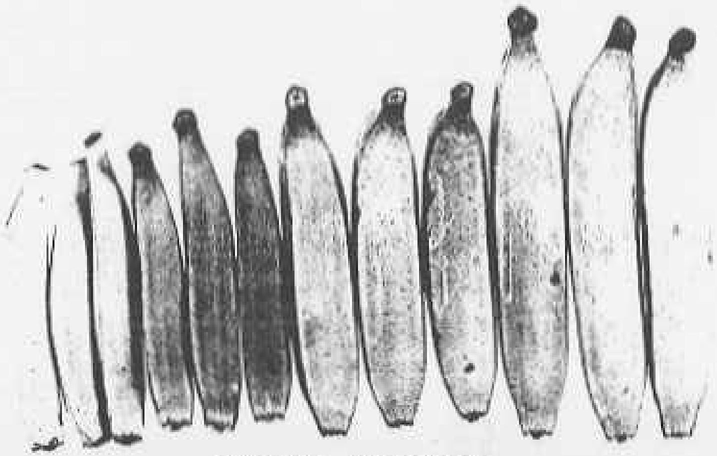
The incidence of pitting disease, diamond spot, and brown spot was higher in the unsprayed plots for both varieties with means significantly different at the 1% level (Table 53). The indication is that even with short cycles of

Table 52. Mean number of spots per finger of 10 replications of fruit aged 2-14 weeks inoculated with 22 x 10^3 spores per ml of *Pyricularia grisea*.

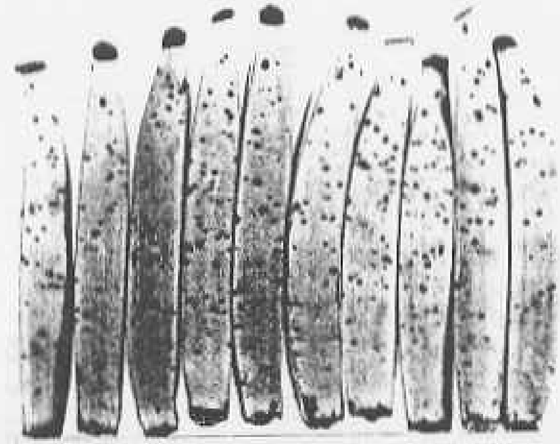
Age of fruit in weeks	Mean number of spots per finger
14	167.6 x*
12	126.0 x
10	18.0 z
8	14.9 z
6	12.3 z
4	5.9 z
2	40.4 z

* Means followed by the same letter are not significantly different at the 1% level of probability as determined by Duncan's Multiple Range Test.

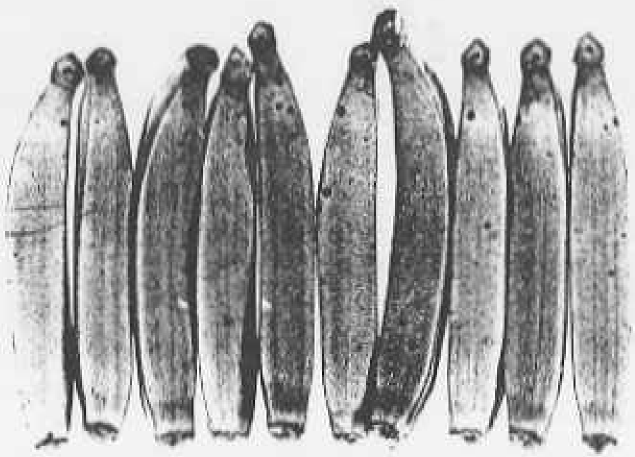
Figure 23



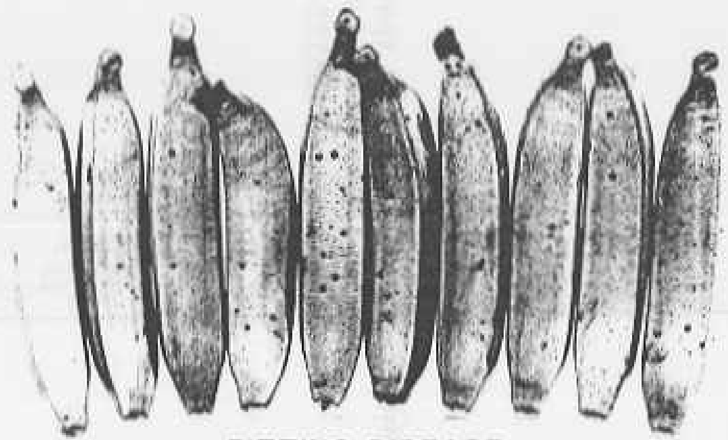
PITTING DISEASE
ARTIFICIAL INOCULATION
CONTROL



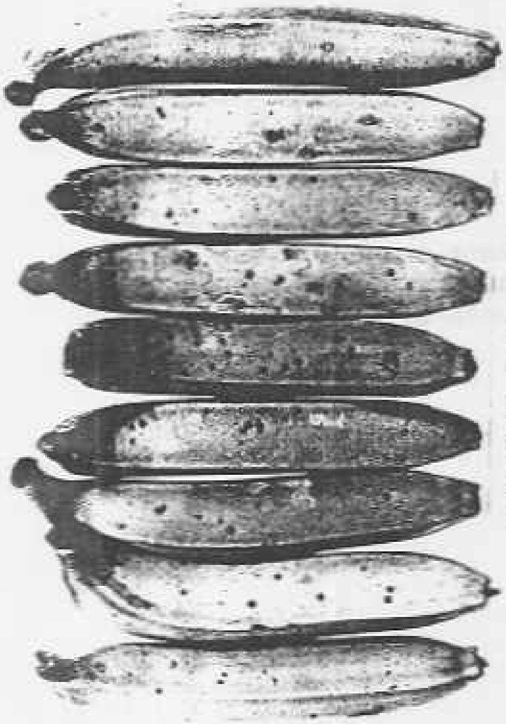
PITTING DISEASE
ARTIFICIAL INOCULATION
2 WEEKS OLD



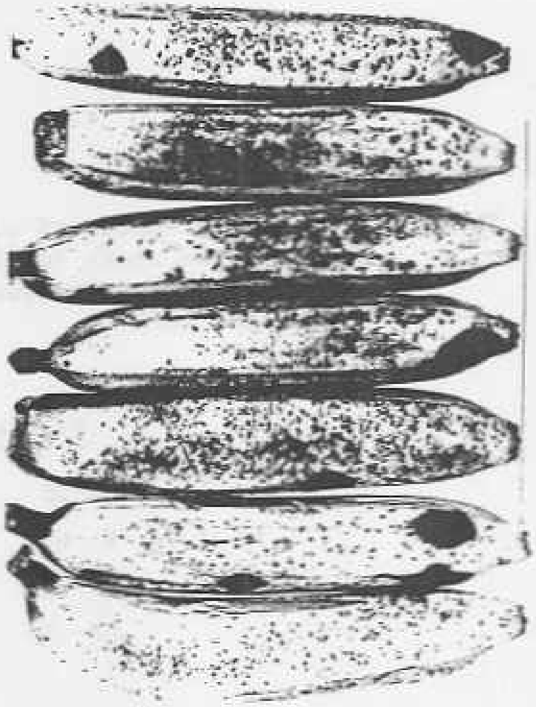
PITTING DISEASE
ARTIFICIAL INOCULATION
4 WEEKS OLD



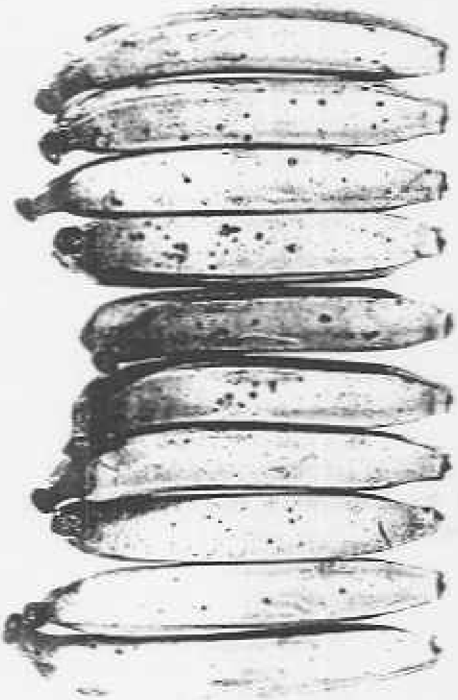
PITTING DISEASE
ARTIFICIAL INOCULATION
6 WEEKS OLD



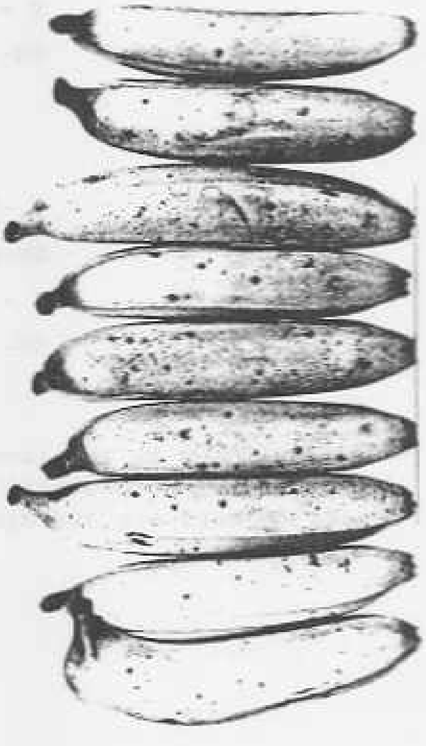
PITTING DISEASE
ARTIFICIAL INOCULATION
10 WEEKS OLD



PITTING DISEASE
ARTIFICIAL INOCULATION
14 WEEKS OLD



PITTING DISEASE
ARTIFICIAL INOCULATION
8 WEEKS OLD



PITTING DISEASE
ARTIFICIAL INOCULATION
12 WEEKS OLD

Table 53. The mean number of pitting disease spots, diamond spots, and brown spots for 25 stems each of VALERY (V) and Grand Nain (GN) for sprayed (S) and unsprayed (US) sections of Indiana Farm.

Pitting Disease

GN-US	19.1	x*
V -US	16.0	xy
V - S	5.82	yz
GN- S	4.27	z

Diamond Spot

GN-US	17.1	y*
V -US	16.7	y
V - S	7.8	z
GN- S	4.2	z

Brown Spot

V -US	180.1	y*
GN-US	166.6	y
V - S	40.2	z
GN- S	16.4	z

* Mean followed by the same letter are not significantly different at the 1% level of probability as determined by Duncan's Multiple Range Test; numbers are average of 11 replicates.

Benlate for Sigatoka control, it will be necessary to spray for fruit spot part of the year. When comparing the percent fruit spotting on hands, VALERY and Grand Nain showed no mean difference for the unsprayed treatments (Table 54). For the sprayed treatments, the percent hands with spotting was significantly different for the mean comparisons of Grand Nain and VALERY. This could be due to a varietal effect or better spray coverage of the shorter Grand Nain. This should be further investigated. The percent of fruit selected out (for pitting and diamond spot) was decreased by spraying (Table 55). Though these levels of fruit spot are low, 1976 was not a severe fruit spot year, particularly during the period when data were being collected. Therefore, the lack of high losses in non-sprayed fruit should not be taken as a guide to the elimination of fruit spot spraying. Also, the development of fruit spot on non-sprayed fruit should be evaluated after simulating a container shipment since there is always more fruit spot development in containers than in breakbulk fruit. (DICKSON, DARLINGTON)

VIRUS DISEASES

Comparison of Meristem-cultured Grand Nain and Commercial Grand Nain "Seed" Sources

Rhizomes were collected from Comayagua and Coulee where the virus-free stock derived from meristem cultures was being grown. These were compared with rhizomes from commercial plantings collected in November 1974. The plots were planted in Section 38, Guaruma 2. The experimental design was two treatments and four replicates of 25 plants/replicate. Data collection included the following: 1) days to shooting, 2) days to harvest, 3) plant height, 4) number of leaves at shooting, 5) stem weight, 6) peduncle weight, 7) fruit or hand weight, 8) number of hands, 9) caliper grade, 10) fingers/stem, 11) fingers/hand, 12) length of the central finger of each hand (average for all hands). Data are presented in Table 56 for the first two crops. F-test comparisons of means from an analysis of variance indicate that there was no significant difference between "seed" from the virus-free meristem source and the commercial source.

The slightly greater average height of the meristem-derived plants is due to a reversion from the Grand Nain to the VALERY height class in a portion of the plots. Reversion was 60%, 0%,30% and 44% for the four replicates. The change in height class was traced to some of the meristem-derived plants in the Comayagua seedbed. It is possible that the heat-treatment and meristem process may favor a reversion through somatic mutation from the more dwarf to the taller varieties in the Cavendish group. (BUSTAMANTE, STOVER, DARLINGTON)

MOKO DISEASE - HONDURAS

Are Buffer Zones Necessary? The present control practice regarding buffer zones in Honduras is to buffer cases in high-incidence areas (three cases per cayo per month, or 0.5 cases per 100 acres) but not in the low-incidence

Table 54. Total number of hands (T), infected hands (I) and percent of infected hands from sprayed and unsprayed sections in Indiana Farm.

Date evaluated	Unsprayed						Sprayed					
	Grand Nain			VALERY			Grand Nain			VALERY		
	T	I	%	T	I	%	T	I	%	T	I	%
Sept. 27	253	76	30.0	268	99	40.7	268	16	6.0	244	43	17.8
Oct. 4	259	105	40.5	246	171	69.5	261	14	5.4	245	42	17.1
11	267	100	37.4	246	74	30.1	268	11	4.1	252	22	8.7
19	251	141	56.2	238	65	27.3	247	19	7.7	235	26	11.1
25	257	69	24.9	211	62	29.4	249	11	4.4	233	24	10.3
Nov. 1	251	135	53.8	220	73	33.2	247	3	1.2	237	22	9.3
8	252	112	44.4	220	96	43.6	261	15	5.8	240	26	10.8
15	246	116	47.2	221	114	51.6	244	17	7.0	228	18	7.9
22	245	123	50.2	217	117	53.9	246	27	11.0	236	63	26.7
29	234	110	47.1	200	127	63.5	242	22	9.1	245	36	14.7
Dec. 6	261	145	55.6	221	155	70.1	254	43	16.9	229	38	16.6
Means[1]	252.3	112	44.4x*	225.7	1048	46.4x	253.4	18.0	7.1y	238.5	32.7	13.7z

[1] Data were converted to arcsin $\sqrt{\%}$ for analysis; % calculated as $^{I}/_{T}$ for 11 replications of 25 stems each of VALERY and Grand Nain.

* Means followed by the same letter are not significantly different at the 1% level of probability as determined by Duncan's Multiple Range Test.

Table 55. Percent fruit weight loss due to discarding fingers infected with pitting disease or diamond spot for the last three fruit cuts - Data converted to arcsin $\sqrt{\%}$ for analysis.

	Percent Weight Loss
V -US	1.1 y*
GN-US	0.9 y
GN- S	0.3 z
V - S	0.3 z

* Means followed by the same letter are not significantly different at the 1% level of probability as determined by Duncan's Multiple Range Test.

Table 56. Comparison of commercial Grand Nain plants (C) and plants derived from virus-free meristem cultures (V) (F-test values from analysis of variance are listed for treatments and blocks).

	PLANTILLA				RATOON			
			F-value				F-value	
Parameters	C	V	T	B	C	V	T	B
Days to shooting	306.0	325.3	6.89	.77	-	-	-	-
Days to cutting	104.9	108.2	1.98	.84	97.3	97.2	.00	5.40
Plant height (in)	80.8	87.6	4.28	.77	105.5	110.5	.51	.09
Number of leaves	12.9	12.1	23.06*	7.06*	12.4	12.1	.51	.34
Stem weight	51.0	51.6	.08	.44	89.0	85.6	.56	.60
Peduncle weight	5.6	5.3	.38	.54	8.6	7.5	6.87	.16
Fruit weight	45.4	46.4	.24	.89	80.4	78.1	.31	.75
Number of hands	9.0	9.1	.13	1.03	11.0	10.7	1.07	.57
Caliper	10.7	11.1	.43	.70	13.2	13.9	15.84*	3.76
Number of fingers/ stem	140.1	137.6	1.13	6.53	212.5	192.6	3.98	1.05
Number of fingers/ hand	15.6	15.2	1.85	4.02	-	-	-	-
Finger length	8.1	8.2	.10	.57	9.3	9.1	.60	1.25

* Means are significantly different at the 5% level of probability.

areas. It was reported (1973 Annual Report, p. 49) that the spread of Moko was controlled without the use of buffer zones in San Juan Farm if all other control measures were enforced. Thus, a comparison of buffered and non-buffered areas surrounding Moko cases was made in Cobb Farm. This experiment should help to determine whether root contact is an important factor in Moko spread.

A 22 ft zone (radius) was outlined around each Moko case. One-half of the zone was designated as the area of observation and received no treatment. The remaining half of the zone was buffered to a radius of 15 ft with the remaining 7 ft being retained as the area of prevention (Figure 24). In the area of prevention, all mats were inspected for Moko by cutting into the old bullheads. Each case was mapped at the time of treatment and all plants within the areas of prevention and observation were plotted by number or letter. The areas were checked every 14 days and any new cases within the areas were plotted by position. The date of treatment, type of infection (mature mat, sucker, and fruit), and Moko strain were recorded for each case.

Twenty-three original Moko cases were studied. There has been only one possible case of secondary spread within any of these plots and it occurred in the area of prevention. Both the original and possible secondary spread case yielded the F-strain. In addition, three instances of possible secondary spread occurred in two original plots started in 1975 (August and October). All of these possible secondary spread cases occurred in the areas of prevention and one of these three cases yielded a Moko strain which was not the same as isolated from the original case. It was previously reported (1975 Annual Report, p. 64) that seven new cases occurred within the plots of 27 original cases. Five of those seven cases occurred in the area of prevention with the remaining two occurring in the area of observation. Two of the seven cases could not have spread from the original cases since the strains isolated from the original and new cases were not identical. In any case, it is doubtful that any of this secondary spread occurred via root contact since all of the cases developing within the 22 ft zone occurred in the area of prevention.

Effectiveness of Beloran and Vanodine As Tool Disinfectants in Moko Control

Vanodine (product of Pfizer of Costa Rica) is an iodine disinfectant which has been promoted as a bactericide, fungicide and viricide. It has the advantage of being readily available in Central America. An experiment was initiated to determine the bactericidal effectiveness of Vanodine using Beloran (Lot No. BA 1-76) as the standard.

Concentrations were prepared in 100 ml aliquots with the concentrations based on the total chemical solution (not active ingredient). After thorough agitation to ensure good distribution of the disinfectant, a 10 ml aliquot of each concentration was distributed into each of four test tubes. One ml of latex was added to two of these tubes with disinfectant. One test tube with disinfectant and one tube with disinfectant plus latex were stored for seven days before testing to determine if any bactericidal activity was lost by volatilization, chemical degradation, or latex tie-up. All test solutions stored for seven days were kept sterile by inserting sterile cotton plugs in the test tubes. Inoculum was prepared by inoculating nutrient broth tubes with the F-strain of *Pseudomonas solanacearum* and incubating them for 60 hr

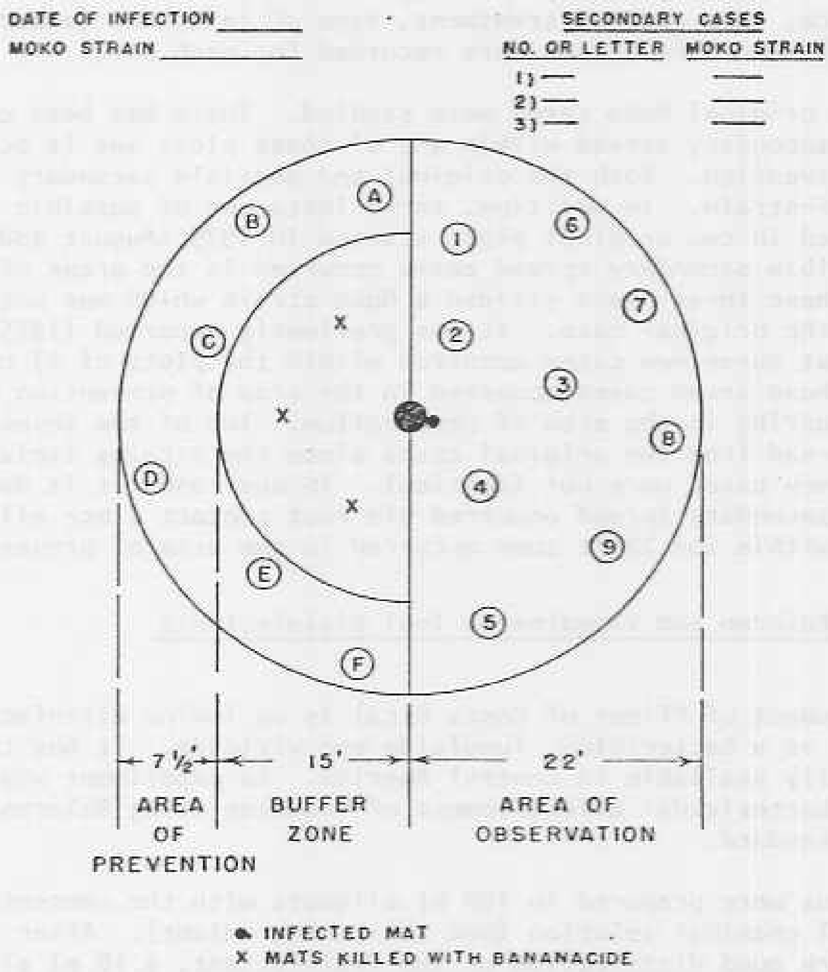


Figure 24. Diagram of a Moko buffer test plot showing the areas of the plot and the buffer zone.

at 30° C. The 60 hr nutrient broth cultures were dispensed in 0.1 ml aliquots with sterile pipettes to the test tubes containing various concentrations of disinfectant. After exposing the bacteria to the disinfectant for 15 or 30 sec, a loop of bacterial suspension was transferred aseptically to sterile nutrient broth in each of five test tubes and incubated at 30° C for 48-60 hr. After incubation, the nutrient broth inoculated with treated bacteria was checked for turbidity and streaked on tetrazolium chloride medium (0.05 g tetrazolium chloride + 5 g dextrose + 10 g peptone + 1 g casamino acids + 20 g agar/lt) to confirm the test tube results. Each treatment had five replicates and the experiment was repeated five times.

Beloran was slightly more effective than Vanodine without latex added when tested right after mixing. However, Vanodine was as effective as Beloran in the presence of 10% latex. In the presence of latex, the bactericidal activity of Beloran and Vanodine right after mixing was reduced up to 50% (Table 57). The loss of bactericidal activity in the presence of latex did not increase after one week of storage, as indicated by the data (Tables 57 and 58). Vanodine in the absence of latex lost a small amount of activity during the one week of storage, but no real losses in Beloran activity were observed (Tables 57 and 58). In the presence of latex for one week, the Vanodine solution retained a higher level of bactericidal activity than Beloran (Table 58). It was previously reported (1967 Annual Report, p. 38) that a 1% solution of Beloran in the presence of latex retained sufficient bactericidal activity for effective tool disinfection when the bacteria (SFR-strain from Honduras) were exposed for only 10 sec to the disinfectant. Those results are not in agreement with this experiment which suggests that a 2% solution is required to get the desired quality of disinfection (Tables 57 and 58). This discrepancy in results indicates increased tolerance to Beloran or a difference in tolerance to Beloran among the F- and SFR-strains. Approximately 87% of the Moko samples now processed by this laboratory are the F-strain.

<u>Moko Cases in Honduras - 1976</u>

During 1975, the SFR- and F-strains of <u>Pseudomonas</u> <u>solanacearum</u> were isolated from 46.9 and 53.1 percent of the samples, respectively, processed for strain identification. Most of these cases (68.9%) were sucker infections which indicated transmission by tools (1975 Annual Report, p. 64).

The percents of SFR- and F-strains isolated from 224 samples during 1976 were 8 and 87, respectively. This represents a big shift in strain frequency indicating selective pressure against the SFR-strain and/or increased adaptation of the F-strain to insect transmission. The remaining 5% of the isolations yielded a strain(s) which had the cultural characteristics of both the SFR- and F-strains on tetrazolium chloride agar (TZC). Although this strain(s) was isolated from only 5% of the samples, 80% of these isolations were obtained during the last five months of 1976. Is this a new strain or a mixture of the SFR- and F-strains? Forty-three percent of the infections were reported as occurring in the fruit and almost all of the fruit cases (92%) yielded the F-strain (Table 59). This suggests that the F-strain has become more adapted to insect transmission, or the SFR-strain is changing in terms of cultural characters in the TZC agar medium.

Table 57. Bactericidal effectiveness of Beloran and Vanodine against Pseudomonas solanacearum immediately after mixing.

Concentration of test chemical (%)[1]	Mean percent of cultures with growth			
	BELORAN		VANODINE	
	15 sec[2]	30 sec	15 sec	30 sec
A - 0.00	100[3]	100	100	100
0.25	90	77	90	93
0.50	33	20	33	23
0.79	10	0	13	3
1.00	0	0	3	0
2.00	0	0	0	0
4.00	0	0	0	0
B - 0.00	100	100	100	100
0.25	97	100	100	100
0.50	93	87	100	97
0.79	67	57	63	53
1.00	63	43	33	23
2.00	0	0	0	0
4.00	0	0	0	0

[1] A = No latex added; B = Latex added (10%).

[2] Time of bacterial exposure to the disinfectant.

[3] Each statistic is the mean of 30 samples based turbidity in nutrient broth culture.

Table 58. Bactericidal effectiveness of Beloran and Vanodine against <u>Pseudomonas</u> <u>solanacearum</u> seven days after mixing.

Concentration of test chemical (%)[1]	Mean percent of cultures with growth			
	BELORAN		VANODINE	
	15 sec[2]	30 sec	15 sec	30 sec
A - 0.00	100[3]	100	100	100
0.25	90	90	97	100
0.50	50	53	50	43
0.79	13	3	30	10
1.00	0	0	10	3
2.00	0	0	0	0
4.00	0	0	0	0
B - 0.00	100	100	100	100
0.25	100	100	100	100
0.50	97	97	87	90
0.79	83	80	83	73
1.00	50	33	30	30
2.00	0	0	0	0
4.00	0	0	0	0

[1] A = No latex added; B = Latex added (10%).

[2] Time of bacterial exposure to the disinfectant.

[3] Each statistic is the mean of 30 samples based turbidity in nutrient broth culture.

Table 59. A comparison of Moko bacterium strain to the site of disease symptom observation.

	Type of Infection					
	F-Strain			SFR-Strain		
Farm	Fruit	Sucker	Mature mat	Fruit	Sucker	Mature mat
Cobb	8	0	9	0	0	1
Indiana	2	0	3	0	0	0
La Fragua	8	0	2	0	0	0
Laurel	3	0	2	0	0	0
Los Indios	14	13	6	1	2	1
Lupo	2	5	2	0	1	0
Mopala	1	4	1	0	0	0
Tibombo	27	5	1	6	0	0
Ceibita	2	1	1	0	0	0
Barranco	0	0	1	0	0	0
Palomas	1	0	0	0	0	1
San Juan	14	11	19	0	0	0
Omonita	0	1	1	0	0	2
Copen	1	0	0	0	0	0
Guaruma	1	1	3	0	0	0
Caimito	0	1	0	0	0	0
Santa Rosa	0	0	0	0	0	1
Total	84 (43.8)	42 (21.8)	51 (26.5)	7 (3.6)	3 (1.5)	5 (2.8)

( ) Numbers represent the percent of total samples.

The Division reported the occurrence of 725 Moko cases this year. This represents 40% fewer Moko cases treated this year. (SLABAUGH)

FUSARIAL WILT - TAIWAN RACE

Studies were continued at Perrine with the Taiwan race of *Fusarium oxysporum* f. *cubense* that attacks Cavendish varieties. Previous studies at Perrine showed Cavendish varieties were not attacked by the Taiwan race in a South Florida marl soil high in lime. A cement box 14 ft square and 3-1/2 ft high was filled with a low-calcium sand from Central Florida. This soil had only 950 ppm of calcium and a pH of 4.4. The box was planted with six Grand Nain and three Highgate rhizomes on January 3. Soil was pulled back from the roots and an oatmeal culture of the Taiwan race was applied on March 19. The plants were dug up on July 22 or 4 months after inoculation. Two of the Highgate and one of the Grand Nain plants showed heavy rhizome infection. These infected plants were chopped up and diseased tissue placed around young suckers of the six Grand Nain and three Highgate plants. These suckers were dug up three months later on October 19. Four out of six of the Grand Nain rhizomes had from medium to heavy infection. All Highgate were heavily diseased.

These studies show Grand Nain, and most likely all Cavendish varieties, are susceptible to the Taiwan race of Panama disease in a low calcium soil. Studies will now be initiated with some of the key breeding lines. Two plantings can be made yearly: March to June and July to November. Bananas do not grow well from December through February because of low temperatures at Perrine. (STOVER)

YELLOW MAT

An outbreak of yellow mat ("mata amarilla") was investigated in Surinam. An outbreak occurred for the first time in Ecuador in late 1975. Scattered cases continue to appear in Changuinola. Internal symptoms consist of pronounced vascular discoloration where the rhizome stele joins the cortex. Anatomical studies showed the discoloration is associated with phloem tissue plugged with a yellow amorphous substance, and discoloration of the phloem walls including adjacent companion cells.

Suckers with various degrees of rhizome discoloration from plants showing yellow mat symptoms in Changuinola were planted in concrete tanks in Honduras. At first these suckers grew more slowly than healthy suckers. Within three months of planting, growth rate was normal and all plants appeared healthy. Six months after planting, all new rhizomes were healthy and showed no symptoms. (STOVER)

ELEPHANTIASIS

Diseased plants were examined in Turbo. Internal rhizome discoloration is similar to that found in yellow mat. External symptoms are different consisting of twisting and bending of the suckers with or without swelling and splitting of the outer leaf sheaths. As in yellow mat, discoloration was associated with phloem plugging and discoloration of the phloem walls.

Phloem diseases are usually caused by mycoplasmas transmitted by insect vectors. If this is the case with yellow mat and elephantiasis, the vector must be very inefficient as disease incidence is sporadic and occasional. (STOVER)

PUBLICATIONS

1. Stover, R. H. and J. D. Dickson. 1976. Banana leaf spot caused by *Mycosphaerella musicola* and *M. fijiensis* var. *difformis*: A comparison of the first Central American epidemics. F.A.O. PLANT PROTECTION BULLETIN 24 (2): 36-42.

2. Stover, R. H. 1976. Distribution and cultural characteristics of the pathogens causing banana leaf spot. TROPICAL AGRICULTURE 53(2): 111-114.

3. Salas, J. A., R. Oyuela and R. H. Stover. 1976. Effect of fallow on the burrowing nematode (*Radopholus similis*) of bananas. PLANT DISEASE REPORTER 60(10): 863-866.

4. Mulder, J. L. and R. H. Stover. 1976. *Mycosphaerella* species causing banana leaf spot. TRANS. BRITISH MYCOL. SOCIETY 67(1): 77-82.

NEMATOLOGY

Culturing Nematodes for Experimental Use

Monoaxenic cultures of plant parasitic nematodes may be used for critical pathogenicity studies, fungi interaction evaluation, and as convenient sources of uniform inoculum for other laboratory and greenhouse tests. Culture of nematodes started in May 1976 by attempting to raise two important banana pathogens, Radopholus similis and *Pratylenchus coffeae* on carrot discs.

The most successful methods tried have been the ones described by E. H. Moody *et al*, Journal of Nematology 5: 255-256 (1973), and J. H. O'Bannon in Phytopathology 58: 385 (1968). Both methods include modifications.

The main problem encountered in these methods has been contamination, especially when the source of nematodes comes from the field. This can be originated by several causes: bacteria (the most common), fungi and nematodes. They can account for a large loss in incubated material even if techniques are followed with care. Observations also indicate that the carrot material used as a substrate might contain fungi and/or bacteria internally that will decompose carrot tissue within a short time (2-6 weeks). The average contamination with the method described by Moody has been approximately 80% and for the O'Bannon method 95% at 4 months after inoculation. Due to this problem, it is most convenient to maintain a continuous supply of cultures by making separate batches of 20-30 jars per month. The procedure itself is tedious and time-consuming (Figure 25).

Transfer of nematodes from old cultures to new cultures has been more successful, since they already are free or low in contaminants. Contamination from jars has been approximately 20% at three months which is very low. There are no reports in the literature of loss in infectivity of nematodes due to change of host. Both nematodes, R. similis and P. coffeae, reproduce well on carrot discs, although the latter does it at much slower rate. Population increase in some jars initially inoculated with 20 specimens have shown up to 650,000 nematodes after four months of incubation. Average population per jar ranges between 80 and 100,000 nematodes at 3-4 months.

Nematode Survey in Belize

In October a nematode survey was done in the banana-growing area of Big Creek and South Stann Creek, Belize. Two different kinds of nematode surveys were taken into account. The first one dealing with the burrowing nematode, *Radopholus similis*, consisted in digging five rhizomes at random per acre, peeling them superficially and checking for nematode lesions which are characterized by the formation of dark necrotic lesions with reddish borders. A second nematode survey involved the recollection of 54 soil samples from the different farms covering the whole plantation. The purpose of this survey was to determine the different genera and species of plant parasitic nematodes associated with bananas in Belize. The amount of acreage surveyed was 1,296 out of a total of approximately 1,400. An additional 500 acres under one year were not surveyed. Using the same rhizome for nematode-lesion evaluation, a survey for root-borers was also performed.

The results of this survey indicate that there is an increase in *R. similis* infestations as compared to other surveys made in October, 1975 and May, 1976, the highest being recorded in Farm 2, Section D with an average infestation of 80% (Tables 60, 61, 62, 63, 64). This nematode was found widely distributed in the four farms in Big Creek. Root-knot nematodes, *Meloidogyne* sp., were found present in all 54 soil samples (Table 65). This was the most abundant plant parasitic nematode in the soil, their population reaching up to 1,860 nematodes in 250 cc of soil. The spiral nematode, *Helicotylenchus* spp., was found in low population. The rest of the plant parasitic nematodes are of little or no economic importance found on a wide array of soils. The lesion-nematode, *Pratylenchus coffeae*, similar in damage to *R. similis* and frequently found in banana plantations throughout the world, was not encountered. Root-borer infestation was fairly low, the highest reaching 35%. Many areas were found free of these insect pathogens. In many cases root-borer damage was present in rhizomes showing extensive nematode lesions.

Nematode Collection

A Nematode Survey Collection (NSC) from banana and other crops is available in permanent slides mounted in glycerine. This collection is expected

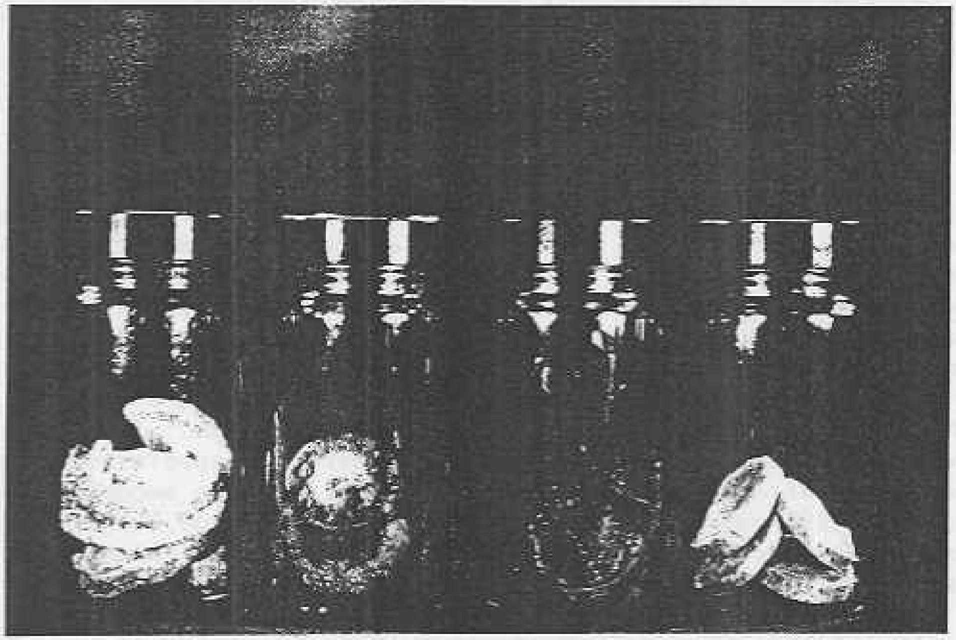


Figure 25. Incubation jars showing carrot cultures. A) Healthy growing culture 4 months after inoculation with 20 specimens of Pratylenchus coffeae. B) Four-month old contaminated culture that appears in the form of a hard rot. This form is probably caused by bacteria and fungi and deteriorates slower than the soft rotting form. C) Two-month old contaminated culture that appears in the form of a soft rot. This is probably caused by bacteria. Notice bacterial ooze in the bottom of jar. D) Healthy culture 15 days after inoculation with 20 specimens of Radopholus similis.

Table 60

Date of Survey: 10/15/76 B.C.B. Farm
Total Acreage: 368
Total Acres Surveyed: 368

Section	# of rhizomes surveyed	Nematode inf. rhizomes	% of nem. infested	Root borer inf. rhizomes	% of R.B. inf.
A-8	40	6	15	6	15
9	40	3	7.5	10	25
10	40	17	42.5	10	25
11	40	11	27.5	6	15
12	40	8	20	4	10
13	40	13	32.5	14	35
14	40	9	22.5	7	17.5
15	40	12	30	2	5
B-2	40	18	45	5	12.5
3	40	8	20	-	0
4	40	17	42.5	2	5
5	40	8	20	1	2.5
6	40	24	60	4	10
7	40	15	37.5	1	2.5
8	40	21	52.5	-	0
9	40	11	27.5	-	0
10	40	22	55	-	0
11	40	16	40	-	0
12	40	24	60	5	12.5
13	40	26	65	2	5
14	40	24	60	-	0
15	40	17	42.5	-	0
16	25	10	40	-	0
17	25	17	68	1	2.5
18	20	14	70	2	5
19	50	25	50	1	2.5
C-2	40	26	65	5	12.5
3	40	20	50	5	12.5
4	40	22	55	2	5
5	40	8	20	4	10
6	40	3	7.5	5	12.5
7	40	28	70	6	15
8	40	8	20	16	40
9	40	23	57.5	-	0
10	40	4	10	3	7.5
11	40	15	37.5	-	0
12	40	6	15	16	40
13	40	8	20	-	0
14	40	11	27.5	2	5
15	40	9	22.5	3	7.5
16	40	15	37.5	12	30
17	40	12	30	4	10
18	40	19	47.5	7	17.5
19	40	9	22.5	3	7.5
20	40	34	85	2	5
21	40	13	32.5	2	5
22	40	24	60	4	10
Average A	40	9.8	24.6	7.3	18.4
Average B	37.7	17.6	46.6	1.3	3.5
Average C	40	15.0	37.7	4.8	12.0

Table 61

Date of Survey: 10/18/76 **Farm 2**
Total Acreage: 372
Total Acres Surveyed: 347

Section	# of rhizomes surveyed	Nematode inf. rhizomes	% of nem. infested	Root borer inf. rhizomes	% of R.B. inf.
D-9	40	30	75	7	17.5
10	40	31	77.5	6	15
11	40	29	72.5	14	35
12	40	35	87.5	13	32.5
13	40	31	77.5	5	12.5
14	40	31	77.5	4	10
15	40	30	75	8	20
16	40	35	87.5	6	15
17	40	34	85	8	20
18	40	32	80	8	20
19	40	35	87.5	6	15
20	40	35	87.5	8	20
21	40	30	75	7	17.5
22	40	30	75	7	17.5
E-9	40	17	42.5	-	0
10	40	20	50	-	0
11	40	17	42.5	2	5
12	40	10	25	1	2.5
13	40	18	45	3	7.5
14	40	17	42.5	-	0
15	40	9	22.5	2	5
16	40	26	65	4	10
17	30	8	26.6	1	2.5
18	40	15	37.5	2	5
19	40	35	87.5	4	10
20	40	24	60	4	10
21	40	27	67.5	3	7.5
22	40	33	82.5	5	12.5
23	40	19	47.5	2	2.5
24	40	13	32.5	-	0
25	37	11	29.7	3	7.5
26	40	17	42.5	2	5
27	28	11	39.2	6	15
F-9	40	10	25	1	2.5
10	40	7	17.5	3	7.5
11	40	11	27.5	3	7.5
12	40	11	27.5	1	2.5
13	40	12	30	2	5
14	40	17	42.5	6	15
15	40	11	27.5	3	7.5
16	40	5	12.5	1	2.5
17	40	7	17.5	-	0
18	40	22	55	2	5
19	40	16	40	1	2.5
20	40	7	17.5	2	5
Average D	40	32	80	7.6	19.0
Average E	38.6	19.2	49.9	2.4	6.2
Average F	40	11.3	28.3	2.1	5.2

Table 62

Date of Survey: 10/16/76

Total Acreage: 304

Total Acres Surveyed: 303

Farm 3

Section	# of rhizomes surveyed	Nematode inf. rhizomes	% of nem. infested	Root borer inf. rhizomes	% of R.B. inf.
Y-1	35	18	51.4	3	7.5
2	40	24	60	8	20
3	40	21	52.5	3	7.5
4	40	26	65	14	35
5	40	30	75	8	20
6	40	35	87.5	4	10
7	40	25	62.5	10	25
D-1	40	19	47.5	5	12.5
2	40	30	75	7	17.5
3	40	37	92.5	8	20
4	40	33	82.5	10	25
5	40	12	30	14	35
6	40	21	52.5	7	17.5
7	40	12	30	2	5
8	40	15	37.5	5	12.5
X-1	40	15	37.5	5	12.5
2	40	18	45	8	20
3	40	15	37.5	1	2.5
4	40	25	62.5	13	32.5
5	40	11	27.5	0	0
6	40	10	25	4	10
7	40	10	25	4	10
E-1	40	23	57.5	2	5
2	40	22	55	4	10
3	40	24	60	5	12.5
4	40	23	57.5	1	2.5
5	40	25	62.5	3	7.5
6	40	13	32.5	2	5
7	40	9	22.5	1	2.5
8	40	31	77.5	9	22.5
F-1	40	18	45	2	5
2	40	8	20	0	0
3	40	26	65	5	12.5
4	40	6	15	0	0
5	40	15	37.5	3	7.5
6	40	11	27.5	2	5
7	40	11	27.5	11	27.5
8	40	30	75	0	0
Average Y	39.2	25.5	64.8	7.1	17.8
Average D	40	22.3	55.9	6.6	14.8
Average X	40	14.8	37.1	5	12.5
Average E	40	21.2	53.1	3.3	8.4
Average F	40	15.6	39	2.8	7.1

ıble 63 .

ıte of Survey: 10/18/76

ıtal Acreage*: 228

ıtal Acres Surveyed: 208

Farm 4

Section	# of rhizomes surveyed	Nematode inf. rhizomes	% of nem. infested	Root borer inf. rhizomes	% of R.B. inf.
G-18	40	19	47.5	-	0
19	40	21	52.5	-	0
20	40	12	30	1	2.5
21	40	17	42.5	-	0
H-17	40	13	32.5	-	0
18	40	19	47.5	10	25
19	40	13	32.5	4	10
20	40	16	40	3	7.5
21	40	29	72.5	5	12.5
22	40	21	52.5	4	10
23	25	1	4	-	0
24	20	-	0	-	0
25	20	2	10	-	0
26	21	3	14.2	-	0
27	26	8	30.7	1	3.8
28	25	6	24	1	4
29	23	6	26	-	0
I-18	40	16	40	1	2.5
19	40	13	32.5	-	0
20	40	12	30	-	0
21	40	14	35	-	0
22	40	17	42.5	1	2.5
23	40	18	45	1	2.5
24	40	9	22.5	-	0
25	40	11	27.5	-	0
26	40	8	20	-	0
27	40	9	22.5	2	5
28	40	5	12.5	-	0
29	40	13	32.5	-	0
Average G	40	17.2	42.1	0.2	0.5
Average H	30.7	10.5	34.2	2.1	6.8
Average I	40	12	30	0.4	1

* Total acreage - minimum one year.

Table 64

Date of Survey: 10/16/76

Total Acreage: 135

Total Acres Surveyed: 70

South Stann Creek

Section	# of rhizomes surveyed	Nematode inf. rhizomes	% of nem. infested	Root borer inf. rhizomes	% of R.B. inf.
1	42	29	69	4	9.5
2	42	20	47.6	2	4.7
4	42	5	11.9	-	0
6	42	8	19	-	0
8	42	11	26.1	1	2.3
10	45	18	40	4	8.8
12	45	30	65.2	4	8.8
14	22	9	40.9	-	0
15	28	13	46.4	2	7.1
Average	38.8	15.8	40.7	1.8	4.6

Table 65. Average population of plant-parasitic nematodes in positive samples and their percentage of occurrence (in brackets).

Nematodes	Locality							
	BCB Farm 16*		Farm 2 12*		Farm 3 13*		Farm 4 13*	
Radopholus similis	20**	(56)	33	(92)	43	(84)	58	(66)
Meloidogyne sp.	609	(100)	498	(100)	239	(100)	186	(100)
Helicotylenchus erithrinae	57	(100)	78	(50)	23	(46)	15	(41)
Helicotylenchus multicinctus	45	(6)	0	(0)	30	(8)	0	(0)
Macroposthonia onoense	11	(37)	103	(17)	5	(8)	30	(8)
Discocriconemella limitaneum	17	(19)	0	(0)	130	(8)	119	(38)
Tylenchus sp.	13	(25)	8	(25)	13	(31)	9	(53)
Paratylenchus sp.	12	(44)	17	(25)	8	(15)	5	(8)
Trichodorus sp.	13	(31)	8	(33)	10	(8)	0	(0)
Xiphinema ensiculiferum	5	(12)	10	(8)	0	(0)	0	(0)
Xiphinema simillimum	0	(0)	0	(0)	0	(0)	15	(8)
Aphelenchus sp.	9	(25)	0	(0)	0	(0)	0	(0)
Psilenchus sp.	10	(6)	0	(0)	0	(0)	0	(0)
Nothocriconema sp.	0	(0)	13	(17)	0	(0)	0	(0)

* Number of soil samples.

** Number of nematodes in 250 cc of soil.

to increase with time and will be used as reference material, training purposes and demonstrations. The collection includes only plant parasitic specimens, classified to genus and species level, males and females mounted alone or in root tissue, and perineal patterns of root-knot nematodes (*Meloidogyne* spp.). Each slide contains information on host, locality, collector and date. At present, the collection holds 34 different nematode species and 215 root-knot perineal patterns (Tables 66 and 67).

Occurrence, Fungal Association and Spatial Distribution of Root-Knot Nematode on Bananas and Plantains

A study to determine the root-knot species present, their frequency in the field, association with fungi, and spatial distribution in areas where *Radopholus similis* and *Helicotylenchus multicinctus* are also present was conducted in the banana and plantain farms of Guaruma 1, 2, San Juan and Paleto. Infested roots showing typical symptoms were selected at random. Females in roots were dissected from galls and perineal sections were mounted on permanent slides. Fungi associated with firm-textured root-knot galls were isolated from tissue adjacent to root-knot females and egg masses. Spatial distribution was determined by recovering soil samples at 30, 60, 90 and 120 cm intervals from the rhizome on plants chosen at random. In order to determine vertical distribution, soil samples at 10, 20, 30 and 40 cm of depth were recovered in composite samples taken at 75 cm distance from the rhizome.

Perineal sections indicate that the predominant root-knot species found was *M. incognita* (58%) (Table 68, Figure 26). Also present were *M. arenaria* (11%), *M. javanica* (9%), and *M. exigua* (4%). This is the first time *M. exigua* is reported on banana host in Honduras. Several other perineal sections (six) could not be correctly identified due to their resemblance to more than one type. These are considered overlapping patterns between species. Different species were often found in the same gall, especially *M. incognita* with *M. arenaria* and *M. javanica*. In plantains, *M. incognita* was the most frequent (96%) species encountered. An undetermined and distinct species of *Meloidogyne* was present. Its perineal pattern does not resemble any of the known types in literature and is characterized by the absence of formation of visible galls.

Penicillium on bananas (14 isolates) and *Fusarium solani* on plantains (8 isolates) were the most common fungi recovered from nematode-galled root tissue (Table 69). Microscopical observation revealed that root-knot females in firm gall showed very little necrotic tissue formation. The small necrotic areas were noticeable near egg masses and limited to 2-6 cell layers surrounding nematode. It would appear that fungi do not spread easily to adjacent healthy tissue. This pattern might also be related to low number of successful isolations as compared to total (51 out of 550). Fungi isolated in the course of this study are believed to be mainly saprophytic of little or no plant pathogenic importance found in a wide array of soils.

Banana and plantain material showed typical root-knot symptoms such as root distortion, sub-apical galling and root bifurcation (Figure 27). These symptoms were most evident toward the distant end of the root. Some roots also showed extensive lesions caused by *R. similis*, the damage appearing most evident in the portion closer to the rhizome and in the rhizome.

Table 66. Permanent slides of plant parasitic nematodes mounted in glycerine and deposited in the Nematode Survey Collection (NSC).

Nematode Species	Male	Female	Host
Radopholus similis	+	+	Plantain, banana
Meloidogyne incognita	+	+	Banana
Helicotylenchus erithrinae	+	+	Banana
Helicotylenchus multicinctus	+	+	Banana, melon
Pratylenchus coffeae	+	+	Banana
Pratylenchus scribneri*	+	+	Fern
Tylenchorhynchus cylindricus*		+	Melon, corn
Rotylenchulus reniformis		+	Acacia, banana, oil palm
Discocriconemella limitanea*		+	Banana, cedar
Discocriconemella inauratus*		+	Plantain
Discocriconemella retroversa*		+	Guarumo
Hemicroconemoides cocophillus		+	Grass
Hemicriconemoides mangiferae		+	Mango, banana
Hemicriconemoides litchi*		+	Mango, acacia
Macroposthonia onoense		+	Banana
Macroposthonia denoudeni*		+	Araucaria
Xiphinema ensiculiferum		+	Plantains
Xiphinema americanum		+	Oil palms, bananas, plantains
Xiphinema simillimum*		+	Bananas, tuft fish tail palm
Peltamigratus holdemani*		+	Oil palm
Trophurus sp.	+	+	Banana

Cont'd....

Table 66 (Cont.)

Nematode Species	Male	Female	Host
Hoplolaimus sp.		+	Ariana palm, grass
Paratylenchus sp.		+	Banana, plantain
Paralongidorus sp.		+	Banana
Hemicycliophora sp.	+	+	Banana, grass
Xiphinema sp.		+	Banana
Lobocriconema sp.*		+	Plantain
Nothocriconema sp.*		+	Banana

* Reported in Honduras for the first time.

Table 67. Perineal sections of root-knot nematodes mounted in glycerine and deposited in the NSC.

Root-knot nematodes	No. perineal patterns	Host
Meloidogyne incognita	158	Melon, banana, oil palm, plantain, beans
Meloidogyne javanica	11	Banana
Meloidogyne arenaria	21	Banana, plantain
Meloidogyne exigua	4	Banana
Meloidogyne hapla	2	Banana
Unidentified	19	

Table 68. Meloidogyne spp. present and their frequency in the banana and plantain growing areas of the Sula Valley, Honduras.

	BANANA		PLANTAIN	
Nematode Species	Perineal sections	%	Perineal sections	%
M. incognita	63	58	50	96
M. arenaria	11	10	2	4
M. javanica	9	8	0	0
M. exigua	4	4	0	0
Overlapping P.S.*	6	5	0	0
Undetermined**	16	14	0	0
TOTAL	109	100	52	100

* Perineal sections that may correspond to M. incognita, M. arenaria, M. javanica or M. exigua.

** Perineal sections correspond to an undetermined but distinct root-knot species not reported in the literature.

Table 69. Fungi associated with Meloidogyne spp. isolated from galled root tissue of bananas and plantains.

	Number of isolations	
Fungi Genera	Banana	Plantain
Acremonium	(3)	(2)
Alternaria	(1)	
Aspergillus	(2)	
Curvularia		(1)
Cylindrocarpon	(1)	(4)
Fusarium solani	(2)	(8)
Geotrichum		(2)
Penicillium	(14) (2) (1)*	
Rhizocthonia		(4)
Cladosporium	(4)	

* Three different cultures of Penicillium.

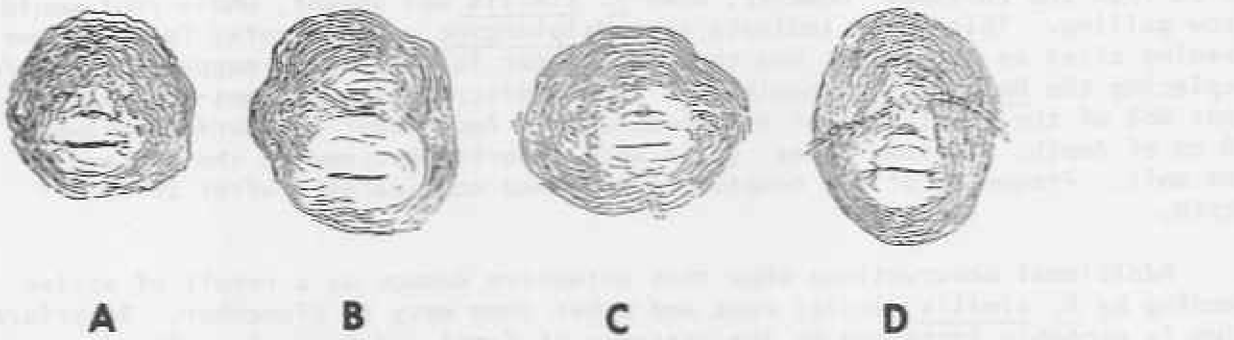


Figure 26 (A-D). Perineal sections of root-knot nematodes associated with bananas and plantains. A) Meloidogyne incognita, B) M. arenaria C) M. exigua and D) M. javanica.

Figure 27. Meloidogyne spp. symptoms on roots of bananas.

Root-knot nematodes were seldom found in the first 40 cm of root and none in the rhizome itself. Helicotylenchus sp. lesions were present fairly evenly distributed throughout the length of the root. Root-knot population in the soil (Figure 28) would seem to confirm that the area of influence of this nematode would start 60 cm from the rhizome. However, when R. similis was absent, whole root would show galling. This would indicate that Meloidogyne spp. competes for the same feeding sites as R. similis and that the latter is capable of suppressing and/or replacing the Meloidogyne population. Depth distribution of root-knot showed that 66% of the population of this nematode is found near the surface between 10 cm of depth. In some cases, galls were clearly observed on the surface of the soil. Frequency of the nematode diminished considerably after 20 cm of depth.

Additional observations show that extensive damage as a result of active feeding by R. similis girdles root and makes them easy to dismember. Deterioration is probably increased by the presence of fungi and bacteria. The destruction of roots is reflected in the reduction of the number of feeding sites for Meloidogyne spp. and the interruption of their life cycles. (PINOCHET)

DBCP and Bromine Phytotoxicity to Bananas

For nematode control, applications of DBCP (1,2-dibromo-3-chloropropane) at 14 cc/mat of an 86% emulsifiable concentrate in two cycles per year represent 4.8 gal/a/yr at 650 production units per acre. Fumazone 86E contains 12.1 lbs DBCP and related compounds/gal and is 66.7% bromine by weight. Thus, 38.7 lbs/a/yr are applied of elemental bromine. EPA has established a tolerance of 125 ppm bromine in whole fruit and 75 ppm bromine in pulp of bananas as residue tolerances for DBCP.

In 1974 an unknown malformation of the plants in Armuelles resulted in the name of "Higueron Malady" for what has been shown to be linked with excess bromine or bromine toxicity in bananas. The same year Golfito and Bocas reported distortion of the suckers by apparent over-injections of DBCP. Thus, there are two forms of phytotoxicity associated with the application of DBCP to bananas: 1) Direct phytotoxicity as manifested in splitting and abnormal growth of the sucker and 2) Indirect phytotoxicity from the accumulation of bromine following the degradation of DBCP releasing bromine in the soil.

In 1975 plants from Higueron Farm showing symptoms of bromine phytotoxicity averaged 134 ppm bromine (seven samples) compared to 108 ppm bromine (eight samples) in whole fruit in symptomless plants.

In 1962 it was reported that bromine levels in the plant would be highest in the rhizome. During 1975 three sections of Higueron Farm at three plants per section were sampled. Section 2 (currently 57) was not treated, whereas Sections 1 (currently 56) and 10 (currently 65) were treated with 21, 14 and 14 cc/mat in three cycles. Samples were collected at 177 and 188 days from last application for Sections 10 and 2, respectively. Plants from Section 10 had severe symptoms, from Section 1 moderate symptoms, and from Section 2 no symptoms of bromine toxicity. Plant parts included for bromine analysis were: finger (whole fruit of harvest grade from largest hand on sunny side), crown, peduncle or fruit stalk at last bract scar, pseudostem (actually peduncle taken at 6 ft from ground), rhizome

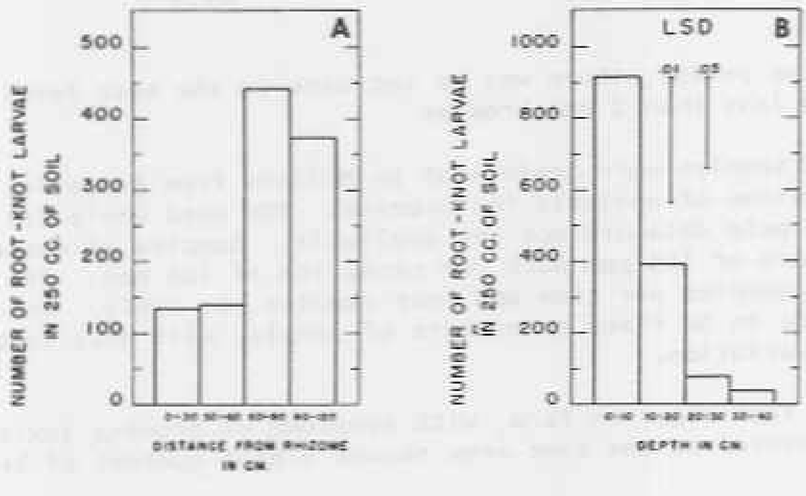


Figure 28. Spatial distribution of Meloidogyne spp. in banana soils infested with R. similis and H. multicinctus. A) Distribution of Meloidogyne spp. at different distances from the rhizome. B) Depth distribution at 75 cm from the rhizome.

(upper part of peduncle), rhizome lower part, and the growing point of the sucker. The means of three samples are presented in Table 70. The data are extremely variable but the trend is present that when symptoms become more severe, bromine content is higher. It was also noted that after repeated treatment, bromine content was higher in the fingers in contrast to the findings of 1962 when following a single cycle of DBCP, bromine content was highest in the rhizome.

In Palmar, Costa Rica during 1975, samples from Farm 3 (Cables 30 and 31) which had been treated with DBCP at 14 cc/mat over four cycles were sent to Midland, Michigan for analysis by DOW Chemical. Farm 12 fruit was sent as an untreated control. Samples were sent at 4, 16, 30 and 78 days from application. Tabulated findings are listed below for an average of eight samples:

Time	Bromine - ppm	
(Days)	Pulp	Whole Fruit
4	18.5	42.2
16	16.5	24.9
30	20.9	33.1
78	18.0	25.9

Over this time period, there was no increase in the base level of bromine. Controls averaged less than 2 ppm bromine.

During 1976, samples were again sent to Midland from Armuelles and Golfito to compare the systems of analysis for bromine. DOW used whole fruit in the first reading and pulp data are not yet available. Samples of whole fruit were well below tolerance of 125 ppm with one exception of 105 ppm. The samples were handled as double samples per stem and four samples per cable. The variation between samples needs to be fixed or numbers of samples will have to be greatly increased to cover variation.

Leaf samples from Higueron Farm, with symptoms of bromine toxicity, compared to symptomless leaves from the same area showed a high content of bromine:

Farm	Bromine - ppm	
Section	Symptoms	Symptomless
38	290	180
56	307	112
65	325	123

Sinker fruit from Armuelles had low content bromine and this problem could not be related to bromine toxicity.

Fruit from the DBCP phytotoxicity study where injections were at 2, 4, 6 and 8 in from the mat in the 9 x 5 and 5 x 9 configuration showed bromine content at less than 40 ppm (pulp). Plants showed bromine toxicity, particularly young leaves on the suckers.

Fruit from dry triangles in areas where plants were showing phytotoxicity symptoms had pulp readings of 10-25 ppm of bromine compared to a reading of 2 ppm from fruit in an adjacent area which was receiving sufficient water.

Table 70 . Bromine content (ppm) in various plant parts showing bromine phytotoxicity in Armuelles, Panama

Plant Part	SYMPTOMS Normal	Medium	Severe
Finger (whole fruit)	4	107	124
Crown	3	67	102
Fruit Stalk	2	30	33
Pseudostem	23	50	90
Rhizome (upper)	2	31	74
Rhizome (lower)	0	34	87
Rhizome (sucker)	0	23	43

In Armuelles, changing the pattern of injection or diluting the emulsifiable concentrate with water had no effect on the content of bromine in the fruit:

cc DBCP	Pattern	Dilution	Bromine ppm
14	semicircle	1:0	30
20	circle	1:0	38
14	semicircle	1:1	25
20	circle	1:1	25
14	semicircle	1:4	38
20	circle	1:4	29

A series of ten water samples from areas showing bromine toxicity symptoms in Armuelles were taken from the piezometers. These values ranged from 1 ppm to 28 ppm in the soil water (Table 71). The readings of pulp content, where available, were not correlated with the soil water readings.

In Honduras the symptoms of bromine phytotoxicity were reproduced artificially on suckers grown in clay pots. In the first experiment, DBCP and equivalent amounts of NaBr were added to clay pots of soil in which established sword suckers were growing. Rates used were 0, 4, 8, 16 and 32 cc/pot. Symptoms developed first in bromine-treated pots showing typical leaf symptoms. At the end of the experiment, all plants in the 8, 16 and 32 cc treatments were dead. At 4 cc, three plants died and the fourth was showing symptoms. The DBCP was less severe but both forms of phytotoxicity developed - leaf burning and split pseudostems. A second test using 2, 4, 6 and 8 cc is currently underway. Bromine toxicity symptoms appeared first on the 6 and 8 cc level of bromine and subsequently on the 6 and 8 cc level of DBCP. In small pots using established *Musa acuminata* seedlings, 2 and 4 cc of DBCP killed the seedlings within 4 days. Treatments of NaBr, KBr and NH_3Br are showing varying degrees of leaf symptoms. The 4 cc rate of NH_3Br also resulted in rapid seedling death.

The information accumulated to date indicates that bromine is the primary cause of the condition referred to as Higueron Malady. However, it is not clear-cut that an area showing these symptoms will be carrying high bromine. It is possible that a shock of bromine from a rapid breakdown and release of bromine from DBCP can result in phytotoxicity. The growing point is apparently affected as the leaf or fruit stalk forms. The soil content of bromine in regard to the expression of toxic symptoms needs to be worked out. Also, the movement of the chemical in the soil should be studied since we have not experienced the problem in areas of high rainfall as in Changuinola or on the Atlantic coast of Costa Rica. Apparently, the element can be leached out with proper drainage. Drought could also cause an excessive accumulation of bromine. (TAYLOR, DONALDSON, ESPINOZA, STEPHENS, CALDERON)

Effect of Watering Schemes on *Radopholus similis* Infestation of Bananas

The three areas selected for nematicide studies in Honduras were infested with *Radopholus* based upon rhizome index surveys greater than 50%. Root sampling in the areas showed Higuerito to contain a moderate infestation and San Juan and Los Limones low infestations compared to similar index levels in areas of higher rainfall. Therefore, a series of three experiments was undertaken to study the effects of

Table 71. Free bromine content of soil water in piezometers from areas showing cases of bromine phytotoxicity in Armuelles, Panama

Farm	Section	Piezometer	DBCP cycles	ppm-Br Water	ppm-Fruit
Caoba	5	13	3	3	7 (VII/76 - P)*
Zapatero	8	20	2	2	NA*
Zapatero	10-11	18	2	1	NA
Higueron	B18	8	3	3	120 (XI/76-WF)*
Bogamani	13	1	3	2	NA
Bogamani	5	2	?	28	NA
Javillo	17	22	3	21	35 (VII/76-P)
Níspero	12-16	4	2	6	11 (VII/76-P)
Palo Blanco	24	5	2	5	21 (VIII/76-P)
Higuito	4-8-9-5	1	3	6	12 (VIII/76-P)

* NA - Not available
P - Pulp
WF - Whole fruit

watering schemes on plant growth and nematode infestation.

Water Experiment I. In this experiment water was applied at the rate of 3 cm per day with drainage, 3 cm/day without drainage, and 6 cm/week with drainage. Peeled VALERY suckers from Guaruma (10-20 cm diameter) were planted in Guaruma soil in 28 cm diameter clay pots. Infested pots were inoculated with Higuerito Radopholus-infested root pieces at the rate of 30,000 nematodes/pot. Inoculation was a ring of root pieces around the rhizome at planting. Non-infested controls were included for each watering scheme. Five replicates per treatment were included. Plants were inoculated on July 9, 1975 and harvested 50 days later. The lack of drainage was accomplished by placing aluminum pans under the pots so that a water table could be held in the pot. For data analysis, only four replicates were used and nematode data were converted to Log X. Plants were grown under a carport.

Table 72 is the tabulation of the experimental findings. No differences in means were found for root weight, root length, lesion index, or Radopholus/100 g of roots. Only one of the control plants contained a detectable level of Radopholus. There was a tendency towards more root necrosis in the wet soils.

Water Experiment II. This experiment was similar to the first experiment except that the source of inoculation was infested rhizomes from Higuerito that were peeled free of roots but not nematode lesions. Treatments were: Sub-irrigation with daily filling of the pan below the pot (A); Sub-irrigation with daily filling of the pan below the pot but no inoculation by root pieces (B); 1.5 cm water two times/week (C); 1.5 cm water once a week (D); 1.5 cm water every two weeks (E); and no more water after the initial 1000 ml of water at planting (F). All treatments except B were infested with root pieces to obtain 75,000 Radopholus/pot. The experiment was planted September 10, 1975 and harvested 60 days later.

Table 73 is a tabulation of the experimental findings. Only four replicates per treatment were used for the data analysis and Radopholus/100 g of root data were converted to Log X for analysis. The only significant mean difference (1% level) was for plant height. Three treatments of 1.5 cm of water every two weeks and no water after planting had mean differences that were significant from each other and the other four treatments. Lack of water apparently had no effect on the amount of roots produced or the length of the roots. Radopholus levels were not greatly different in the treatments but the level of lesion index was again higher where more water was applied. It is interesting to note that an equal infestation could be obtained without inoculating the pots (Treatments A vs. B) which is a labor intensive step in nematode experimentation.

Water Experiment III. As continuation from the findings in Experiments I and II, an experiment was established to compare three watering schemes and a source of nematode infestation. Rhizomes were used from Higuerito and handled as in Experiments I and II. In the no-nematode treatment, the rhizomes were peeled free of all lesions. No root pieces for additional inoculum were included. Treatments were watered with 1.5 cm of water on 7 (A), 14 (B), 28 (C), and 7 (D) day cycles, D being the treatment without nematodes. Rhizomes were planted November 20, 1975 and harvested 60 days later. Replicates were increased to ten per treatment.

Table 72. Water Experiment I - Growth parameters and *Radopholus* determination for three watering schemes

Treatments Water applied	Radopholus	Root Weight (g)	Root Length (cm)	Radopholus/100 g roots[a]	Lesion Index (cm/100 cm)
Soaked - poor drainage					
3 cm/day	Present	93.3	140.0	105,783	32.1
	Absent	82.8	144.8		
Wet - drainage					
3 cm/day	Present	96.6	165.6	124,142	33.0
	Absent	124.6	161.7		
Dry - drainage					
6 cm/week	Present	96.3	187.1	279,462	17.8
	Absent	76.4	115.3		
F observed					
Treatments		0.55 NS	0.37 NS	0.26 NS	1.30 NS
Blocks		0.50 NS	0.20 NS	0.05 NS	1.08 NS

a/ Data converted Log X for analysis.

Table 73. Water Experiment II - Growth parameters and <u>Radopholus</u> determination for watering schemes

TREATMENT	Plant[a/] Height (cm)	Root Weight (g)	Root Length (cm)	Lesion Index	Radopholus/100 g roots
A	50.8 x	44.4	232	36	56,492
B	50.7 x	27.9	250	28	45,197
C	53.5 x	33.2	152	48	46,567
D	43.4 x	35.2	236	41	54,744
E	26.0 y	20.9	146	22	16,589
F	11.1 z	37.8	222	11	54,089

A - sub-irrigation daily.

B - sub-irrigation daily - no root pieces.

C - 1.5 cm water 2 times a week.

D - 1.5 cm water once a week.

E - 1.5 cm water every two weeks.

F - No subsequent water.

a/ Means followed by the same letter are not significantly different at the 1% level. Other treatments means not significantly different.

Table 74 is a tabulation of the experimental findings. Lack of water in this experiment had a deleterious effect on plant height and root weight. Peeling of the rhizome also had a deleterious effect on plant growth. Total root length obtained which could be split for lesion index was not different based upon mean comparisons. Lesion Index and Radopholus/100 g of roots means were not significantly different where nematodes were not peeled away, even though the Lesion Index is lower in the treatment receiving the least amount of water. The mean of total number of nematodes in the roots (obtained by converting the numbers of nematodes/sample to the total weight of the sample) was significantly different at the 1% level. Watering once a week produced more nematodes in more roots than did watering every two and four weeks. The peeling treatment was very effective in reducing the nematode population.

To summarize the findings of the three experiments, it was noted that under the conditions of shade and plants grown in clay pots, sufficient moisture remains to support plant growth and nematode survival. Lack of water apparently has more of an effect upon top growth than on root growth. As roots grow, the nematode population increases with the roots. Moist soil is apparently conducive to lesion development. It was also found that if infested rhizomes are used for experiments and not peeled free of Radopholus, populations develop to a level similar to those found under conditions of areas where yield loss occurs from this nematode and thus making the inoculation with rhizome chips or root pieces unnecessary. The next step is to go to the field and determine if under conditions of either drought or high water table, nematode populations are higher under natural conditions when moist and lower when dry. Soil temperature should be included in the analysis. (TAYLOR, CALDERON)

Source of Inoculation for Pot Studies of Radopholus on Banana - Honduras

Following the water studies, an experiment was established to check the source of infestation of Radopholus in Honduras. When studying water, nutritional levels, soil features, and other factors interacting with Radopholus infestations in bananas, it will be desirable to obtain a uniform and high degree of infestation at the start of the experiments. Four different sources of inoculum were compared by using soil and rhizomes from Higuerito and San Juan in the four possible combinations of: Higuerito rhizome in Higuerito soil (A); San Juan rhizome in Higuerito soil (B); Higuerito rhizome in San Juan soil (C); and San Juan rhizome in San Juan soil (D). Planting and growing conditions are similar to those described in the water studies. The pots were watered with 3.5 cm of water per week. Rhizomes were planted February 11, 1976 and harvested 126 days later. Ten replicates/treatment were used.

Results are presented in tabular form in Table 75. In regard to plant growth, mean comparisons for root weight and root length large enough to be split for lesion index showed no differences between rhizome and soil sources. Plants growing in San Juan soil were shorter than those grown in Higuerito soil with means significantly different at the 5% level.

For nematode populations, there was a progression from Higuerito rhizomes in Higuerito soil to San Juan rhizomes in San Juan soil. The fact that the Higuerito soil with San Juan rhizomes produced more nematodes per 100 g of

Table 74. Water Experiment III - Growth parameters and Radopholus determination for watering schemes

	1.5 CM WATER EVERY[a/]			
	7 DAYS	14 DAYS	28 DAYS	7 DAYS[b/]
Plant Height (cm)	43.1 x	25.3 xy	17.5 z	33.6 xy
Root Weight (g)	59.2 x	28.1 y	33.7 y	32.5 y
Root Length (cm)	264 x	184 x	238 x	137 x
Lesion Index[c/]	29 x	24 x	11 x	0 y
Radopholus/100 g roots[c/]	233,450 x	154,509 x	231,890 x	320 y
Radopholus/root system[d/]	141,023 x	32,591 y	27,298 y	85 z

a/ Means not followed by the same letter are significantly different at the 1% level - Duncan's Multiple Range Test.

b/ Peeled free of Radopholus lesions.

c/ Converted to log (X + 1) for analysis.

d/ Converted to log (X + 100) for analysis.

Table 75. Growth parameter and Radopholus determination for rhizome-soil source for infestation study.

	RHIZOME/SOIL SOURCE			
	A	B	C	D
PARAMETERS	Higuerito Higuerito	San Juan Higuerito	Higuerito San Juan	San Juan San Juan
Plant height (cm)	50.0 a	50.6 a	46.4 ab	43.5 b
Root weight (g)	36.6 a	45.1 a	40.9 a	37.6 a
Root length (cm)	149.0 a	182.6 a	173.6 a	178.3 a
Lesion Index	26.1 x	19.4 xy	15.9 xy	1.8 y
Radopholus/100 g roots	46,500 x	31,750 xy	16,650 xy	6,550 y

Means followed by the same letter are not significantly different at the 1% (x-y) or 5% (ab) level - Duncan's multiple range test.

roots than did the reverse situation is of significance. In experiments comparing soil type or fertility, the resident population of nematodes is going to have to be eliminated and equal levels of nematodes introduced. Lesion index follows the same pattern as does nematode infestation.

In regard to pathogenicity of the nematode, suckers showed no indication of reduced plant growth with a high population of nematodes in the roots. In general, there appeared to be no correlations between measurements of plant growth and nematode populations. Tall plants could have either a high or low nematode population. Root weight showed the same lack of relationship.

Banana Nematode Sample Transportation for Counting in Honduras

In many cases, it is going to be adviseable to process root and soil samples for nematode counts in an area where a microscope is not available. Also, the processing of the samples is an operation that a trained field worker can perform but the actual counting of the nematodes requires a higher degree of training. Storage of nematode samples in a 5% formalin solution after heat-relaxing at 52° C for 10 min is a standard nematology procedure. The formalin is prepared by diluting commercial 36.6% formaldehyde in the ratio of 1:3 with water to obtain a 10% formalin solution. This is then mixed with the nematode suspension 1:1 to result a 5% formalin storage solution.

To determine if samples processed by standard methods of blending and wet screening 25 g of banana roots for the extraction of Radopholus and Helicotylenchus would yield similar results after dilution and storage, an experiment was established using three different handling sequences. The four types of counts that were derived can be described as:

A. Standard Method: 25 g of roots processed for nematodes and the solution brought up to 500 cc. Counts were made of 4 ml subsample with a correction factor of 500X to determine numbers/100 g of roots.

B. Subsample and Concentration: 10 ml of the standard solution were allowed to settle for an hour, 5 ml removed, the nematodes heat-relaxed, and 5 ml of 10% formalin added to bring the solution back to 10 ml. From this, 4 ml were counted and the conversion factor was still 500X.

C. Subsample and Dilution: 10 ml of the standard solution were collected, nematodes heat-relaxed, and 10 ml of 10% formalin added. An aliquot of 4 ml was counted and the dilution factor became 1000X.

D. Subsample and Dilution (Hot Formalin): This is the same procedure as used in C, except that instead of heat-relaxing the nematodes, 10 ml of hot 10% formalin (80-90° C) were added directly to the 10 ml from the standard solution. An aliquot of 4 ml was counted and the dilution factor became 1000X.

Four different standard samples were processed. For each sample, steps A-D were repeated in order six times. Counts were made of Radopholus and Helicotylenchus. For data analysis, counts of 4 ml were doubled in treatments C and D since these had been diluted by half. Comparisons of means of the six readings were compared by Analysis of Variance and Duncan's Multiple Range Test.

The results of the statistical analysis of mean differences resulted in two of four sets of samples not giving the same population mean for the standard sample (Tables 76-77). This is related to the amount of nematodes which are collected in the 10 cc subsample but there is no explanation as to why these values should be either higher or lower than the standard since 6 subsamples were collected. Of the three subsample methods, the system whereby the nematodes were fixed and preserved by adding hot 10% formalin (Treatment D), the mean of this method was not different from the readings from the standard method (Treatment A). The within treatment variation was lower for the Radopholus readings than the Helicotylenchus readings (Tables 76-77). Relative variation ranged from 6 to 29% in the Radopholus samples and 8 to 58% in the Helicotylenchus samples. The analysis of variance showed no block effect so that although variation is present within treatments, this variation between treatments is of the same magnitude. The variation between means derived from six observations per mean for the same population is of the same magnitude as the variation within the readings making up the mean (Table 78).

Since the Treatment D, where 10 cc of standard solution was killed and preserved by the addition of 10 cc of 10% formalin, was not different from the standard method based upon the means of six readings for each of the four samples, this is the system that will be used to kill and fix nematodes for transport to the laboratory for counting. Since these samples are a 5% formalin solution, no special permits will be required for transport from one country to another. (TAYLOR, CALDERON)

Establishing Infestation of Radopholus for Studying Interactions with Fungi

Previous inoculations with Radopholus were not highly successful due to failure to obtain a Radopholus infestation. An inoculation study using levels of 20,000; 10,000; 5,000; 2,500 and 1,000 Radopholus per inoculation site was initiated. Roots were produced from rhizomes which had been surface sterilized and then grown in vermiculite. Nematodes were surface sterilized and cleaned using screening and centrifugation. Following concentration, the nematodes were added to the inoculation site in 5 ml of solution. The roots were covered again with vermiculite and incubated for one month. Results are presented in Table 79. To insure that a nematode infestation is obtained, it is going to be necessary to inoculate with at least 5,000 nematodes/site. At this level and above, lesions are formed and nematodes can be recovered. For further studies, it is suggested that the test run at least two months to insure at least one generation and possibly two generations of the nematodes. (TAYLOR, CALDERON)

Nematode Sampling in DBCP Experiments in Honduras

The DBCP experiments were sampled twice during 1976. The standard method of sampling was used to obtain root weight, lesion index, Radopholus/100 g of roots and Helicotylenchus/100 g of roots. In Higuerito, the second sampling was made 24 weeks from the fifth treatment, in San Juan it was 18 weeks from the fifth treatment, and in Los Limones 3 weeks from the sixth treatment. Five individual samples were taken in each replicate and the mean of these

Table 76. Counts of <u>Radopholus</u> using different storage preparation procedures. Means, standard deviations, and relative variation of four samples - six readings/mean*

	A	B	C	D
1)	128.5 $\pm$ 14.0 a	115.5 $\pm$ 16.0 ab	99.3 $\pm$ 10.4 b	109.7 $\pm$ 19.7 ab
	11%	14%	10%	18%
2)	101.5 $\pm$ 7.1	90.2 $\pm$ 7.8	108.0 $\pm$ 20.2	96.0 $\pm$ 6.4
	7%	9%	19%	6%
3)	245.3 $\pm$ 19.1 y	190.7 $\pm$ 11.0 z	369.0 $\pm$ 33.4 x	267.7 $\pm$ 38.4 y
	8%	6%	9%	14%
4)	184.5 $\pm$ 16.7	163.3 $\pm$ 47.9	203.3 $\pm$ 22.9	196.0 $\pm$ 39.4
	9%	29%	11%	20%

A - Standard process
B - Subsample and concentrate
C - Subsample and dilute
D - Subsample and dilute (Hot formalin)

* Means not followed by the same letter are statistically different at the 1% (x,y,z) and 5% (a,b) level.

Table 77. Counts of *Helicotylenchus* using different storage preparations. Means, standard deviation, and relative variation of four samples - six readings per mean*.

	A	B	C	D
1)	12.5 ± 3.7	15.8 ± 4.1	19.3 ± 6.2	14.0 ± 8.1
	30%	26%	32%	58%
2)	14.7 ± 4.8 b	18.2 ± 4.4 b	27.0 ± 4.3 a	20.3 ± 8.8 ab
	33%	24%	16%	43%
3)	16.8 ± 5.1 y	25.8 ± 5.0 y	49.7 ± 11.8 x	20.0 ± 10.6 y
	30%	19%	24%	53%
4)	24.8 ± 5.9	29.2 ± 2.2	44.3 ± 14.2	34.3 ± 9.6
	24%	8%	32%	28%

A - Standard process
B - Subsample and concentrate
C - Subsample and dilute
D - Subsample and dilute (Hot Formalin)

* Means not followed by the same letter are statistically different at the 1% (x,y,z) and 5% (a,b) level.

Table 78. Means and relative variation of combined methods of handling nematode samples for storage and transportation

Sample	Mean*	Relative Variation	Radopholus/100 g of roots
Radopholus			
1	113.3 ± 12.2	11%	56,650
2	98.9 ± 7.6	8%	49,450
3	268.2 ± 74.6	28%	134,100
4	186.8 ± 17.5	9%	93,400
Helicotylenchus			
1	15.4 ± 2.9	19%	7,700
2	20.1 ± 5.2	26%	10,050
3	26.8 ± 16.0	60%	13,400
4	33.1 ± 8.4	25%	16,550

* Number of samples = 24 - Combined readings of treatments A, B, C, and D.

Table 79. Radopholus recovery following inoculation at various rates to banana roots

Nematode level		Lesions (cm)	Root weight (g)	Radopholus recovered/ 100 ml solution	Percent recovery (%)	Radopholus/ 100 g of roots
20,000	1.	4.0	1.7	1525	7.63	88450
	2.	2.5	3.0	1250	6.25	41250
	3.	6.2	2.3	3325	16.63	142980
	4.	5.9	2.3	2250	11.25	96750
$\bar{x}$		4.7		2087	10.44	92360
10,000	1.	6.5	1.6	4475	44.75	277450
	2.	8.8	5.2	1750	17.50	33250
	3.	3.7	1.6	1000	10.00	62000
	4.	3.4	1.4	300	3.00	21300
$\bar{x}$		5.6		1881	18.81	98500
5,000	1.	2.1	2.2	200	4.00	9000
	2.	4.6	1.3	425	8.50	32300
	3.	2.1	0.9	350	7.00	38850
	4.	3.3	2.1	1000	20.00	47000
$\bar{x}$		3.1		494	9.88	20050
2,500	1.	5.2	3.2	775	31.00	24025
	2.	1.5	2.4	175	7.00	7180
	3.	2.6	1.5	425	17.00	28050
$\bar{x}$		3.1		458	18.33	19750
1,000	1.	0.0	2.3	100	10.00	4300
	2.	0.0	2.4	0	0.00	0
	3.	0.0	2.0	0	0.00	0
$\bar{x}$		0.0		33	3.33	1430

five samples used for the mean of the replicate. Lesion Index, Radopholus/100 g of roots, and Helicotylenchus/100 g of roots means were analyzed using the analysis of variance. A result of the six samplings is presented in Table 80. In Higuerito at the last sampling, the mean differences for lesion index, Radopholus/100 g of roots, and Helicotylenchus/100 g of roots were significant at the 1% level. Here, the level of control was 94% for the Radopholus, 99% for Helicotylenchus, and 83% for the amount of lesioning. In San Juan, mean differences between the treated and the controls for Helicotylenchus were significant at the 1% level, for Radopholus mean differences were significant at the 5% level and the lesion index means were not significantly different. Mean differences in Los Limones were significant at the 1% level for Radopholus and at the 5% level for Helicotylenchus and Lesion Index. Thus, after five cycles of DBCP at originally 16 and currently 14 cc/mat and two cycles per year, we have obtained a good degree of control for Radopholus and Helicotylenchus, particularly in Higuerito. (TAYLOR, CALDERON)

Sucker Height As an Indicator of Response to Nematode Control

Reports in the literature indicate that a faster ratooning rate can result from nematode control. To determine if we were getting a growth response in the DBCP experiments in Honduras, a survey was made for sucker growth. All suckers were measured for the last three cutting ribbons in each of the experiments and recorded separately by cutting ribbon. Data are presented in Table 81. Mean differences were tested by analysis of variance. Results indicate that there is no effect on sucker height by the time the mother plant has reached harvest age. Subsequent surveys will be made to determine if a difference can be detected at a younger age of fruit. (TAYLOR, CALDERON)

Guying Surveys in DBCP Experiments in Honduras (H-74-N4, H-74-N5, H-74-N6)

A method of evaluation of guying is required to determine how well this agricultural operation is being done in regard to protecting the plants from up-root losses. During 1976 two surveys were made in the three DBCP experiments in Honduras. Six different classes of guying were used:

AOK: Guys are attached correctly, angle is correct, and none of the guys have been broken.

0 guys: The two guys have been broken, cut or never attached.

1 guy: A guy missing so a single guy holds up the plant.

Slack guys: Guys attached so that either one or both do not have any tension.

Angle wrong: The guys are not attached in the normal triangle directly behind the fruit or in the direction to which the fruit is leaning.

Table 80. Summary of nematode sampling in DBCP experiments in Honduras for 1974-1976

	Lesion Index				Radopholus/100 g of roots				Helicotylenchus/100 g of roots			
	D	C	%C	F Test	D	C	%C	F Test	D	C	%C	F Test
Higuerito (H-74-N4)												
9/76	5.6	33.0	83	163.18**	2,120	34,020	94	44.37**	150	11,520	99	37.32**
2/76	6.1	24.8	75		3,800	25,150	85		1,730	9,720	82	
9/75	5.8	24.6	76		4,350	37,930	89		1,870	19,650	91	
4/75	5.2	20.0	74		3,530	23,550	85		650	9,830	93	
8/74	16.4	27.9	41		8,450	36,410	77		3,570	19,420	82	
San Juan (H-74-N5)												
9/76	5.7	10.6	46	1.75 NS	1,980	14,130	86	4.98*	1,170	14,130	92	84.27**
2/76	5.8	10.2	43		3,980	13,580	56		480	7,420	94	
9/75	3.9	7.5	48		3,130	7,620	59		820	9,900	95	
4/75	1.4	3.7	62		1,230	6,500	81		1,420	11,630	88	
9/74	12.5	5.2	X		3,610	6,800	47		4,960	18,650	73	
Los Limones (H-74-N6)												
9/76	1.9	3.8	50	8.91*	683	6,720	90	11.03**	900	8,470	89	5.68*
2/76	2.6	6.4	59		200	9,680	98		1,150	3,970	71	
9/75	2.0	6.3	68		720	9,500	92		600	2,930	80	
4/75	1.6	4.6	65		120	7,030	98		400	4,470	91	
4/74	3.5	6.0	42		3,170	8,070	61		2,280	19,417	88	

D - DBCP treatment
C - Control treatment
%C - Percent control
F Test - F Test from analysis of variance

* - 5% level of significance
** - 1% level of significance
NS - Not significant

Table 81. Height of mother and daughter in mean feet for last three cutting ribbons in DBCP trials - Honduras

RIBBON	MOTHER DBCP	MOTHER CONTROL	DAUGHTER DBCP	DAUGHTER CONTROL	F. OBS.*
Higuerito - XII/24/76 (H-74-N4)					
Brown	11.9	12.1	8.7	8.7	0.01 NS
Orange	12.2	11.9	9.5	9.1	0.67 NS
Silver	12.2	11.9	9.0	8.5	3.21 NS
San Juan - 1/3/77 (H-74-N5)					
Brown	12.4	12.3	8.5	9.0	6.41 NS
Green	12.2	12.4	8.3	8.9	4.77 NS
Silver	12.2	12.1	8.9	9.1	0.36 NS
Los Limones - XII/29/76 (H-74-N6)					
Brown	11.7	12.3	8.6	8.5	0.00 NS
Orange	11.8	11.7	8.5	8.2	0.00 NS
Silver	12.0	11.6	9.1	9.1	0.00 NS

* Analysis of variance - F Test - Sucker height

Angle wrong
but no choice: The angle of the guy(s) is not correct but there is no other choice since the placement of the mats may be such that either another mat is not close or the stem is on a ditch or roadway.

When surveys are taken, 50 stems in an area or plot are counted and the results converted to percent. In the DBCP experiments, 50 plants per plot were counted.

The results of the two surveys in 1975 are reported in Table 82. The lack of guying in the case of 0 guys and single guys is in the range of 12-27% (8/76) and 11-18% (12/76). Four spot surveys in Bocas (6/76) indicated that 0 guys and single guys ran 10-14% and a single survey in Golfito (7/76) indicated 8% 0 and single guys. In order to maximize yield and reduce losses, it is going to be necessary to give the plants 100% support. Thus, the economics of reguying cycles should be worked out to insure proper protection. (TAYLOR, CALDERON)

Nematicidal Properties of Kepone

Application of Kepone for banana root borer control in Armuelles has resulted in a 50% reduction in up-rooting. In Golfito, the results have not been as dramatic. Examination of recent up-rooted plants have not indicated excessive amounts of root borer damage. The Golfito test areas were treated with DBCP for nematode control, whereas those in Armuelles were not treated. This raised the question of the nematicidal activity of Kepone.

Two experiments were established in pots to determine if Kepone could be classed as a nematicide using beans as the host plant for nematodes. Treatments were as follows:

Chemical	37-day test g a.i.[1]	33-day test g a.i.[1]
Kepone 20%	2.0	1.0
Nemacur 10% G	2.0	1.0
Furadan 5% G	2.0	1.0
Mocap 5% G	2.0	0.5
Dursban 0.5%	1.6	0.8
Control	0	0

[1] g a.i./7500 cc soil - 1500 cc soil/pot.

Naturally infested Radopholus similis, Helicotylenchus multicinctus, and Meloidogyne sp. soil from the Higuerito area was mixed with the chemical. In clay or plastic pots, 1500 cc of soil was planted to ten Burpee Bush Bean - Red Kidney - No. 5082 seeds. Plants were grown in the greenhouse.

Table 82. Summary of percent guying surveys during 1976 in the DBCP (D) and Control (C) plots in Honduras.

	PLOT	AOK	0 - GUYS - 1		SLACK	ANGLE	ANGLE-NC
Higuerito (H-74-N4)							
8/76	C	32	16	11	27	7	6
	D	24	8	16	36	6	11
12/76	C	41	1	14	12	20	12
	D	40	7	11	14	16	13
San Juan (H-75-N5)							
8/76	C	30	2	10	36	6	15
	D	21	2	18	26	18	20
12/76	C	57	1	13	8	8	12
	D	63	1	13	4	7	12
Los Limones (H-75-N6)							
8/76	C	32	3	10	38	11	7
	D	22	2	17	36	9	13
12/76	C	50	3	11	8	21	8
	D	48	2	9	10	13	18

AOK - Correct guying
Guys - 0 or 1 - cut, broken or missing
Slack - No tension on one or both guys
Angle - Positioning wrong
Angle NC - Positioning wrong but no choice

Results of readings on root weight, top growth, and nematode populations are reported in Table 83 for Kepone, Nemacur and the control treatment. Dursban, Mocap and Furadan were extremely phytotoxic at the rates used in the experiment. Nemacur was slightly phytotoxic. This nematicide-insecticide virtually eliminated all three nematodes from the roots of the beans. Kepone gave a high degree of control of <u>Meloidogyne</u> sp. and <u>Helicotylenchus</u>. Therefore, this chemical can be classed as possessing nematicidal properties.

When this insecticide is applied for borer control, it is applied to the base of the plant adjacent to and on the rhizome. Also, since the chemical is a chlorinated hydrocarbon, it is persistant in the soil. Thus, the chemical is in contact with the area of heavy nematode infestation of the rhizome for a longer period of time than the nematicides currently in use. This could result in a weak nematicide giving a higher degree of control. (TAYLOR, OSTMARK, CALDERON)

<u>Cones for Nematicide Application</u>

During the year, a new system of application of small amounts of chemical such as nematicides, insecticides, or microelements in granular, wettable powder, or dust forms was developed. An application cup that would be easily filled and discharged with a minimum of error and time was desired. Previous cups were cut-off cans or pipes. The new concept was to obtain a wide opening of the cup to allow rapid filling and distribution without having low sides. Cones were prepared to fulfill this need by using 1/4, 3/8, or 1/2 a circle of tin formed into the cone. A set of standards of each size should be developed for preparing cones. As the volume of the chemical increased, the size of the part of a circle was increased. In Golfito, a handle was devised to be soldered all the way around the cone to present a form of protection about the lip of the cup.

It is suggested that when cups are to be fabricated, first the particle density (cc/g - bulk density = g/cc) of the chemical should be determined by obtaining the average volume of three different lots of 100 g of chemical. When the particle density of the chemical is known, a formula of:

Chemical Weight (g) x 0.90 x Particle Density (cc/g) = Volume of Cone

Example: 40 g x 0.90 x 0.73 cc/g = 26.3 cc cone required.

The constant of 0.90 represents 90% of the chemical in the cup and 10% overfill as is common in the field. When the desired volume is known, the size of the cone can be determined by filling one of the series of standard cones and determining the radius of the cone to be cut. This radius is used for the radius of the tin circle. Any further modification to individual cone can be made with a tin snip.

In the process of developing the cones, the amount of fill obtained was checked. When the cone was filled-level, mounded, and completely overfilled, variation for field application could range at 650 production units per acre from 98 through 109 to 119 lbs/acre for a cone (level-fill) delivering 68.3 ± 2.0 g of chemical. Although the slight overfill was more variable at about

Table 83. Nematode population suppression by Kepone compared to Nemacur and an untreated control using red kidney beans as an indicator plant.

Parameter	37 Day Test - 2.0 g ai			33 Day Test - 1.0 g ai		
	Nemacur	Kepone	Control	Nemacur	Kepone	Control
Radopholus/100 g of roots	0	1,192	2,224	0	2,732	20,506
(Percent Control)	(100%)	(46%)	-	(100%)	(87%)	-
Helicotylenchus/100 g of roots	0	3,705	34,532	0	6,236	40,808
(Percent Control)	(100%)	(89%)	-	(100%)	(85%)	-
Meloidogyne/100 g of roots	154	1,538	17,784	0	102	12,232
(Percent Control)	(99%)	(91%)	-	(100%)	(99%)	-
Root Weight/Plant (g - wet)	0.65	1.24	1.56	0.46	0.55	0.59
Top Weight/plant (g - wet)	2.76	3.04	3.33	2.83	2.46	4.09

All means based upon 5 replicates/treatment.

Grams active ingredient is total for 5 replicates.

7%, this is the type of fill that is obtained by field crews and thus is the standard to be used for cone size selection. In general, cones developed to deliver 40, 50 or 60 g of chemical yielded within 10% of the desired weight of the chemical using volume as a criterion for cone preparation. (TAYLOR)

ENTOMOLOGY

CORKY SCAB - PHILIPPINES

Corky scab continues to be a serious blemish of Philippine fruit (see 1974 Annual Report, p. 53). During April and May 1976, a series of experiments was conducted to find a control method other than bud spraying. Briefly, the thrips enters emerging buds and feeds on the inner surface of the fruit within the bud. As the bracts lift, the thrips desert the exposed hands and continue to feed and reproduce on the remaining enclosed hands. The inner surface of fingers within the bud becomes the outer surface when the fingers turn upward. Corky scabbing appears on the outer surface of the fruit as it reaches maturity.

Biology of Thrips

In addition to the work conducted in 1974, a series of nine ice-cream carton traps (see 1966 Annual Report, p.108) was placed directly under the hanging fruit of each of ten plants dated when the buds first began peeping from the crown. As thrips emerged from the soil under the traps, they moved upward and stuck to the Stickem coating on the polyethylene top of the trap where they were counted daily and marked with a ball-point pen so they were only counted once. The results are shown in Figure 29.

The entire life cycle of attacking adult to newly emerged adult took a minimum of 11 days. Since fruit was debudded and left with no suitable feeding sites for *Thrips florum* at approximately 14 days, the maximum time required for larvae entering the soil, passing through prepupal, pupal stage, then emerging as new adults was six days.

In 1974, males were found to generally emerge before the females (1974 Annual Report, p. 55), but 1976 studies showed both sexes emerging from the soil in a two females to one male sex ratio at approximately the same time.

Control of Corky Scab

There are two approaches to corky scab control: 1) Reduce the population of *Thrips florum*, and 2) Modify farm practices to reduce the formation of corky scab on fruit already thrips-damaged. In order to base control tests on an agreed-upon standard, photos were taken of corky scabbed hands and given an Index Number of 0 (clean) to 4 (heavy). To be sure that the Index was practical, the assistance of Richard Judin, Quality Control Inspector, was elicited. The following index supplemented with photos (Figure 30) was developed. Six sets of photos were sent to the Philippines to standardize

EMERGENCE OF THRIPS FLORUM FROM SOIL BENEATH HANGING STEMS TADECO, PHILIPPINES.

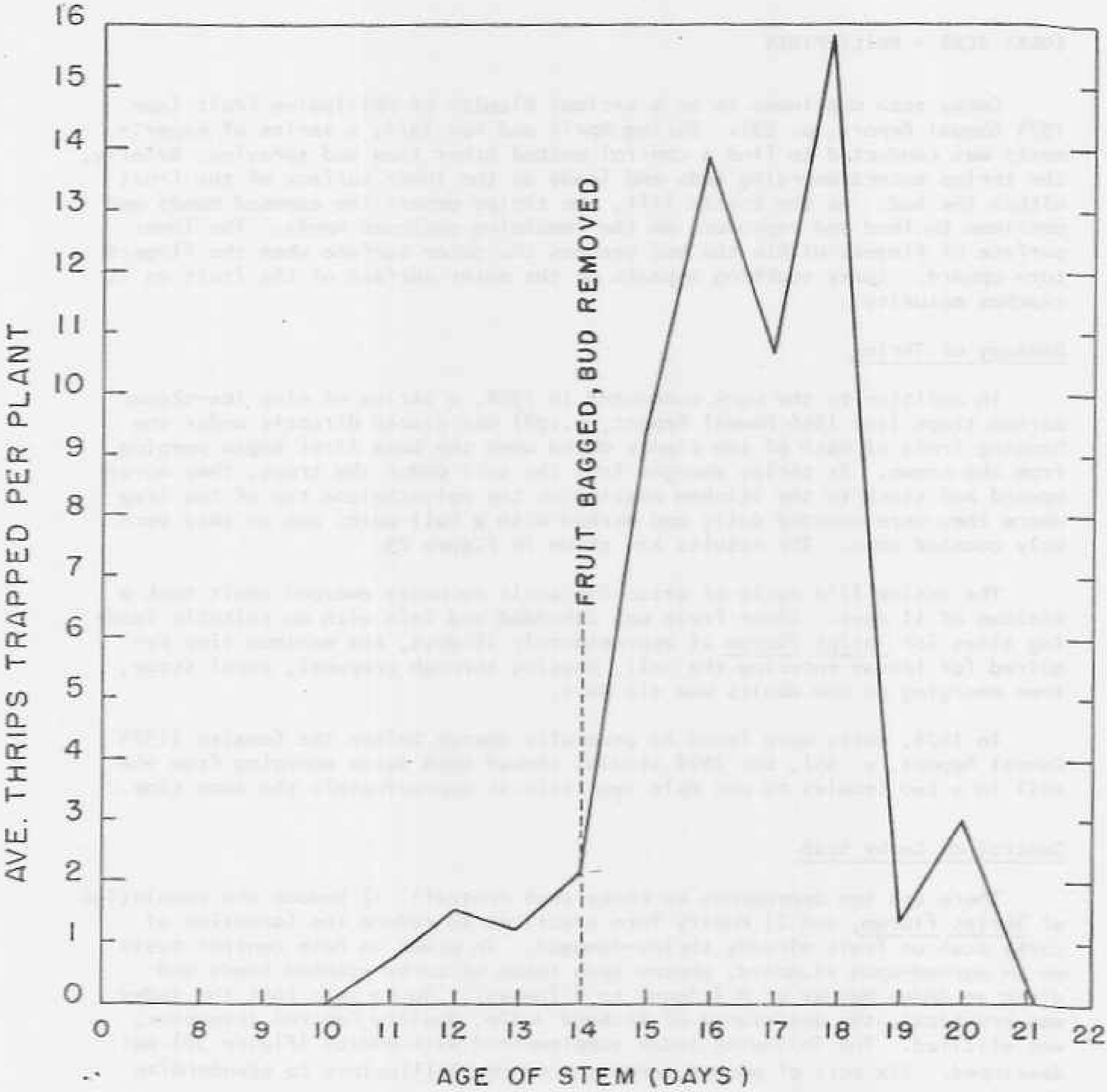


Figure 29

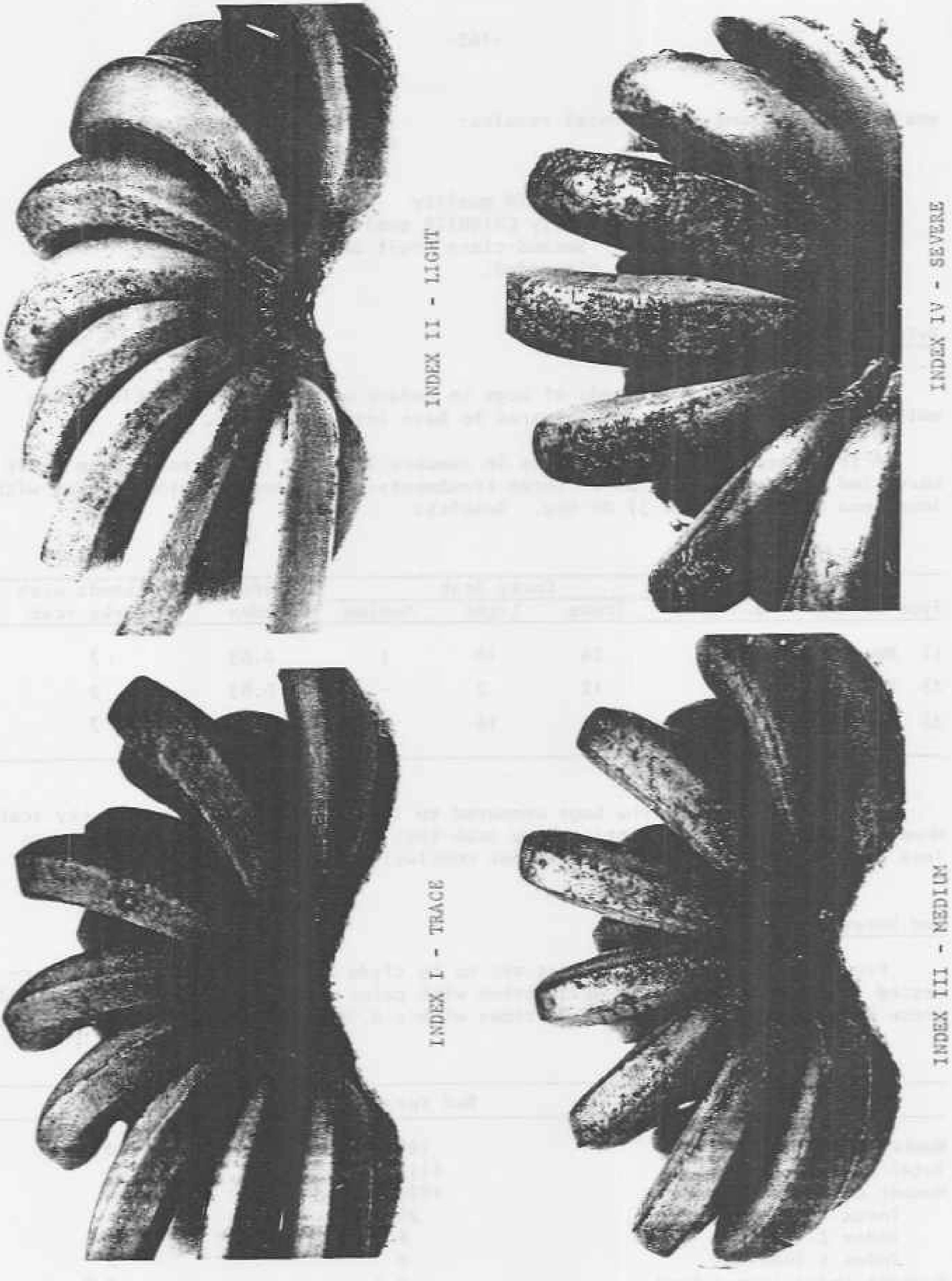


Figure 30. Index of corky scab damage, Tagum, Philippines.

quality control and experimental results:

0 - clean
1 - trace - CHIQUITA quality
2 - light - Barely CHIQUITA quality
3 - medium - Second-class fruit or discarded
4 - heavy - Discarded.

Tying Bad End to Reduce Corky Scab

While tying the lower ends of bags to reduce wind tearing, Dr. Lloyd Berg noticed that stems so treated appeared to have less corky scab.

A trial begun by Clyde Stephens in January in order for me to examine fruit harvested in April consisted of three treatments: 1) Normal bagging, 2) Bag with lower end tied shut, and 3) No bag. Results:

Type of bag	No. hands	Corky Scab			Overall index	% hands with corky scab
		Trace	Light	Medium		
1) Normal	564	24	14	1	0.09	7
2) Tied	604	12	2	-	0.03	2
3) None	527	21	16	-	0.09	7

Tying the bottom of the bags appeared to inhibit the formation of corky scab. However, the area had so little corky scab that the Index in all treatments was less than 1 (trace) so the test was not conclusive.

Bud Spraying

Fruit from a bud-spraying test set up by Clyde Stephens in January was harvested in early May. Plants were marked with paint when buds began to emerge and these buds were each sprayed three times with a 0.06% diazinon spray. Results:

	Bud Sprayed	Not Sprayed
Number of stems	128	130
Total hands	1113	1200
Number of hands clean	1079	1040
Index 1 (trace)	28	114
Index 2 (light)	6	46
Index 3 (medium)	0	0
Average Index lowest hand	0.2	0.8

Bud spraying reduced corky scab under ideal experi. farm practice some reduction can be expected and should co ere, bud spraying will reduce losses. This experiment was i. even the lowest hand (which is normally the most severely blem. scab) on unsprayed bunches did not average Index 1 (trace). Also, ing is always more effective in research experiments than in farm p. Under farm practice some buds are missed while spray cycles lag at tim. lowing thrips to enter the buds. There are few treatments that effecti kill thrips within buds.

Economics of Bud Spraying

Besides the problems of labor shortage, poor application, over-loo and resistance build-up inherent in a full-scale bud spraying project, a cost consideration. The Japanese market has never downgraded our fru corky scab so there is no monetary loss at that end.

Figuring that 1,000 buds can be sprayed with 20 gal of mix includi lb of 40% diazinon, 9,450 twenty-gal mixes would be sprayed yearly. Th amounts to 11,812 lb diazinon at $3 lb or $35,437 per cycle. At three per bud, a year's supply of diazinon would cost $106,300.

Labor would require 180 men @ ₽ 8.00 x 6 days/week x 52 or $61,700

Equipment consists of 180 sprayers, booms and nozzles which cost $ unit and last 2 years, or $5,400 for equipment.

Total: $173,400 per year to be weighed against corky scab losses.

Early and Regular Bagging

An experiment was conducted to compare the effects of early and nc ging using Poly-D, diazinon-impregnated (experimental) and plain, 0.5 m ethylene. There were six treatments including an unbagged check descri Table 84.

Although 25 stems in each treatment were either bagged or marked (May 3, 1976), only 15 to 19 stems per treatment were harvested on Augu because the rest blew down.

Results showed that Poly-D bags attached to 7-8 day-old stems pre corky scab from developing to more than "light", a category generally for CHIQUITA quality. Strangely, the Poly-D bags placed on 2-week-old resulted in only seven hands with corky scab as compared to 41 for unb. fruit and 16 for the Poly-D early bags. From the biological data I wo assumed that normal bagging is too late to kill many Thrips florum.

Poly-D normal bagging was then extended to a farm scale to thorou test it before considering the more labor intensive early bagging. (O RAROS)

Table 87. Effect of treatments on stem weight - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number*			
	1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Stem Weight			
	kg			
A: Water levels				
1) 25 mm of water/week	28.36 a	39.68 a	52.68 a	35.09 b
2) 38 mm of water/week	26.13 a	40.81 a	51.22 a	36.63 b
3) 50 mm of water/week	28.36 a	40.59 a	52.45 a	38.18 a
C. V., %	5.50	5.40	5.10	2.64
B: Nitrogen levels				
1) 84 kg of N/ha/year	27.36 a	41.59 a	52.0 a	36.77 a
2) 168 kg of N/ha/year	26.00 a	41.59 a	51.5 a	36.36 a
3) 252 kg of N/ha/year	26.86 a	39.90 a	53.81 a	37.22 a
C. V., %	6.01	3.10	4.40	3.42
C: Nº of drippers/plant				
1) 1 dripper per plant	21.44 b	38.59 a	49.59 a	31.86 a
2) 2 drippers per plant	24.95 a	40.50 a	49.45 a	34.86 a
3) 3 drippers per plant	25.40 a	38.31 a	48.31 a	34.31 a
C. V., %	5.32	4.40	6.30	5.13

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 88. Effect of treatments on maturation period - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number*			
	1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Maturation Period			
	days			
A: Water levels				
1) 25 mm of water/week	100.6 a	95.4 a	103.0 a	98.7 a
2) 38 mm of water/week	101.4 a	103.0 a	99.9 a	101.8 a
3) 50 mm of water/week	98.6 b	103.7 a	99.6 a	100.8 a
C. V., %	0.68	5.06	3.10	2.50
B: Nitrogen levels				
1) 84 kg of N/ha/year	100.6 a	102.8 a	98.6 a	101.3 a
2) 168 kg of N/ha/year	103.4 a	103.7 a	100.1 a	103.0 a
3) 252 kg of N/ha/year	104.4 a	104.7 a	103.6 a	104.4 a
C. V., %	2.66	1.80	2.30	1.70
C: Nº of drippers/plant				
1) 1 dripper per plant	104.2 a	100.1 a	104.8 a	102.4 a
2) 2 drippers per plant	101.4 b	103.0 a	105.7 a	102.6 a
3) 3 drippers per plant	102.3 b	102.0 a	104.9 a	102.5 a
C. V., %	0.97	3.20	1.95	1.56

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 89. Effect of treatments on plant height - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number* 1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Plant Height			
	---------- m ----------			
A: Water levels				
1) 25 mm of water/week	2.13 a	2.89 a	3.50 a	2.65 b
2) 38 mm of water/week	2.16 a	2.92 a	3.44 a	2.71 a
3) 50 mm of water/week	2.22 a	2.92 a	3.44 a	2.74 a
C. V., %	3.97	1.79	2.54	1.63
B: Nitrogen levels				
1) 84 kg of N/ha/year	2.55 a	2.92 a	3.41 a	2.68 a
2) 168 kg of N/ha/year	2.22 a	2.92 a	3.47 a	2.71 a
3) 252 kg of N/ha/year	2.25 a	2.92 a	3.50 a	2.74 a
C. V., %	2.36	1.20	1.60	1.74
C: Nº of drippers/plant				
1) 1 dripper per plant	2.10 a	2.86 a	3.38 a	2.59 a
2) 2 drippers per plant	2.13 a	2.86 a	3.35 a	2.59 a
3) 3 drippers per plant	2.16 a	2.83 a	3.35 a	2.62 a
C. V., %	4.05	1.17	2.80	2.51

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 90. Effect of treatments on pseudostem circumference - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number* 1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Pseudostem Circumference			
	cm			
A: Water levels				
1) 25 mm of water/week	48.76 a	69.08 a	82.29 a	61.97 b
2) 38 mm of water/week	49.78 a	70.35 a	82.29 a	64.00 a
3) 50 mm of water/week	51.30 a	70.35 a	82.55 a	65.27 a
C. V., %	3.77	1.35	2.57	1.59
B: Nitrogen levels				
1) 84 kg of N/ha/year	51.30 a	70.61 a	82.55 a	63.75 a
2) 168 kg of N/ha/year	50.80 a	71.12 a	82.29 a	64.26 a
3) 252 kg of N/ha/year	51.30 a	70.10 a	82.29 a	64.77 a
C. V., %	2.17	1.48	2.30	1.49
C: Nº of drippers/plant				
1) 1 dripper per plant	46.48 a	68.83 a	53.59 a	59.69 a
2) 2 drippers per plant	49.02 a	68.83 a	56.64 a	61.46 a
3) 3 drippers per plant	49.27 a	68.07 a	56.38 a	61.72 a
C. V., %	3.97	2.13	2.80	3.18

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 91. Effect of treatments on length of the basal finger - Drip Irrigation Experiment, Guaruma II Farm, Honduras.

Treatments	Harvest Number*			
	1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Finger Length			
	cm			
A: Water levels				
1) 25 mm of water/week	23.11 a	22.60 a	24.38 a	23.11 a
2) 38 mm of water/week	22.86 b	22.60 a	24.63 a	23.11 a
3) 50 mm of water/week	23.62 a	22.60 a	24.38 a	23.36 a
C. V., %	0.65	1.60	1.44	0.83
B: Nitrogen levels				
1) 84 kg of N/ha/year	22.86 a	22.60 a	24.38 a	23.11 a
2) 168 kg of N/ha/year	22.86 a	22.60 a	24.63 a	22.86 a
3) 252 kg of N/ha/year	23.11 a	22.35 a	24.89 a	23.11 a
C. V., %	1.91	.86	2.46	0.76
C: Nº of drippers/plant				
1) 1 dripper per plant	22.35 a	22.35 a	24.63 a	22.47 b
2) 2 drippers per plant	22.86 a	22.86 a	24.63 a	23.05 a
3) 3 drippers per plant	22.86 a	22.60 a	24.38 a	22.92 a
C. V., %	1.30	1.20	1.23	.56

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 92. Effect of treatments on length of middle finger - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number*			
	1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Finger Length			
	cm			
A: Water levels				
1) 25 mm of water/week	21.08 a	20.32 a	22.35 a	20.82 a
2) 38 mm of water/week	21.08 a	20.32 a	22.35 a	21.08 a
3) 50 mm of water/week	21.36 a	20.32 a	21.84 b	21.08 a
C. V., %	1.20	1.08	.99	0.53
B: Nitrogen levels				
1) 84 kg of N/ha/year	20.82 a	20.32 a	22.35 a	20.82 a
2) 168 kg of N/ha/year	20.82 a	20.06 a	22.60 a	20.82 a
3) 252 kg of N/ha/year	20.82 a	19.81 a	22.60 a	20.82 a
C. V., %	2.10	1.09	2.56	1.06
C: Nº of drippers/plant				
1) 1 dripper per plant	20.57 a	20.32 a	22.09 a	20.57 a
2) 2 drippers per plant	21.08 a	20.06 a	22.60 a	20.82 a
3) 3 drippers per plant	21.08 a	20.06 a	22.35 a	20.82 a
C. V., %	1.20	1.20	2.97	0.79

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 93. Effect of treatments on length of apical finger - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number* 1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Finger Length			
	cm			
A: Water levels				
1) 25 mm of water/week	18.79 a	17.78 a	18.79 a	18.28 a
2) 38 mm of water/week	18.79 a	17.78 a	19.05 a	18.54 a
3) 50 mm of water/week	19.05 a	18.03 a	18.79 a	18.54 a
C. V., %	1.35	0.79	2.09	1.21
B: Nitrogen levels				
1) 84 kg of N/ha/year	18.54 a	10.03 a	19.05 a	18.28 a
2) 168 kg of N/ha/year	18.54 a	17.78 a	19.05 a	18.28 a
3) 252 kg of N/ha/year	18.54 a	17.78 a	19.30 a	18.28 a
C. V., %	1.94	0.79	2.66	1.15
C: Nº of drippers/plant				
1) 1 dripper per plant	18.28 b	18.03 a	19.30 a	18.28 b
2) 2 drippers per plant	18.79 a	18.03 a	19.30 a	18.54 a
3) 3 drippers per plant	18.79 a	18.03 a	19.30 a	18.54 a
C. V., %	1.36	1.05	2.70	0.94

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 94. Effect of treatments on number of hands at harvest - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number* 1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Stem Size			
	Hands			
A: Water levels				
1) 25 mm of water/week	7.4 a	10.5 a	12.1 a	9.3 c
2) 38 mm of water/week	7.6 a	10.6 a	12.1 a	9.6 b
3) 50 mm of water/week	7.9 a	10.8 a	12.1 a	9.9 a
C. V., %	4.16	2.90	4.10	1.54
B: Nitrogen levels				
1) 84 kg of N/ha/year	7.9 a	10.7 a	12.1 a	9.7 a
2) 168 kg of N/ha/year	7.5 a	10.8 a	12.2 a	9.6 a
3) 252 kg of N/ha/year	7.8 a	10.6 a	12.2 a	9.7 a
C. V., %	3.17	2.07	2.74	1.76
C: Nº of drippers/plant				
1) 1 dripper per plant	6.7 b	10.4 a	11.9 a	8.9 a
2) 2 drippers per plant	7.4 a	10.4 a	11.8 a	9.3 a
3) 3 drippers per plant	7.5 a	10.2 a	11.9 a	9.3 a
C. V., %	3.66	3.30	4.15	3.03

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 95. Effect of treatments on number of potential hands at shooting - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number* 1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Stem Size			
	Hands			
A: Water levels				
1) 25 mm of water/week	8.4 a	11.5 a	13.1 a	10.3 c
2) 38 mm of water/week	8.6 a	11.6 a	13.1 a	10.6 b
3) 50 mm of water/week	8.9 a	11.8 a	13.1 a	10.9 a
C. V., %	3.76	2.66	3.79	1.39
B: Nitrogen levels				
1) 84 kg of N/ha/year	8.9 a	11.7 a	13.1 a	10.7 a
2) 168 kg of N/ha/year	8.5 a	11.8 a	13.2 a	10.6 a
3) 252 kg of N/ha/year	8.8 a	11.6 a	13.2 a	10.7 a
C. V., %	2.80	1.90	2.54	1.57
C: Nº of drippers/plant				
1) 1 dripper per plant	7.9 a	11.4 a	12.9 a	9.9 a
2) 2 drippers per plant	8.4 a	11.4 a	12.8 a	10.3 a
3) 3 drippers per plant	8.5 a	11.2 a	12.9 a	10.3 a
C. V., %	3.21	3.70	3.83	2.73

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 96. Effect of treatments on number of leaves at harvest - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number*			
	1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Leaves/plant			
A: Water levels				
1) 25 mm of water/week	8.1 a	8.1 a	8.5 a	8.1 b
2) 38 mm of water/week	8.1 a	8.1 a	8.8 a	8.2 b
3) 50 mm of water/week	8.2 a	8.4 a	8.7 a	8.4 a
C. V., %	3.48	3.35	2.96	1.16
B: Nitrogen levels				
1) 84 kg of N/ha/year	8.5 a	8.2 a	8.6 a	8.4 a
2) 168 kg of N/ha/year	7.9 b	8.1 a	8.7 a	8.1 a
3) 252 kg of N/ha/year	8.0 b	8.0 a	8.8 a	8.2 a
C. V., %	3.00	2.06	3.49	2.37
C: Nº of drippers/plant				
1) 1 dripper per plant	7.7 a	8.2 a	8.8 a	8.0 a
2) 2 drippers per plant	8.2 a	8.1 a	8.5 a	8.2 a
3) 3 drippers per plant	8.2 a	8.0 a	8.5 a	8.2 a
C. V., %	3.28	1.36	2.14	1.35

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

Table 97. Effect of treatments on number of leaves at shooting - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	Harvest Number*			
	1 (Plantilla)	2 (1st Ratoon)	3 (2nd Ratoon)	1 + 2 + 3
	Leaves/plant			
A: Water levels				
1) 25 mm of water/week	13.8 a	15.1 a	15.4 a	14.6 b
2) 38 mm of water/week	14.0 a	15.1 a	15.5 a	14.7 b
3) 50 mm of water/week	14.3 a	15.2 a	15.5 a	14.9 a
C. V., %	1.88	0.85	.88	0.68
B: Nitrogen levels				
1) 84 kg of N/ha/year	14.2 a	15.2 a	15.4 a	14.8 a
2) 168 kg of N/ha/year	13.9 a	15.2 a	15.4 a	14.7 a
3) 252 kg of N/ha/year	14.1 a	15.2 a	15.5 a	14.8 a
C. V., %	1.23	0.73	1.44	0.49
C: Nº of drippers/plant				
1) 1 dripper per plant	14.0 a	15.1 a	15.5 a	14.6 a
2) 2 drippers per plant	14.2 a	15.2 a	15.4 a	14.8 a
3) 3 drippers per plant	14.0 a	15.2 a	15.4 a	14.7 a
C. V., %	3.48	1.37	1.69	1.64

* Values within columns within subtables followed by different letters are significantly different at 0.05 probability level.

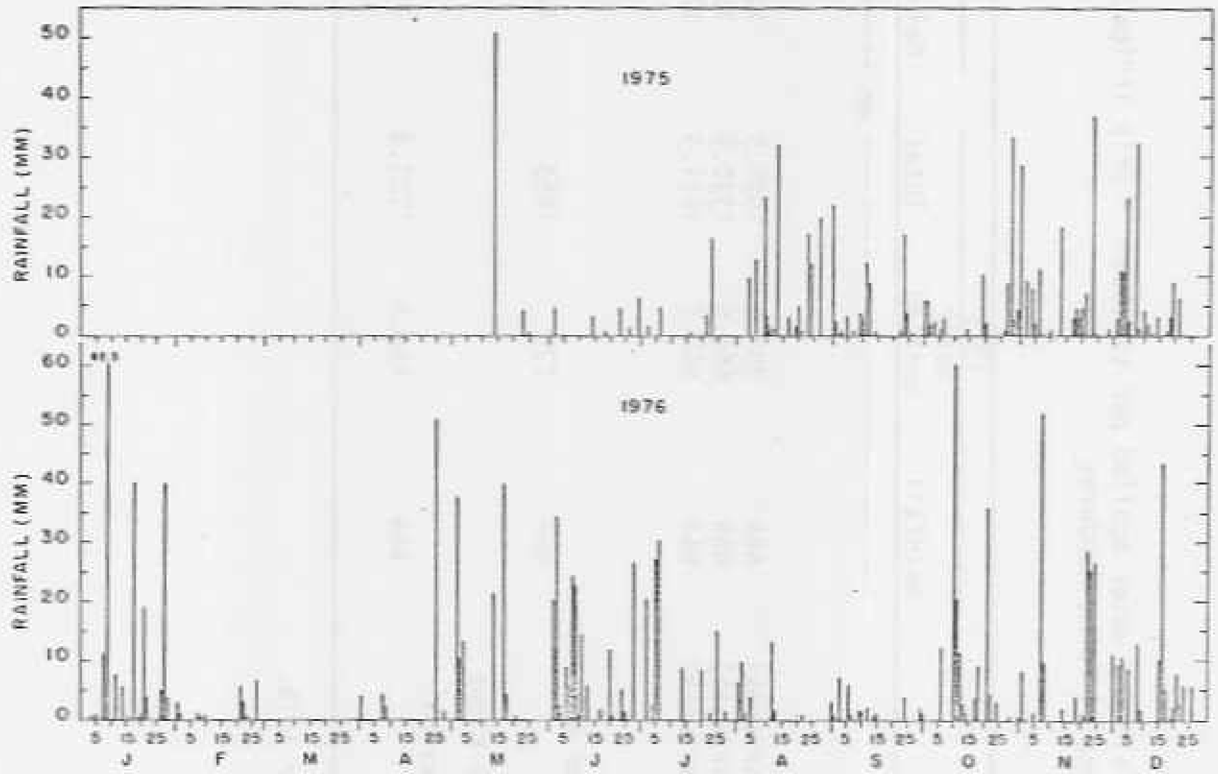


Figure 31. Daily rainfall (mm) distribution at Guaruma II Farm from May 1975 through December 1976.

Table 98. Rainfall and water applied per treatment - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Treatments	1975			1976*		
	Rainfall	Water applied	Total	Rainfall	Water applied	Total
	mm					
Experiment A: Water levels						
Treatment 1 (25 mm of water per week)	664	394.5	1058.5	1267	512.6	1779.6
Treatment 2 (38 mm of water per week)	664	666.6	1330.6	1267	836.7	2103.7
Treatment 3 (50 mm of water per week)	664	967.5	1631.5	1267	1139.9	2406.9
Experiment B: Nitrogen levels						
(Irrigating with 44 mm of water per week)	664	779	1463	1267	997	2264.0
Experiment C: Nº of dripper per plant						
(Irrigating on a daily evaporation basis)	664	459.6	1123.6	1267	643.3	1910.3

* Data collected through October 1976.

Experiment B - Nitrogen Levels

Eighty-four, 168 and 252 kg of N per ha per year (75, 150 and 225 lb of N per acre per year) are compared in this trial. All treatments receive 44 mm of water per week and each plant in these plots is irrigated with two drippers per plant.

No statistical differences were found among treatments for any of the parameters studied (Tables 87-97). This experiment has shown uniform behavior through all harvests. The average stem weight in this trial was very similar to the average stem weights for the water levels trial (harvest 1 + 2 + 3 in Table 87). These values were higher than the weights found in the experiment for number of drippers per plant which receive the same amount of N than the water levels trial. These data indicate that probably there is a water-N interaction, but with the actual experimental design we were unable to detect it. Perhaps if this experiment had been designed taking into consideration first and second order interactions, better results could have been obtained. Moreover, the number of replications is quite low.

Trial B indicates that 84 kg of N per ha per year is as effective as 252 kg per ha per year to produce high yields of quality fruit under the conditions of this experiment. A tendency for the maturation period to increase when higher quantities of N were applied can also be observed.

In order to determine the efficiency of N applied through the drip irrigation system, a determination of the uniformity of N application was made. All the solution from one emitter per replication in each treatment was collected during the fertilization. Nitrogen concentration was determined in each sample. The results shown in the following table were obtained:

Nitrogen applied	Nitrogen recovered	Efficiency of nitrogen application
------- kg/ha/yr	---------	- % of amount applied -
84	78	93
168	150	89
252	260	103

Leaf lamina samples for chemical analysis were collected in February and September 1976 in order to determine whether there was any effect of treatments on chemical composition. The following table shows an increase in N concentration with each increment in N applied. On the other hand, K content in the leaf decreased at higher N levels:

Nitrogen level	Sampling month (1976)			
	February		September	
	Nutrient concentration in the dry matter			
	N	K	N	K
kg/ha/yr	----------	---------- %	----------	----------
84	2.70	3.19	2.39	3.02
168	2.71	3.02	2.53	2.90
252	2.79	3.03	2.55	2.75

The above data indicate that even the lowest N rate supplied sufficient N to the banana plant for adequate growth and production. On the other hand, K concentration for the highest N rate in the September sampling may be close to the minimum required for maximum production of quality fruit. The average concentration of P, Ca and Mg was 0.16, 1.04 and 0.26%, respectively; while micronutrient content was 92, 187, 21 and 27 ppm for Fe, Mn, Cu and Zn, respectively.

Experiment C - Number of Drippers Per Plant

One, two and three drippers per plant are compared in this trial. All treatments receive a basal application of 252 kg of N per ha per year. This experiment is irrigated based on the daily evaporation.

The following differences among treatments at 0.05 probability level were found for the first harvest: stem weight was superior in treatments 2 and 3 than in treatment 1 (Table 87). These two treatments also had longer apical finger than treatment 1 (Table 93). Differences were not observed for plant height, pseudostem circumference, number of hands and number of leaves (Tables 89, 90, 94, 95, 96 and 97).

Stem weight, maturation period, plant height, pseudostem circumference, length of basal and middle fingers, number of hands at shooting and at harvest and number of leaves at shooting and at harvest did not show differences at any probability level when harvests were analyzed separately or together. Statistical differences at 0.05 probability level were observed among treatments for length of apical finger. Treatment 2 was statistically equal to treatment 3 and both had longer fingers than treatment 1 (Table 93).

Although there were no statistical differences among treatments in trial C for the ratoon crops, one dripper per plant showed a lower stem weight than two and three drippers per plant. These results can be explained in terms of the different patterns of water distribution formed.

The estimated fruit yield and stems harvested per plant per year are shown in Table 99. Considering water application at the same N rate, there was a reduction of 9.10 tons per ha of fruit when going from 50 to 38 mm of water per week. Taking into consideration an average of 16% of fruit losses at the packing station, it means 424 boxes (18.18 kg) per hectare. These values correspond to two and a half harvests obtained between October 1975 and November 1976, or 147 boxes per acre per year. There was also a considerable reduction in yields when going from 50 to 25 mm of water per week with the same amount of nitrogen applied.

A decrease in production for the same amount of water applied was observed when different numbers of drippers per plant were used. The smaller amount of water was applied to the number of drippers per plant experiment. It also produced the lowest yields. The above information shows that when the banana plant is irrigated on a daily evaporation basis, as used in the third trial, the plant is probably not receiving an adequate quantity of water for maximum production and a correction factor may be needed. However, it is evident that two and three drippers per plant have a similar response and they are better than one dripper per plant.

Table 99. Estimated fruit production and stems harvested per plant per year - Drip Irrigation Experiment, Guaruma II Farm, Honduras

Expt.	Treatment	Stems harvested per mat per year from planting through November 1976	Stems harvested per mat per year from first date of harvest through November 1976	Estimated production of stem fruit for all harvests
		-----------------Stem/mat/year-----------------		Metric tons/hectare
A	1) 25 mm of water/week	1.22	1.91	120.6
	2) 38 mm of water/week	1.31	2.07	136.05
	3) 50 mm of water/week	1.35	2.12	145.24
B	1) 84 kg of N/ha/year	1.24	1.96	129.21
	2) 168 kg of N/ha/year	1.27	2.00	130.57
	3) 252 kg of N/ha/year	1.34	2.10	140.37
C	1) 1 dripper per mat	1.18	1.86	106.56
	2) 2 drippers per mat	1.24	1.96	122.42
	3) 3 drippers per mat	1.27	2.00	123.09

The following conclusions can be drawn from the data obtained:

1. Twenty-five mm of water per week is not sufficient to obtain maximum production; the required rate appears to be 50 mm per week.

2. Eighty-four and 168 kg of N per ha per year produce approximately the same quantity of fruit per hectare, but their production is less (although no statistically different) that that obtained with 252 kg of N per hectare per year.

3. Two drippers per plant appear to be adequate, while one dripper per plant is not sufficient.

4. Irrigating bananas on a daily evaporation basis may not guarantee an optimum moisture content and a correction factor may be needed.

(RODRIGUEZ, JACOME, LANZA)

CHEMISTRY LABORATORY SERVICES

The distribution, by regions, of banana leaf and soil samples analyzed in 1976 is shown in Table 100. A total of 9,532 banana leaf samples were chemically analyzed, while the chemical and mechanical analysis of 2,244 and 418 soil samples from banana plantings or potential banana areas, respectively, was made. These values represent 107% more banana leaf samples and 22% less soil samples analyzed this year as compared to 1975. Additionally, Br content was determined in 427 green banana fruit samples, an increment of 10% over last year. (MANZANARES)

NUTRITION

Foliar Analyses - Honduras

A total of 4,485 banana leaf samples were chemically analyzed. This represents a 150% increase for foliar analysis in bananas as compared to last year. Banana leaf samples were collected from fertilizer experiments and from all commercial banana areas in the Division. Since there was a marked decrease in K concentration in leaf samples from areas of La Lima District that did not receive a K application this year, a basal K application to the entire District was recommended for 1977.

Analyses of Ripe Bananas - Honduras

Banana fruit samples were collected from three banana cultivars, Grand Nain (Guaruma I and Omonita), VALERY (San Juan and Mopala) and Giant Cavendish (CAGSSA). Different plant growth conditions - poor, medium and good - were also represented. Soil and leaf samples for chemical analyses were also collected from the same areas where fruit samples were obtained in order to determine whether any relationship in chemical composition among the three materials analyzed existed.

Table 100. Distribution of banana leaf and soil samples from different regions analyzed in 1976

Division	Banana leaf samples	Soil Chemical	Soil Mechanical	Total
	------------ No. of samples analyzed ------------			
Honduras	4,485	93	24	4,602
Golfito	1,668	1,800	12	3,480
Almirante	1,109	127	158	1,394
Armuelles	972	-	-	972
Turbo	1,024	105	105	1,234
Philippines	231	-	-	231
Dominican Republic	39	-	-	39
Others	4	119	119	242
TOTAL	9,532	2,244	418	12,194

Leaf and ripe banana fruit samples (grade 7) were digested by the "Wet Digestion Method" (H_2SO_4 + CH_3OH + H_2O_2). Soil samples were extracted by a NH_4OAc solution at pH 4.8. Nitrogen was determined by the micro-Kjeldahl method; P by the ascorbic acid procedure; and K, Ca, Mg, Fe, Mn, Cu and Zn by atomic absorption spectrophotometry.

Tables 101 and 102 show texture and chemical properties of the soils, and chemical composition of the leaves, respectively; whereas Table 103 depicts the chemical composition of ripe fingers from the upper, middle and lower hands. Each value for fruit analysis is the average of four determinations (samples), and each sample was composed of five sub-samples. Soil samples were composed of 20 sub-samples, taken at a depth from 0-30 cm. Values for leaf analysis are means of two determinations (samples), and each sample was composed of five sub-samples.

Generally, a relationship among chemical composition of the soil, leaf and fruit was observed. Soil from Guaruma I had a very high P content and it was reflected in the higher P concentration in the leaf and in the fruit from this farm. However, no direct relationship in P concentration was observed at lower P levels in the soil. There was a closer relationship between soil K and concentration of this nutrient in the fruit than between K in the leaf and K concentration in the soil or in the fruit. No clear relationship in Ca, Mg or Fe concentration among soil, leaf or fruit samples was observed.

Moisture and ash contents were equal to or higher than values published in the Banana Ripening Manual, Circular No. 14, 1965. On the other hand, generally, nutrient concentrations, except for Na and Fe, were slightly lower than the values published.

Calibration of the Previous Leaf Sampling Method with the New International Standard

In order to determine whether there were differences in nutrient concentration in the lamina of banana leaves when the old and the new standard sampling methods were compared, samples were collected following both procedures from San Juan, La Curva and Tacamiche Farms in Honduras; and from Farm 15 in Changuinola. For the old method, a 10 to 25 cm sample was taken from the leaf lamina side that unfurls first, extending from the leaf margin to the midrib, and midway of the length of the third fully developed leaf of recently (1-15 days) shot plants. In the new method, a 10 cm wide strip is cut on both sides of the midrib, half-way along the length of the third leaf of recently shot plants, but the outer half of the strip in each side of the midrib is discarded. This comparison was required because if differences were found, changes in adequacy levels would have to be made.

Table 104 shows macronutrient concentration when both sampling procedures were followed. Values in this table are averages of six composite samples from San Juan Farm, 18 from La Curva and Tacamiche Farms in Honduras; and seven from Farm 15, Changuinola. There were pronounced differences in concentration of some nutrients when both methods were compared. On the average, samples collected following the new procedure had 0.21% less N and 0.10% more K than the ones obtained using the old scheme. No difference in P concentration was found when both methods were compared. Similarly, little or no differences in Ca or Mg content were found when both procedures were followed.

Table 101. Characteristics of soil samples from various farms in the Honduras Division*

Farm	Section	Cable	Text.	pH	Organic matter	Nutrient concentration							
						P	K	Ca	Mg	Fe	Mn	Cu	Zn
					-- % --	ppm							
Guaruma I	38	C-A	TCL	8.1	2.3	74	170	6,200	494	1.8	3	17	1.5
Omonita	25	30	TL	8.2	2.1	19	490	8,700	131	2.8	8	3	1.3
San Juan	29	24	TL	8.4	2.2	30	85	9,900	413	3.3	10	17	1.8
Mopala	5	2	TL	8.3	1.6	13	255	8,400	138	3.5	12	32	2.8
CAGSSA - 12	14-15	Zone 2	SL	8.3	1.7	39	485	9,900	256	4.3	15	43	2.9
CAGSSA - 12	84	Zone 4	TL	8.3	2.5	21	490	9,800	262	2.8	9	39	2.4

* Samples were composed of 20 sub-samples.

Table 102. Chemical composition of banana leaf samples from various farms in the Honduras Division*

Farm	Section	Cable	Plant appearance	Nutrient concentration in the dry matter								
				N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
				%					ppm			
Guaruma I	38	C-A	Poor	2.41	0.21	3.33	0.86	0.25	75	178	8	21
Omonita	25	30	Good	2.64	0.16	3.23	0.84	0.17	75	94	8	21
San Juan	29	24	Poor	2.68	0.16	2.62	0.86	0.27	124	100	8	21
Mopala	5	2	Good	2.63	0.16	3.40	0.82	0.20	74	94	8	21
CAGSSA - 12	14-15	Zone 2	Good	2.66	0.16	3.06	1.01	0.22	85	90	8	21
CAGSSA - 12	84	Zone 4	Medium	2.43	0.16	3.48	0.84	0.20	69	80	8	21

* Values are means of two determinations (samples). Each sample was composed of five sub-samples.

Table 103. Chemical composition of ripe banana fruit from Honduras

Location of sample							Nutrient concentration *					
Farm	Section	Cable	Var.**	Hand	Moist.*	Ash*	P	K	Ca	Mg	Na	Fe
					------- % ------		----------	----------	mg/100 g	----------	----------	
Guaruma I	38		GN	Upper	77.8	0.8	26.3	301.0	7.8	32.3	6.6	1.1
Guaruma I	38		GN	Middle	77.3	0.8	25.3	303.0	6.5	32.2	5.7	1.0
Guaruma I	38		GN	Lower	76.3	0.9	24.9	301.0	5.3	31.0	5.7	1.3
Omonita	25	30	GN	Upper	79.7	1.0	20.0	341.5	8.8	30.4	6.6	1.5
Omonita	25	30	GN	Middle	79.6	0.9	19.0	347.0	6.8	27.6	4.7	1.3
Omonita	25	30	GN	Lower	79.3	0.8	19.7	356.0	4.8	25.7	5.7	1.4
San Juan	29	24	V	Upper	78.4	0.8	14.6	285.0	5.5	28.8	5.6	1.1
San Juan	29	24	V	Middle	78.4	0.7	13.6	285.0	6.0	28.2	5.8	1.1
San Juan	29	24	V	Lower	78.4	0.7	13.8	285.0	7.0	26.9	5.8	1.1
Mopala	25	2	V	Upper	76.4	0.9	15.8	295.0	5.0	28.9	5.5	1.1
Mopala	25	2	V	Middle	76.3	0.9	15.6	306.0	6.5	27.6	6.3	1.1
Mopala	25	2	V	Lower	76.1	1.0	15.4	317.0	8.0	25.7	6.8	1.0
CAGSSA - 12	14-15	1 Zone 2	C	Upper	77.4	1.0	20.6	309.0	9.0	28.2	7.2	1.0
CAGSSA - 12	14-15	1 Zone 2	C	Middle	77.2	0.6	19.7	309.0	6.5	29.1	6.2	1.0
CAGSSA - 12	14-15	1 Zone 2	C	Lower	77.4	0.9	20.4	306.0	7.5	29.4	7.6	1.0
CAGSSA - 12	84	1 Zone 4	C	Upper	77.5	1.2	20.9	319.0	6.0	29.4	6.5	1.0
CAGSSA - 12	84	1 Zone 4	C	Middle	76.7	1.3	20.2	336.0	6.8	28.8	4.6	1.1
CAGSSA - 12	84	1 Zone 4	C	Lower	77.0	1.1	20.0	336.0	8.3	27.0	5.7	1.0

* Values are averages of four determinations.

** GN = Grand Nain; V = VALERY; C = Cavendish.

Table 104. Effect of sampling procedure on macronutrient concentrations in banana leaf lamina from various farms

	Sampling Procedure									
	New Standard Method					Old Method				
	Macronutrient concentration in the dry matter									
Farm	N	P	K	Ca	Mg	N	P	K	Ca	Mg
	%									
San Juan	2.74	0.14	2.95	0.92	0.26	2.87	0.14	2.90	0.91	0.30
La Curva	2.50	0.13	2.93	0.89	0.26	2.77	0.13	2.69	0.81	0.28
Tacamiche	2.66	0.13	2.69	0.81	0.28	2.91	0.13	2.63	0.88	0.28
Farm 15	2.67	0.16	2.87	0.76	0.35	2.85	0.16	2.82	0.72	0.34
Average	2.64	0.14	2.86	0.85	0.29	2.85	0.14	2.76	0.83	0.30

Table 105 depicts micronutrient concentrations in the lamina using the old and the new sampling methods. The most striking difference between both procedures was for Mn. On the average, there were 97 ppm more Mn when the old method was followed; Fe concentration also was higher when the old procedure was followed, but differences in this case were not as pronounced. No differences in Cu or Zn concentration were observed when both methods were compared.

Based on the limited information available, it was suggested to reduce tentatively the minimum N required for adequacy in the third leaf lamina of recently shot plants from 2.60 to 2.40%, and to increase the minimum K concentration from 2.75 to 2.80%. However, since K fertilization is based on foliar analysis made every six months, we recommend to keep the K content in the leaf above 3.00% as an insurance against a sudden drop in concentration. Since the adequacy level for Mn in leaf lamina has been reported as 150 ppm when the old method was used, it probably can be reduced to 60-70 ppm when the new procedure is followed. For Fe, the minimum level may be reduced from 80 to 60-70 ppm. Values suggested are tentative ones and they may change as more information of this type is obtained.

Nitrogen Sources - Caimito Farm

The literature shows higher N losses when urea is applied solid on the soil surface than when it is applied in solution. Similarly, it has been stated that ammonium nitrate (NH_4NO_3) is more efficient than urea in supplying N to plants growing on alkaline soils. Information received recently indicates that Nitroform, a slow-release N compound, was more efficient than urea as a N source to the banana plant in Ecuador. An experiment was designed to compare the efficiency of solid urea (46% N), liquid urea, NH_4NO_3 (32% N) and Nitroform (38% N), and determine the rate of each material required for maximum fruit production.

The experiment was established in Section 36, Caimito Farm in November 1976. Solid urea is applied to supply 196, 280, 365 and 450 kg/ha/year of N (175, 250, 325 and 400 lb/acre/year). Urea in solution, NH_4NO_3 and Nitroform provide 112, 196, 280 and 365 kg/ha/year of N (100, 175, 250 and 325 lb/acre/year). Solid urea and NH_4NO_3 are applied three times a year and liquid urea applications are made four times a year; while only two Nitroform applications per year are made.

Treatments were arranged in a randomized block design with five replications. Plot size is 0.080 ha (0.20 acre) containing 105 production units approximately, but only the 50 mats in the center of each plot are used to collect information. Number of stems harvested, stem weight, total yield, number of hands per stem and nitrogen concentration in the leaf lamina are the parameters used to evaluate response to the treatments applied. Leaf samples to monitor N concentration were obtained before treatments were applied, and 15 and 30 days after the initial application of treatments, and are being taken once a month thereafter. Results will be analyzed statistically by the Analysis of Variance and treatment means will be compared using Duncan's Multiple Range Test.

Table 105. Effect of sampling procedure on micronutrient concentration in banana leaf lamina from various farms

Farm	Sampling Procedure: New Standard Method — Micronutrient concentration in the dry matter: Fe	Mn	Cu	Zn	Old Method: Fe	Mn	Cu	Zn
	ppm							
San Juan	126	89	24	31	156	203	21	35
La Curva	136	115	20	32	153	202	19	33
Tacamiche	117	136	23	32	132	237	22	32
Farm 15	96	287	17	29	104	375	18	26
Average	119	157	21	31	136	254	20	32

Table 106 shows treatments and N concentration in the leaf before treatments were applied, and 15 and 30 days after application of treatments. The data show that a high N concentration has been absorbed by the banana plant 15 days after the application of N. Except for treatments 1, 2, 10 and 13, N concentration in the leaf 30 days following the application of treatments was slightly lower than 15 days after application of the fertilizer materials, indicating that an equilibrium had already been reached.

Nitrogen-Potassium - Laurel Farm

This trial was established in January 1975. Nitrogen is being applied three times a year in January, May and September and K is applied in February and August. Leaf lamina samples, for chemical analysis, were collected in June and November. The main objective of the foliar analysis was to study the relationship between response to treatments and nutrient concentration in the leaf.

Table 107 shows the relationship between treatments and nutrient concentration in the lamina. Slightly lower N content was observed in plots receiving 225 kg/ha/year (200 lb/acre) of N than the ones receiving 336 kg/ha (300 lb/acre). However, a foliar analysis carried out in November 1976 showed that plots receiving 225 kg/ha of N had 2.61% N in the leaf; while those receiving 336 kg/ha had 2.62% N. There was no influence of N application on P, K, Ca or Mg concentration. Similarly, K treatment did not affect N or P content in the leaf, but generally, K application increased K concentration and reduced Ca and Mg levels. The antagonistic effect of K in the absorption of the other main nutrient cations is well-established.

The relationship among K rates, stem weight and K concentration in the lamina is shown in Table 108. No difference in average stem weight was obtained with the application of either 225 kg/ha/year of N or 336 kg/ha, indicating that in this soil the application of 225 kg/ha/year may be sufficient to obtain adequate fruit yields. However, more about N needs will be learned when the data for ratoon crops are statistically analyzed separately. Nonetheless, the information obtained agrees with N concentration in the leaf found in the November sampling, where there was a mean N concentration of 2.61 and 2.62% of N with the application of 225 and 336 kg/ha/year of N, respectively. These values for N concentration in the leaf are considered above the minimum required for satisfactory plant growth and adequate production of quality fruit.

The data in Table 108 also show a small increase in stem weight with the application of K. This agrees with the slightly low K content found in the leaf for the 0 and the lower K rate treatments. Although there is not a clear-cut indication of the best K rate, it appears that it varies between 225 and 450 kg/ha/year (200 and 400 lb/acre) of K. A more distinct optimum rate may be found once the ratoon crops are studied separately.

Phosphorus-Potassium - Guaruma II

A small fertilizer trial was established in November 1975 in an area of Guaruma II Farm being irrigated by a drip irrigation system. The objective of this experiment is to determine whether a response, in plant growth, to

Table 106. Treatments and nitrogen concentration in the lamina - Nitrogen Sources Experiment - Caimito Farm, Honduras

Treatment			Days after application of treatments		
	Nitrogen		0	15	30
Nº	Source	Rate	N concentration in the dry matter		
		kg/ha/year	--------------- % ---------------		
1	Solid urea	196	2.12	2.48	2.58
2	" "	280	2.10	2.54	2.59
3	" "	365	2.32	2.70	2.61
4	" "	450	2.24	2.72	2.57
5	Liquid urea	112	2.31	2.61	2.57
6	" "	196	2.22	2.56	2.55
7	" "	280	2.21	2.61	2.56
8	" "	365	2.45	2.64	2.56
9	NH_4NO_3	112	2.32	2.68	2.59
10	"	196	2.36	2.57	2.61
11	"	280	2.36	2.57	2.56
12	"	365	2.34	2.59	2.55
13	Nitroform	112	2.28	2.53	2.55
14	"	196	2.31	2.59	2.56
15	"	280	2.27	2.58	2.56
16	"	365	2.25	2.65	2.62

* Values are averages of five replications.

Table 107. Effect of treatments on nutrient concentration in the leaf - Nitrogen-Potassium Experiment - Laurel Farm, Honduras

Nº	Treatment Nitrogen	Treatment Potassium	Nutrient concentration in the dry matter* N	P	K	Ca	Mg
	kg/ha/year	kg/ha/year	%	%	%	%	%
1	225	0	2.39	0.16	2.82	0.88	0.26
2	225	225	2.29	0.16	2.88	0.81	0.25
3	225	450	2.24	0.15	2.77	0.78	0.22
4	225	675	2.49	0.16	3.25	0.82	0.20
5	225	900	2.29	0.16	3.28	0.81	0.23
6	336	0	2.55	0.17	2.79	0.99	0.26
7	336	225	2.33	0.15	2.67	0.81	0.23
8	336	450	2.51	0.16	3.10	0.84	0.22
9	336	675	2.43	0.18	3.51	0.77	0.22
10	336	900	2.40	0.16	3.16	0.77	0.21

* Sampled in June 1976.

Table 108. Relationship among potassium rates, stem weight and potassium concentration in the leaf lamina - Nitrogen-Potassium Experiment - Laurel Farm, Honduras

Treatment*			Sampling month (1976)	
Nº	Potassium applied	Stem weight	June	November
			K concentration in the dry matter	
	kg/ha/year	kg**	%	
1	0	32.4 b	2.82	3.00
2	225	32.2 b	2.88	2.91
3	450	34.7 a	2.77	3.09
4	675	35.7 a	3.25	3.19
5	900	35.6 a	3.28	3.35
6	0	32.6 b	2.79	2.78
7	225	34.5 a	2.67	2.95
8	450	33.6 b	3.10	3.15
9	675	35.7 a	3.51	3.09
10	900	36.1 a	3.16	3.29

* Treatments 1 through 5 received 225 kg/ha/year of N, and treatments 6 through 10 received 336 kg/ha/year.

** Mean stem weight from planting in January 1975 through December 1976.

the application of P and/or K would be obtained.

The experimental area consists of 0.2 ha planted to the Grand Nain banana cultivar. Each plot encloses 25 production units. The following treatments are being studied:

A. Control

B. 450 kg/ha/year (400 lb/acre) of K as KCl

C. 450 kg/ha/year of K as KCl plus 168 kg/ha/year (150 lb/acre) of P as triple superphosphate.

The fertilizer treatments are applied by hand in one application per year. All plots receive a basal application of 252 kg/ha/year of N as urea distributed in three cycles per year, injected through the irrigation system. The experimental area receives 50 mm of water per week.

The following information is being collected: stem weight, total yield, pseudostem circumference, plant height, number of hands at shooting and at harvesting, number of leaves at shooting and at harvesting, finger length and maturation period. Leaf lamina samples, for chemical analysis, are collected periodically in order to relate response to treatments and nutrient concentration in the leaf.

No statistical differences, among treatments, for any of the parameters studied were found for the first or second harvests. The table below shows stem weight and chemical composition of the lamina for each treatment:

Treat.	Stem weight	Nutrient concentration in the dry matter*								
		N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
	- kg -	%					ppm			
A	52.8 a	2.72	0.15	3.54	1.05	0.24	117	147	8	31
B	52.8 a	2.65	0.16	3.63	1.00	0.24	133	123	8	36
C	53.1 a	2.73	0.15	3.30	0.98	0.20	118	100	8	33

* Sampled in January 1977 from the second ratoon crop.

Small or no differences in chemical composition among treatments were observed. Phosphorus and K concentration for all treatments were adequate, indicating that no response to the nutrients applied was obtained because the soil had a high enough reserve of these elements for normal plant growth and development.

Potassium-Magnesium - Honduras

The main objective of this experiment was to determine whether a response in stem weight and total production would be obtained to the application of K. Stem weight data through December 31 shown in Table 109 indicate a response to K application in all poor areas, except in Copen and Santa Rosa. Lower stem weights were obtained in the poor area of Copen with the application of K;

Table 109. Relationship between average stem weight and potassium concentration in the lamina - Potassium-Magnesium Trial - Honduras

		SITE									
		Poor					Good				
				Sampling month (1976)					Sampling month (1976)		
			Stem	April	Sept.	Dec.		Stem	April	Sept.	Dec.
Farm	Treat.**	Sec.	weight*	K concentration			Sec.	weight*	K concentration		
			kg	--------- % ---------				kg	--------- % ---------		
San Juan	1	31	38.9	3.17	3.13	2.88	8	42.5	3.45	3.29	3.41
San Juan	2	31	38.0	3.35	3.08	3.05	8	42.1	3.58	3.27	3.45
San Juan	3	31	34.2	2.68	3.03	2.53	8	41.3	3.32	3.07	3.21
San Juan	1	41	33.7	3.42	3.21	3.12	25	46.2	3.45	3.07	3.33
San Juan	2	41	35.1	3.47	3.15	3.29	25	45.4	3.50	3.28	3.41
San Juan	3	41	32.5	2.90	2.64	2.65	25	45.0	3.47	2.92	3.10
La Curva	1	13	37.7	3.13	2.96	3.07	22	43.7	3.55	3.27	3.47
La Curva	2	13	40.9	3.27	3.08	2.88	22	42.3	3.47	3.03	3.58
La Curva	3	13	38.3	2.96	2.87	3.16	22	41.5	3.32	3.05	3.20
La Curva	1	33	42.5	3.25	3.17	3.16	--	--	--	--	--
La Curva	2	33	42.9	3.21	3.06	3.33	--	--	--	--	--
La Curva	3	33	33.2	2.91	2.76	3.01	--	--	--	--	--
Copen	1	3	27.8	3.25	3.19	3.40	16	40.4	3.10	2.95	2.79
Copen	2	3	26.4	3.33	3.01	3.31	16	39.0	3.09	3.11	3.31
Copen	3	3	31.4	2.94	2.86	3.17	16	33.9	2.67	2.55	2.36
Sta. Rosa	1	20	31.4	3.56	3.35	3.33	50	45.1	3.59	3.00	3.44
Sta. Rosa	2	20	31.5	3.53	3.49	3.32	50	46.5	3.57	3.11	3.29
Sta. Rosa	3	20	31.9	3.62	3.14	3.13	50	44.4	3.61	2.87	3.37

* Mean stem weight obtained through December 31, 1976.

** 1 = 400 kg/ha/year of K plus 28 kg/ha/year of Mg.
2 = 800 kg/ha/year of K.
3 = Control.

whereas no effect of this nutrient was observed in Santa Rosa. The only pronounced response in stem weight to K application in good areas was obtained in Copen.

Table 109 also shows K concentration in the lamina of recently shot banana plants for three sampling dates. Generally, there was a direct relationship between K concentration in the leaf and response to K application. The reduction in stem weight with K application to the poor area of Copen cannot be explained in terms of concentration of the nutrients determined (N, P, K, Ca, Mg, Fe, Cu, Zn and Mn). Reduction in growth might be related to a decrease in concentration of the cations Ca or Mg. However, concentration of these nutrients were equal or higher in this area than in others where a positive response to K application was obtained. For example, K treated and untreated areas in good and poor sites of Copen had the following chemical composition:

Site		Nutrient concentration in the dry matter								
		N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
		%					ppm			
Good	Treated	2.65	0.17	3.10	0.97	0.31	103	113	17	29
Good	Untreated	2.73	0.16	2.67	1.06	0.33	108	127	17	31
Poor	Treated	2.72	0.17	3.29	0.96	0.31	148	96	15	31
Poor	Untreated	2.73	0.17	2.94	1.02	0.35	145	119	17	31

The lack of response to K application in poor areas of Santa Rosa and in most good areas of all farms is related to a relatively high K concentration in the leaf.

Potassium content, by treatments, in poor and good sites for various sampling dates since April 1975 through December 1976 is shown in Figure 32. There was an increase in K content with the application of this nutrient. On the other hand, little or no difference was observed with the application of either 400 or 800 kg/ha/year (357 or 714 lb/acre) of K. A high K concentration in all treatments was observed for the sampling of April 1976, followed by a decline in K concentration for the September 1976 sampling. As more information of this type is obtained, it will be possible to determine whether K levels in the leaf fluctuate naturally throughout the year. This will be important in deciding best sampling dates or if a correction factor has to be used to adjust K concentration when sampling at different seasons in the year.

Potassium Frequency Trial Monitored by Foliar Analyses - La Curva Farm

Field experiments and foliar analyses indicated that, besides N, the application of K was required for obtaining adequate fruit yields in some areas of La Lima District in Honduras. However, more information was needed regarding K requirement by the banana plant for obtaining optimum fruit yields on soils derived from sediments of the Chamelecon River. A trial was established in July 1976 with the following objectives:

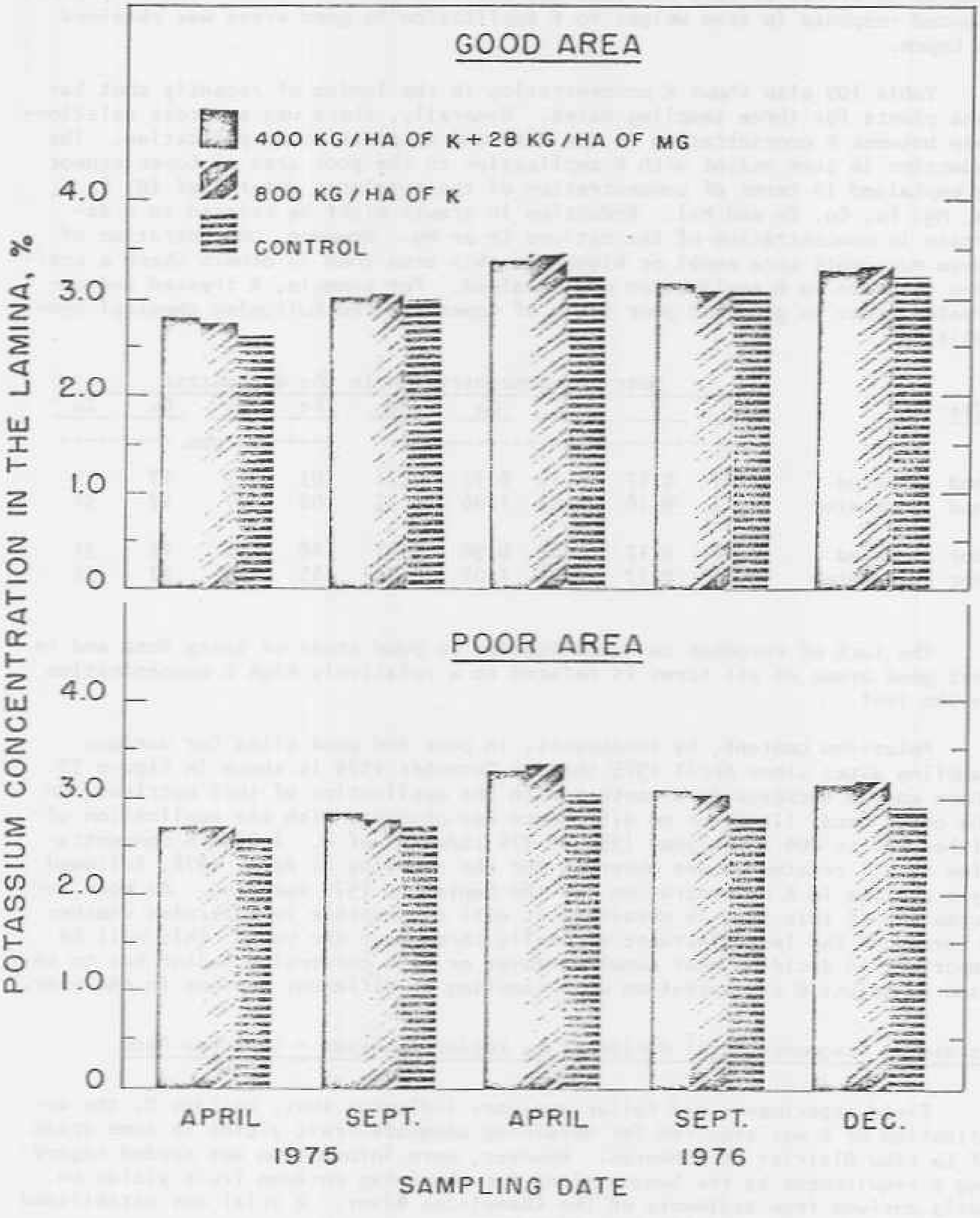


Figure 32. CHANGES IN POTASSIUM CONCENTRATION IN THE LAMINA-POTASSIUM-MAGNESIUM EXPERIMENT, HONDURAS.

1. Determine whether there is any difference between potassium sulfate (K_2SO_4) and potassium chloride (KCl) in their efficiency to supply K to the banana plant.

2. Find out which K rate, 225 or 450 kg/ha, is more suitable for our growing conditions.

3. Determine the required K concentration in the leaf lamina to obtain maximum yields of quality fruit.

4. Find out the optimum frequency of K application needed to maintain the desired K concentration in the leaf.

The experiment was established in Sections 5 and 6, La Curva Farm, Honduras and consists of 13 treatments (Table 110). Plot size is 0.08 ha, containing 100 production units approximately, but only 50 mats in the middle of each plot are being used to obtain data. Potassium concentration in the leaf will be correlated with the agronomic data mentioned above. The experiment is a 2 x 2 x 3 factorial arranged in a complete randomized block design with four replications.

In each plot, K is being applied as frequently as required to keep the desired concentration in the leaf. Collection of agronomic information will be initiated in February. Effect of treatments will be evaluated by the Analysis of Variance for a factorial experiment and treatment means will be compared using Duncan's Multiple Range Test.

Leaf samples for foliar analysis were taken in July, before the initial application of treatments, to determine which plots required a K application. Samples to determine K concentration in the leaf are being taken monthly, from the first application of treatments at the end of July, to determine changes in K concentration and decide, after three to four months from each application, which plots should be treated with potassium.

Lamina samples collected one month after the experiment was established showed the following average composition: 2.63, 0.145, 2.79, 0.94 and 0.26% for N, P, K, Ca and Mg, respectively. Treatments and average monthly K concentrations found in each treatment are shown in Table 110. The average K concentration for all treatments, except the control, was 2.79, 2.80, 3.01, 3.05 and 3.23% for samples collected in July, September, October, November and December, respectively, indicating a continuous increase in K content with time, starting two months after application of treatments.

Foliar Analyses - Golfito

A total of 1,668 banana leaf and 1,800 soil samples from the Golfito Division were chemically analyzed this year. Additionally, textural class of 12 soil samples was determined and Br content was determined in 227 banana fruit samples.

Figures 33 and 34 depict the mean K concentration for 1975 and 1976 in every farm of Palmar and Coto Districts, respectively. There was a marked increase in K concentration from 1975 to 1976 in all farms of Palmar District,

Table 110. Treatments and potassium concentration in the lamina of recently shot banana plants - Potassium Frequency Trial monitored by foliar analyses - La Curva Farm, Honduras

Nº	Treatment: K applied Source	Treatment: K applied Rate	Desired potassium concentration	Sampling month (1976) July	September	October	November	December
				Actual potassium concentration in the dry matter*				
		kg/ha	----- % -----	%				
1	KCl	225	2.75-3.00	2.69	2.60	2.88	2.88	3.01
2	KCl	225	3.00-3.25	2.96	2.71	2.80	2.93	3.07
3	KCl	225	3.25-3.50	2.96	2.82	2.94	3.10	3.11
4	K_2SO_4	225	2.75-3.00	2.76	2.63	2.89	3.03	3.31
5	K_2SO_4	225	3.00-3.25	2.72	2.88	2.92	3.05	3.15
6	K_2SO_4	225	3.25-3.50	2.71	2.90	2.94	3.03	3.19
7	KCl	450	2.75-3.00	2.76	2.75	3.03	2.93	3.06
8	KCl	450	3.00-3.25	2.86	2.84	3.13	3.10	3.20
9	KCl	450	3.25-3.50	2.79	2.92	3.22	3.22	3.54
10	K_2SO_4	450	2.75-3.00	2.79	2.77	3.09	3.07	3.42
11	K_2SO_4	450	3.00-3.25	2.69	2.94	3.15	3.19	3.30
12	K_2SO_4	450	3.25-3.50	2.74	2.85	3.16	3.01	3.41
13	Control	-	- - -	2.78	2.71	2.98	2.92	3.20

* Values are averages of four replications.

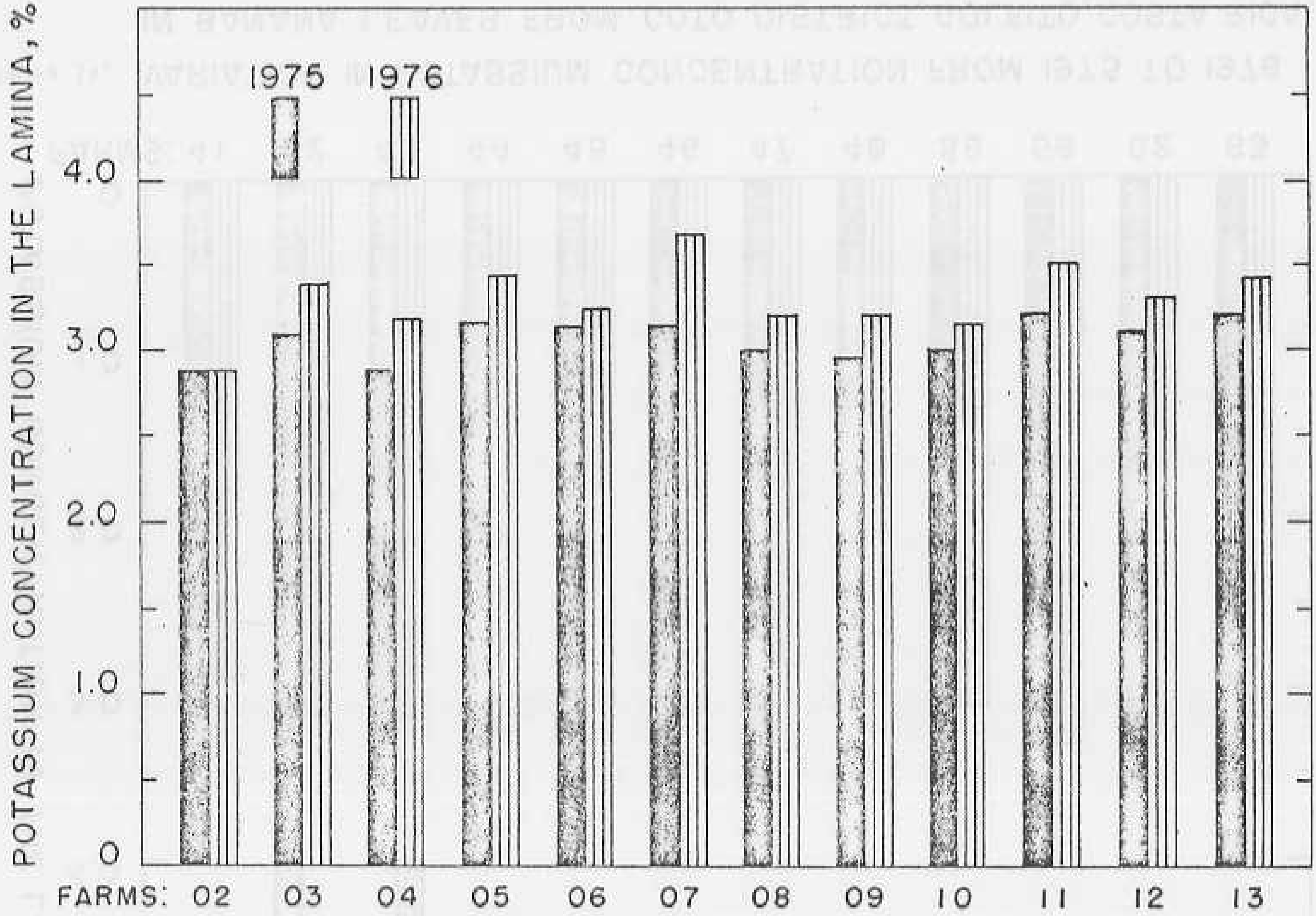


Figure 33. VARIATION IN POTASSIUM CONCENTRATION FROM 1975 TO 1976 IN BANANA LEAVES FROM PALMAR DISTRICT, GOLFITO, COSTA RICA.

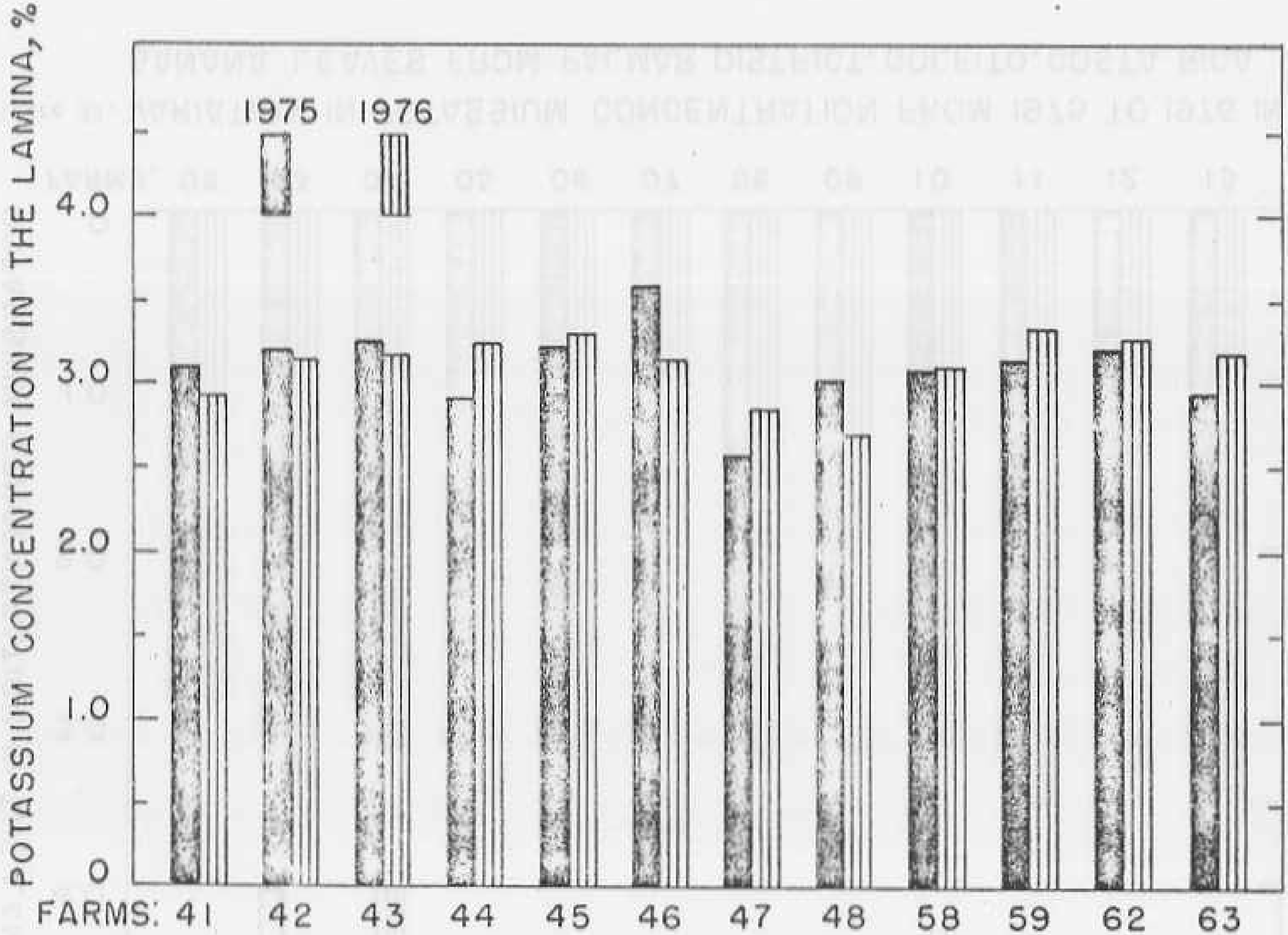


Figure 34. VARIATION IN POTASSIUM CONCENTRATION FROM 1975 TO 1976 IN BANANA LEAVES FROM COTO DISTRICT, GOLFITO, COSTA RICA.

except for Farm 2. On the other hand, K concentration decreased in five farms and increased in seven farms of Coto District.

In 1975, 8, 31 and 61% of samples from Palmar District had less than 2.80, 2.80-3.00 and more than 3.00% K in the leaf, respectively. For 1976, these percentages, in the same order were: 10, 15 and 75% of samples. There was a sharp increase in samples containing more than 3.00% K in the leaf. This trend can also be seen in Figure 33.

Potassium concentration in samples from farms of Coto District collected in 1975 was distributed as follows: 18, 25 and 57% with less than 2.80, 2.80-3.00 and more than 3.00% K in the lamina, respectively. In 1976, 10, 19 and 71% of samples had less than 2.80, 2.80-3.00 and more than 3.00% K in the leaf, respectively. There was a decrease in the percentage of samples containing less than 3.00% and an increase in the proportion of samples with more than 3.00% K in the lamina. The distribution of samples from Palmar and Coto Districts, in the three K concentration categories, was similar in 1976. The decrease in K concentration in five farms of Coto District may be related to weather and/or soil conditions prevailing at sampling.

Nitrogen-Potassium - Palmar

The objectives and procedures for this experiment were given on page 102 of the 1975 Annual Report. Table 111 shows estimated N and K rates for a population density of 1534 production units per hectare (621 per acre). However, the experimental area was planted at a population density of 1373 plants per hectare (556 per acre) and, therefore, rates are slightly lower than those shown in this table. Table 111 also shows total K applied per treatment from June 1975 through October 1976; mean stem weight for the first and second harvests; and N and K concentration for the sampling in July 1976.

The data in Table 111 show little or no difference in mean stem weight with the application of either 140, 280 or 420 kg/ha/year (125, 250 or 375 lb/acre) of N over all K rates. For these N rates, average stem weight was 32.4, 33.0, 34.2 kg for the first harvest and 33.6, 34.5 and 34.4 kg, respectively, for the second harvest. These results are in agreement with apparently adequate N concentration in the leaf for all treatments.

The total amount of K applied per treatment for approximately one and a half year in general is related to desired and actual K concentration in the leaf. Slightly higher K rates appear necessary for higher stem weight at lower N rates. In general, it is probable that 450 kg/ha/year (400 lb/acre) of K is adequate for optimum plant growth in these soils.

Figure 35 shows K concentration in the leaf for four samplings, starting March 1975, before the old NPK trial was modified, through November 1976. In general, there is a close relationship between desired K levels shown in Table 111 and K concentration in the lamina, especially for the last two foliar analyses. These data again suggest that foliar analysis can be used effectively to monitor K nutrition.

Potassium Frequency Trial Monitored by Foliar Analyses - Golfito

The objectives of this experiment were given on page 106 of the 1975

Table 111. Relationship among treatments, stem weight, and nitrogen and potassium concentration in the lamina - Nitrogen-Potassium Experiment - Palmar, Golfito

#	Treatments: Nitrogen	Treatments: Potassium	Desired K concentration in the leaf	Total K applied*	Stem weight**: 1st harvest	Stem weight**: 2nd harvest	Nutrient concentration +: Nitrogen	Nutrient concentration +: Potassium
	---kg/ha/application----		------%------	--kg/ha--	------------kg------------		------------%-----------	
1	140	140	2.75-3.00	157	31.1 e	32.0 bc	2.46	2.75
2	140	280	3.00-3.25	627	31.3 de	32.5 abc	2.56	3.00
3	140	420	3.25-3.50	753	34.3 abc	35.8 ab	2.43	3.23
4	140	560	3.50-4.00	1506	33.6 bcd	34.2 ab	2.42	3.33
5	280	140	2.75-3.00	251	31.2 de	34.2 ab	2.43	2.74
6	280	280	3.00-3.25	439	33.3 bcd	33.6 ab	2.54	3.01
7	280	420	3.25-3.50	941	32.2 cde	34.1 ab	2.53	3.11
8	280	560	3.50-4.00	1380	35.1 ab	36.1 a	2.41	3.34
9	420	140	2.75-3.00	251	31.7 cde	34.0 ab	2.50	2.85
10	420	280	3.00-3.25	439	33.7 bcd	34.0 ab	2.43	2.82
11	420	420	3.25-3.50	941	36.7 a	35.1 ab	2.59	3.34
12	420	560	3.50-4.00	1506	34.6 abc	34.5 ab	2.57	3.32
13	280	0	- - -	0	27.4 f	29.2 c	2.39	2.40

* Potassium applied from June 1975 through October 1976.

** Mean weight for the second harvest. Values within a column followed by different letters are significantly different at the 0.05 probability level.

\+ Sampled in July 1976.

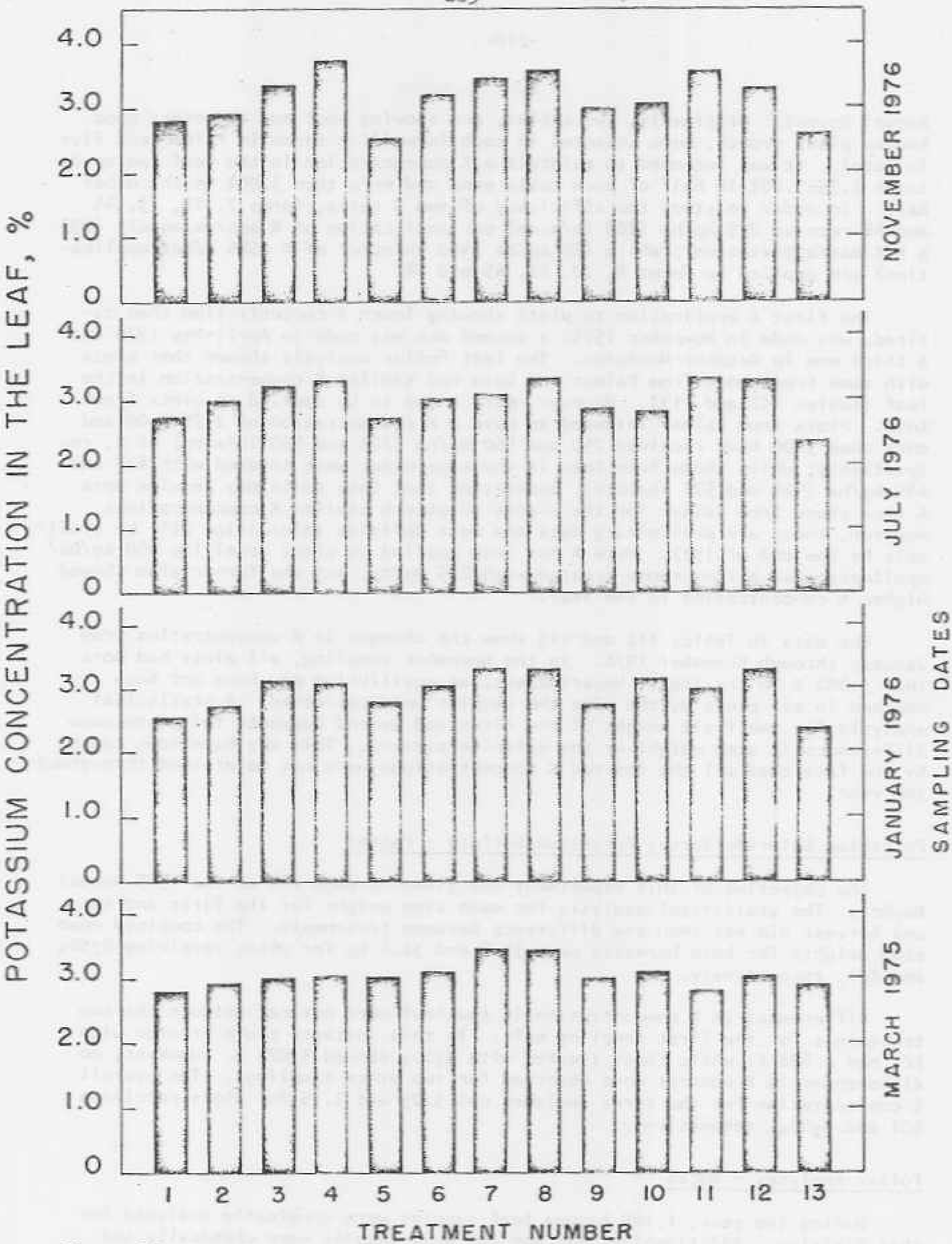


Figure 35.

VARIATION IN POTASSIUM CONCENTRATION AT VARIOUS SAMPLING DATES - NITROGEN - POTASSIUM EXPERIMENT, PALMAR, GOLFITO.

Annual Report. Originally, two cables, one showing poor and the other good banana plant growth, were selected in each farm (five farms in Palmar and five in Coto). It was intended to maintain a K concentration in the leaf lamina between 2.75-3.00% in half of each cable area and more than 3.00% in the other half. In order to study the efficiency of two K rates, Farms 7, 12, 13, 44 and 48 receive 225 kg/ha (200 lb/acre) per application of K approximately (293 g KCl/mat/application); while 450 kg/ha (400 lb/acre) of K (586 g/mat/application) are applied to Farms 4, 10, 42, 45 and 58.

The first K application to plots showing lower K concentration than desired, was made in November 1975; a second one was made in April-May 1976 and a third one in October-November. The last foliar analysis showed that plots with same treatments from Palmar and Coto had similar K concentration in the leaf (Tables 112 and 113). However, more K had to be applied to plots from Coto. Plots from Palmar intended to have a K concentration of 2.75-3.00 and more than 3.00 have received 250 and 560 kg/ha (223 and 500 lb/acre) of K, respectively; while those from Coto in the same order were treated with 475 and 640 kg/ha (424 and 571 lb/acre), indicating that Coto soils may require more K than those from Palmar for the plants to absorb similar K concentrations. However, these are preliminary data and more definite information will be available by the end of 1977. More K has been applied to plots receiving 450 kg/ha/application of K than those treated with 225 kg/ha, but the former also showed higher K concentration in the leaf.

The data in Tables 112 and 113 show the changes in K concentration from January through November 1976. In the November sampling, all plots had more than 3.00% K in the leaf. Nevertheless, an equilibrium may have not been reached in all plots by the time the samples were collected. A statistical analysis for the fruit weight of the first and second harvests failed to show differences in stem weight or any definite pattern. This may have been caused by the fact that all the desired K concentrations were not maintained throughout the year.

Potassium Chloride Versus Potassium Sulfate - Palmar

The objective of this experiment was given in page 106 of the 1975 Annual Report. The statistical analysis for mean stem weight for the first and second harvest did not show any difference between treatments. The combined mean stem weights for both harvests were 32.8 and 32.4 kg for plots receiving K_2SO_4 and KCl, respectively.

Differences in K concentration in the leaf were noticed between the two treatments for the first sampling only. In this instance plots treated with KCl had 2.89% K; while those treated with K_2SO_4 showed 3.07% K. However, no differences in K content were observed for two other samplings. The overall K concentration for the three analyses was 3.09 and 3.15 for plots receiving KCl and K_2SO_4, respectively.

Foliar Analyses - Bocas

During the year, 1,109 banana leaf samples were chemically analyzed for this Division. Additionally, 127 and 158 soil samples were chemically and mechanically analyzed, and Br content was determined in seven green banana samples.

Table 112. Desired and actual potassium concentration in the leaf at various sampling dates - Potassium Frequency Trial monitored by foliar analyses - Palmar, Golfito, Costa Rica.

Farm	Desired K concentration	Sampling month (1976) January	July	November
		K concentration in the dry matter*		
	----- % -----	--------------- % ---------------		
4	2.75-3.00	2.56	2.78	3.26
4	>3.00	2.82	3.26	3.20
7	2.75-3.00	2.77	3.10	3.04
7	>3.00	2.97	2.66	3.12
10	2.75-3.00	2.68	3.12	3.48
10	>3.00	2.94	2.84	3.40
12	2.75-3.00	2.95	2.72	3.06
12	>3.00	2.89	2.60	3.00
13	2.75-3.00	2.54	2.87	3.32
13	>3.00	2.61	2.98	3.16

* Values are averages of samples from two half-cable plots originally showing different banana plant growth, poor and good, but differences in plant appearance are no longer evident.

Table 113. Desired and actual potassium concentration in the leaf at various sampling dates - Potassium Frequency Trial monitored by foliar analyses - Coto, Golfito, Costa Rica

Farm	Desired K concentration	Sampling month (1976) January	July	November
		K concentration in the dry matter*		
	----- % -----	--------------- % ---------------		
42	2.75-3.00	2.60	3.40	3.48
42	> 3.00	2.80	3.40	3.46
44	2.75-3.00	2.50	2.84	3.08
44	> 3.00	2.36	2.76	3.32
45	2.75-3.00	2.36	3.67	3.58
45	> 3.00	2.56	3.54	3.40
48	2.75-3.00	2.46	3.37	3.14
48	> 3.00	2.52	3.38	3.00
58	2.75-3.00	2.40	3.36	3.16
58	> 3.00	2.18	3.34	3.14

* Values are averages of samples from two half-cable plots originally showing different banana plant growth, poor and good, but differences in plant appearance are no longer evident.

In 1975, 31, 26 and 43% of samples analyzed had less than 2.8, 2.8-3.00 and more than 3.00% K, respectively. The distribution of samples in these categories, in the same order, for 1976 was as follows: 23, 53 and 24%, respectively, indicating that there was a decrease in the proportion of samples having less than 2.80 and more than 3.00% K and, hence, there was an increase in percentage of samples containing 2.80-3.00% K.

Phosphorus-Potassium - Changuinola

This trial was cancelled in June 1976 after three years from its establishment. The most striking results from this experiment were the response to application of 450 and 900 kg/ha/year (400 and 800 lb/acre) of K and the close relationship between stem weight and K concentration in the leaf as shown in Table 114. Some variation in K content for the same treatment has been observed for the various sampling dates. Values were especially high for the sampling in April 1975 and may be related to weather and soil conditions prevailing at sampling.

Stem weights shown in Table 114 are averages for all crops, but when the ratoon crops are analyzed separately, the response is generally more pronounced. Since the application of 900 kg/ha/year of K to this soil increased K levels in the lamina just above 3.00% even after three years, this rate appears satisfactory for adequate fruit yields in this soil. For all samplings, except for April 1975, K concentration in the leaf of plants from plots receiving 450 kg/ha/year was less than 2.80%, indicating that this rate was below the amount required for maximum yields in these soils.

Foliar Analyses - Armuelles

A total of 972 banana leaf samples were analyzed. In addition, Br content was determined in 49 green banana samples.

The foliar analysis showed high K concentration in most farms of the Division. Nevertheless, 5, 23, 33, 21 and 26% of samples from Bogamani, Zapatero, Higueron, Caoba and Palmito Farms had less than 3.00% K in the leaf. Although it is recommended to maintain the K concentration in the lamina above 3.00%, a K application to these farms was not recommended since K availability in the soil may be influenced by changes in weather and/or soil conditions. A decision as to whether recommend a K application to these areas will be made after a second sampling.

Foliar Analyses - Colombia

In 1976, 1,019 banana leaf lamina samples were chemically analyzed; this includes 250 samples from Santa Marta. In the same period textural class and chemical characteristics of 105 soil samples were also determined.

Of the samples from Nueva Colonia District analyzed in January, 50 and 11% had low N and K concentration, respectively. Similar results were obtained for samples from this District analyzed in July. All samples from Zungo District had low N content; on the other hand, only the samples from La Astilla and some from La Zumbadora and Lacatan Farms showed low K

Table 114. Relationship between stem weight and potassium concentration in the third leaf - Phosphorus-Potassium Experiment, Changuinola, Panama*

Potassium applied	Stem weight**	Sampling date 9-73	4-75	12-75	7-76
		K concentration in the lamina			
kg/ha/year	kg	%			
0	23.6	1.46	1.92	1.73	1.53
450	32.2	2.54	2.80	2.68	2.51
900	35.7	2.93	3.10	3.09	3.04

* Values are means of three phosphorus levels and eight replications.

** Includes all fruit harvested from planting in June 1973 through June 1976.

concentration. Low N and K content was found in 40 and 26%, respectively, of samples from Santa Marta.

Foliar Analyses - Dominican Republic and Philippines

Thirty-nine banana leaf samples from Dominican Republic were analyzed. Of these, 51 and 31% showed low N (less than 2.40%) and K (less than 3.00%) concentrations, respectively. The application of 336 kg/ha/year (300 lb/acre) of N and 450 kg/ha/year (400 lb/acre) of K was recommended.

A total of 231 banana leaf samples from Philippines were analyzed. All samples analyzed in June had adequate K levels, but 20% had low N content (below 2.40%). On the other hand, of the samples analyzed in October, only one had low N concentration, but 7, 28, 29 and 74% of samples from Farms 8, 9, 11 and 12, respectively, had low K levels. Sulfur and Zn content was low in a large proportion of samples. These samples had less than 0.20% S and less than 15 ppm Zn.

(RODRIGUEZ, FROMM, GUILLEN)

SOIL FERTILITY STUDIES

The soil fertility studies initiated last year (1975 Annual Report, p. 110) with soils from Golfito and Honduras were continued. Several greenhouse experiments were established to study the effect of various nutrients on growth of several indicator plants.

Phosphorus-Potassium

A P-K factorial trial was established in the greenhouse with soils C, E, J and M from Golfito and soils U + V (poor banana areas) and W + X (good banana areas) from Higuerito, Honduras with the purpose of determining optimum P and K rates, and to observe any interaction between these two nutrients on plant growth and/or chemical composition of the plant.

The indicator plant was 'X-105-A' corn (Zea mays L.). One kg of air-dry soil was placed in clay pots. Soil preparation, planting and harvesting procedures were similar to the ones followed last year. Since retention studies carried out in the laboratory showed higher P-fixing capacity for soils from Golfito as compared with the ones from Honduras, higher rates were tested in the former than in the latter. Treatments for soils from Golfito were factorial combinations of 0, 75, 150 and 300 ppm of P and 0, 100, 200 and 400 ppm of K; whereas the same K rates were used for the Honduras soils, the levels of P tested were 0, 37.5, 75 and 150 ppm. A basal application of 200, 50 and 25 ppm of N, S and Mg, respectively, was made. The following reagent grade compounds supplied all nutrients: $NH_4H_2PO_4$, KNO_3, K_2SO_4, KH_2PO_4, H_3PO_4, $MgSO_4 \cdot 7H_2O$, $(NH_4)_2SO_4$, NH_4NO_3 and $Mg(NO_3)_2 \cdot 6H_2O$. Nutrients were applied in solution one day before seeding. Nitrogen at the same rate as at the beginning of the trial was applied after each harvest. All nutrients, including P and K, were applied again after the second harvest. The experiment was a factorial and treatments were arranged in a complete randomized block design with four replications.

Banana plant appearance at sampling, texture and chemical characteristics of soils from Golfito are shown in Table 115. Characteristics of soils from Higuerito were given on page 113 of the 1975 Annual Report. The main differences among Golfito soils are the low P and K content for soil M, and the high concentration of extractable Cu found in soils C and E.

Four and three harvests were obtained in Golfito and Higuerito soils, respectively. The relationship among treatments, herbage yields for the first harvest, and P and K concentration in the above-ground corn plant tissue for Golfito soils is shown in Table 116. Higher yields were generally obtained with the application of 300 ppm of P, regardless of extractable soil P, although in some soils there was no difference in yields with the application of either 150 or 300 ppm of P. Response to K application was related to extractable soil K. Soils C and J had the highest K concentration and showed response to the application of 100 ppm of K, but no further increase in forage yields was obtained with additional increments in K applied. On the other hand, soils E and M contained lower extractable K and produced the highest herbage yields with the application of 400 ppm of K.

The effect of treatments on the first herbage yields and P and K concentrations in soils from Honduras is shown in Table 117. A pronounced response to the application of 37.5 and 75 ppm of P was obtained in both soils, except when K was not applied to soil W + X, where maximum response was obtained with the application of 150 ppm of P. On the other hand, there was no effect of K application in soil U + V on forage yields. However, the best herbage yields on soil W + X were generally obtained with the application of 100 ppm of K.

Figures 36 through 39 show the effect of P and K application in soils from Golfito on total herbage yields for the four harvests obtained; while Table 118 shows statistical comparisons among treatments for each soil. Best growth was obtained with the application of 150 to 300 ppm of P and there was not a well-defined relationship between response and original P concentration in the soil. On the other hand, there was a closer relationship between response to K application and original K content in the soil. Maximum yields in soils C (high K content) was obtained with the application of 100 to 200 ppm of K. Conversely, best growth on soil M (low K concentration) was obtained with the application of 400 ppm of K. There was a significant P x K interaction only in the two soils with low original K concentration (soils E and M).

Figures 40 and 41 depict the relationship between P and K application in soils from Honduras and total herbage yields for three harvests; whereas Table 119 shows statistical comparisons among treatments in each soil. Best yields on soil U + V were obtained with the application of 75 and 100 ppm of P and K, respectively; whereas maximum herbage yields on soil W + X were obtained with the application of 150 and 100 ppm of P and K in this order, although yields in this treatment were not statistical superior to the ones obtained with the application of 37.5 ppm of P and 100 ppm of K. A PxK interaction was not observed in these soils. These results agree with retention studies in the laboratory showing that soils from Costa Rica fixed at least twice as much P as the ones from Honduras (pages 115 and 116 of 1975 Annual Report). Lower K rates required in Honduras soils are related to higher extractable K and lower retention of this element in these soils than in soils from Costa Rica (pages 112, 113 and 117 of the 1975 Annual Report).

Table 115. Texture and chemical characteristics of soils from Golfito, Costa Rica*

								Extractable Nutrients					
								N. Carolina	NH4OAc (pH 4.8)			0.1N HCl	
Soil	Farm	Sec.	Cable	Visual rating	Text.	pH	Org. matter	P	K	Ca	Mg	Cu	CEC
							%	ppm					meq/100 g
Palmar													
C	6	21	49	Good	L	5.5	3.3	25	190	5,475	488	188	46
E	10	11	26	Medium	CL	5.5	3.4	21	130	4,950	450	270	43
Coto													
J	41	32	31	Medium	TL	5.1	2.9	13	225	7,275	569	55	51
M	45	10	-	Very Poor	L	5.3	3.4	2	55	5,000	600	95	44
Q	59	38	20	Medium	SCL	5.9	3.1	19	220	9,000	613	4	57

* Samples were collected in December 1974.

Table 116. Relationship between herbage yields in the greenhouse, and phosphorus and potassium concentration in the forage for the first corn harvest on Costa Rican soils - Phosphorus-Potassium Experiment

Treatment		Soil											
		C			E			J			M		
		Oven-dry forage											
P applied	K applied	Yield*	P	K	Yield	P	K	Yield	P	K	Yield	P	K
------ ppm -----		g/pot	----%-----		g/pot	----%-----		g/pot	----%-----		g/pot	----%----	
0	0	3.4 g	0.07	2.17	3.7 e	0.07	1.07	5.3 e	0.08	2.39	2.8 h	0.07	0.79
75	0	6.4 e	0.08	0.94	6.7 d	0.08	0.66	10.3 d	0.08	1.08	5.4 g	0.10	0.37
150	0	9.3 c	0.11	0.71	8.4 c	0.10	0.57	13.2 bc	0.11	0.83	6.2 f	0.16	0.28
300	0	9.4 c	0.21	0.73	9.4 bc	0.16	0.52	13.0 bc	0.17	0.68	6.5 f	0.32	0.32
0	100	3.7 fg	0.06	2.75	4.3 e	0.06	1.93	5.3 e	0.08	3.09	2.6 h	0.08	2.28
75	100	8.4 d	0.08	1.46	6.6 d	0.07	1.18	11.2 d	0.08	1.34	6.5 f	0.08	0.93
150	100	9.8 bc	0.10	1.01	8.9 c	0.08	0.88	13.6 bc	0.11	1.02	9.8 d	0.12	0.68
300	100	10.5 ab	0.16	0.94	9.8 b	0.15	0.91	14.4 a	0.17	1.10	11.7 b	0.14	0.51
0	200	4.3 f	0.06	3.38	4.1 e	0.06	2.88	5.4 e	0.07	3.35	3.1 h	0.07	4.03
75	200	7.7 d	0.07	2.03	6.6 d	0.07	2.14	11.0 d	0.07	1.71	7.5 e	0.07	2.16
150	200	10.1 ab	0.09	1.70	9.0 bc	0.09	1.63	12.8 c	0.11	1.52	10.0 d	0.09	1.59
300	200	10.8 a	0.18	1.77	9.7 b	0.14	1.54	13.9 b	0.17	1.34	12.3 b	0.12	0.93
0	400	4.2 f	0.06	4.52	4.3 e	0.06	3.29	5.7 e	0.08	4.43	3.2 h	0.07	5.22
75	400	8.4 d	0.08	2.58	6.0 d	0.07	2.59	10.4 d	0.08	2.43	7.2 e	0.07	2.60
150	400	10.3 ab	0.10	2.11	9.8 b	0.09	1.89	13.5 bc	0.10	1.89	10.7 c	0.08	1.67
300	400	10.5 ab	0.18	1.92	11.5 a	0.13	1.55	14.8 a	0.16	1.69	13.0 a	0.13	1.34

*Values within a column followed by different letters are significantly different at the 0.05 probability level.

Table 117. Relationship between herbage yields in the greenhouse, and phosphorus and potassium concentration in the forage for the first corn harvest on Honduras soils - Phosphorus-Potassium Experiment

			Soil					
			U + V			W + X		
	Treatment		Oven-dry forage					
Nº	Phosphorus	Potassium	Yield	P	K	Yield	P	K
	ppm		g/pot*	%		g/pot	%	
1	0	0	3.7 e	0.08	3.70	3.3 c	0.07	2.93
2	37.5	0	13.0 abcd	0.09	2.56	10.5 b	0.09	1.67
3	75	0	10.6 cd	0.10	2.16	10.4 b	0.10	1.12
4	150	0	12.2 abcd	0.10	2.14	14.2 ab	0.13	1.02
5	0	100	4.1 e	0.08	3.49	3.8 c	0.09	3.52
6	37.5	100	10.3 d	0.09	2.68	13.8 ab	0.09	2.03
7	75	100	14.8 a	0.10	2.77	15.3 a	0.10	1.87
8	150	100	13.0 abcd	0.10	2.52	16.1 a	0.14	1.52
9	0	200	3.44 e	0.08	2.96	3.9 c	0.10	3.28
10	37.5	200	11.0 cd	0.09	3.53	10.8 b	0.09	2.59
11	75	200	12.8 abcd	0.11	3.06	15.1 a	0.10	2.12
12	150	200	13.5 abc	0.11	2.91	13.4 ab	0.16	2.22
13	0	400	3.8 e	0.09	3.90	3.5 c	0.09	3.44
14	37.5	400	11.6 bcd	0.10	3.81	15.3 a	0.09	3.10
15	75	400	12.4 abcd	0.10	3.47	14.0 ab	0.12	2.82
16	150	400	14.5 ab	0.12	3.36	13.4 ab	0.14	2.34

* Values within columns followed by different letters are significantly different at 0.05 probability level.

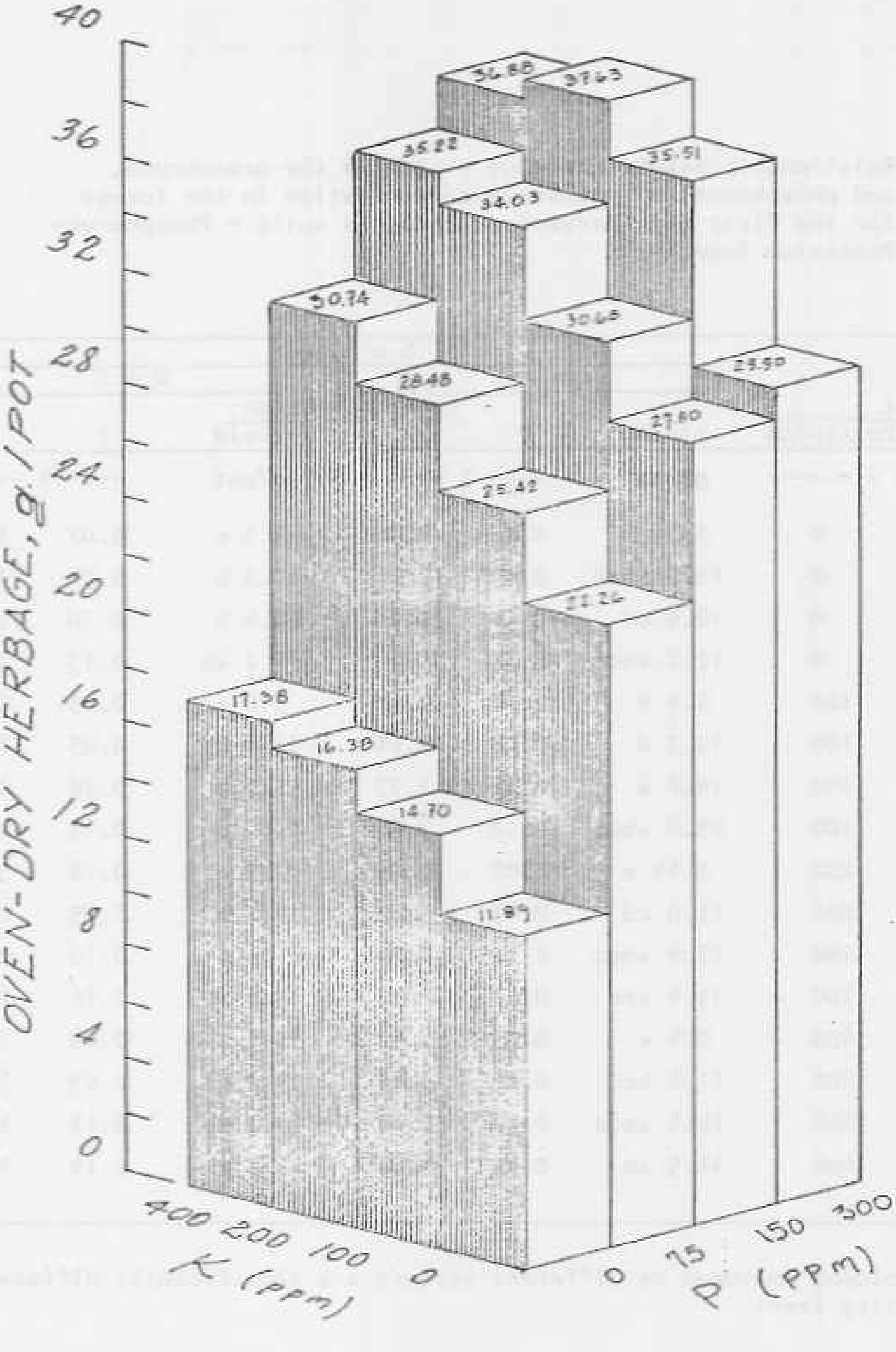


Figure 36.

MEAN EFFECT OF PHOSPHORUS AND POTASSIUM LEVELS ON CORN GROWTH UNDER GREENHOUSE CONDITIONS. SOIL "C", COSTA RICA.

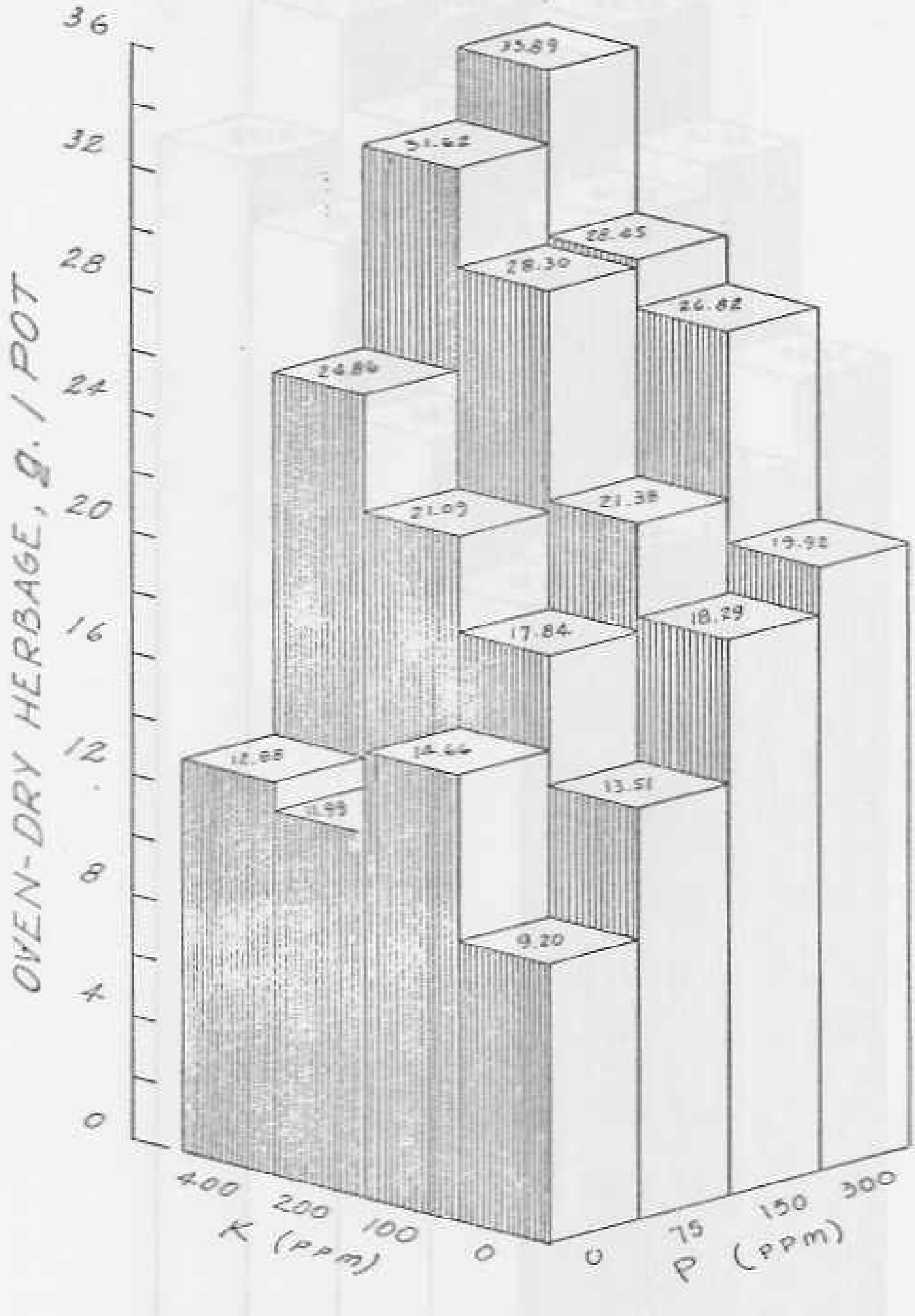


Figure 37.

MEAN EFFECT OF PHOSPHORUS AND POTASSIUM LEVELS ON CORN GROWTH UNDER GREENHOUSE CONDITONS.
SOIL "E", COSTA RICA.

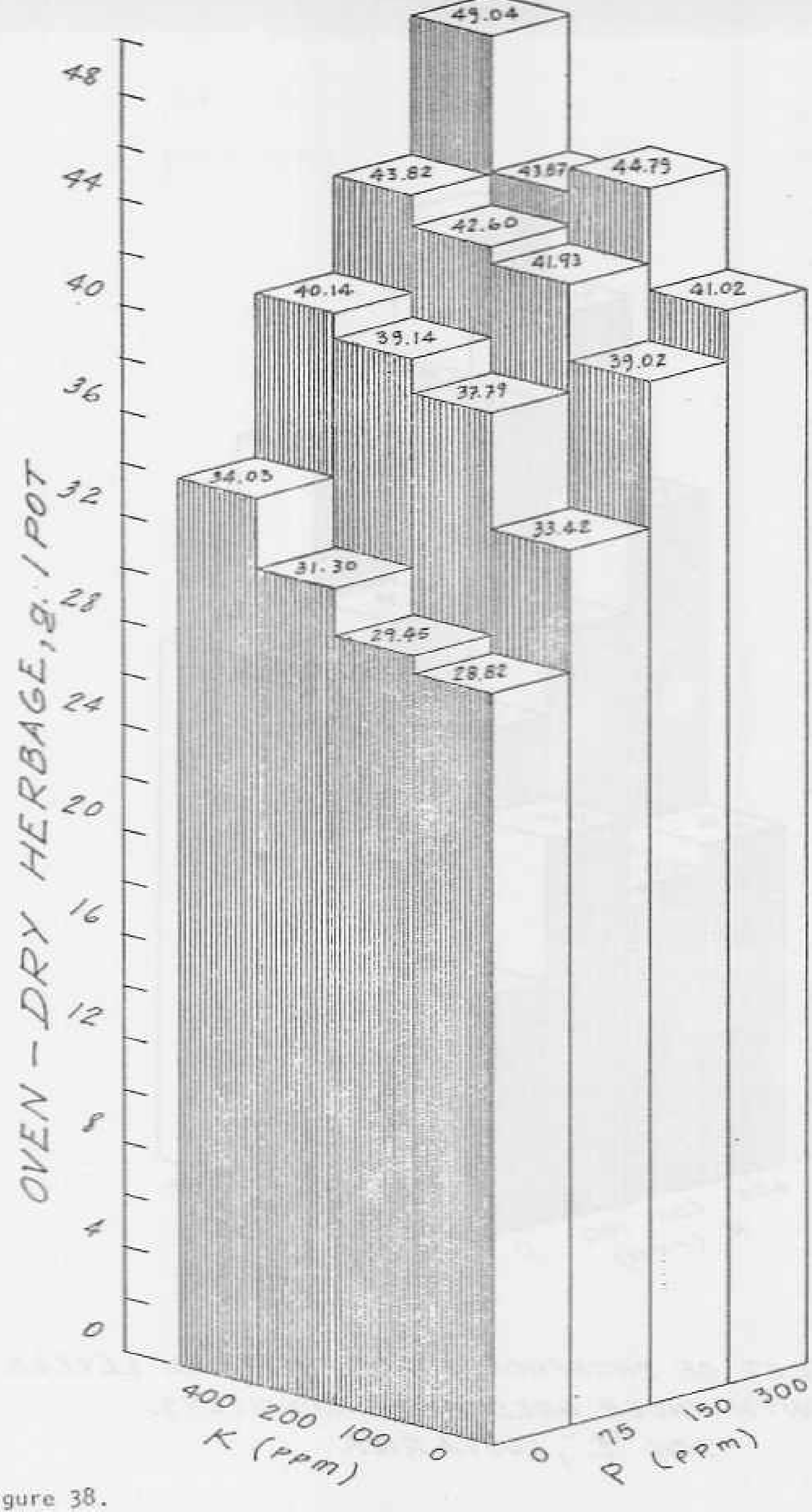


Figure 38.

MEAN EFFECT OF PHOSPHORUS AND POTASSIUM LEVELS ON CORN GROWTH UNDER GREENHOUSE CONDITIONS.

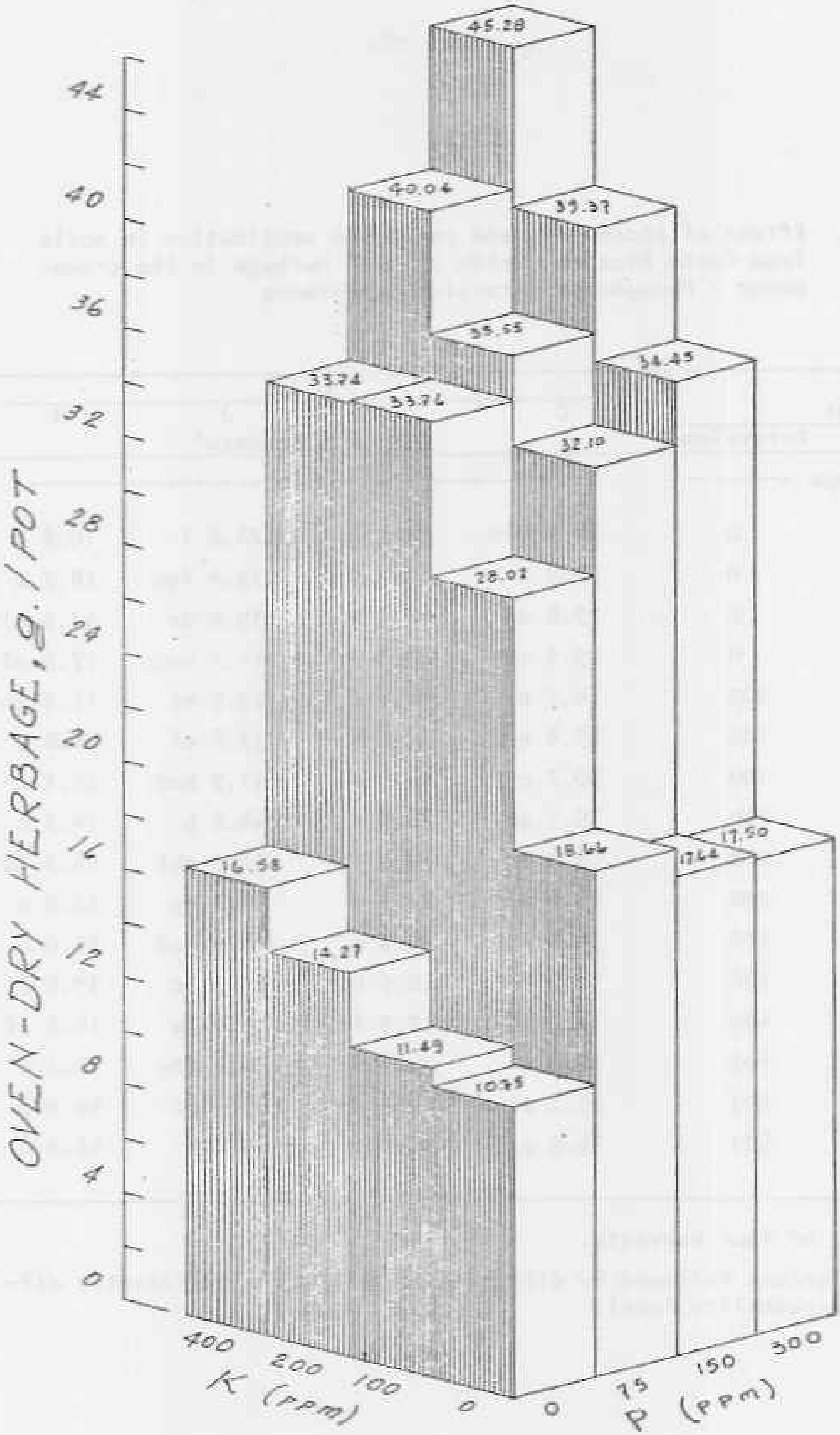


Figure 39.
MEAN EFFECT OF PHOSPHORUS AND POTASSIUM LEVELS ON CORN GROWTH UNDER GREENHOUSE CONDITIONS. SOIL "M", COSTA RICA.

Table 118. Effect of phosphorus and potassium application in soils from Costa Rica on yields of corn herbage in the greenhouse - Phosphorus-Potassium Experiment

Nº	Treatment Phosphorus	Treatment Potassium	Soil C	Soil E	Soil J	Soil M
			Oven-dry herbage*			
	ppm	ppm	g/pot	g/pot	g/pot	g/pot
1	0	0	11.9 i**	9.2 g	28.8 i	10.8 h
2	75	0	22.3 f	13.5 f	33.4 fgh	18.7 e
3	150	0	27.8 de	18.3 e	39.0 de	17.6 ef
4	300	0	29.9 cd	19.9 e	41.1 bcde	17.5 ef
5	0	100	14.7 h	14.7 f	29.5 hi	11.5 gh
6	75	100	25.4 e	17.8 e	37.8 ef	28.0 d
7	150	100	30.7 c	21.4 de	41.9 bcd	32.1 c
8	300	100	35.5 ab	26.8 c	44.8 b	34.5 c
9	0	200	16.4 gh	12.0 fg	31.3 ghi	14.3 fg
10	75	200	28.5 d	21.1 e	39.1 de	33.8 c
11	150	200	34.0 b	28.3 c	42.6 bcd	35.6 c
12	300	200	37.6 a	28.5 bc	43.9 bc	39.4 b
13	0	400	17.4 g	12.9 f	34.0 fg	16.6 ef
14	75	400	30.7 c	24.9 cd	40.1 cde	33.7 c
15	150	400	35.2 ab	31.6 ab	43.8 bc	40.0 b
16	300	400	36.9 a	33.9 a	49.0 a	45.3 a

* Values are total of four harvests.

** Values within a column followed by different letters are significantly different at 0.05 probability level.

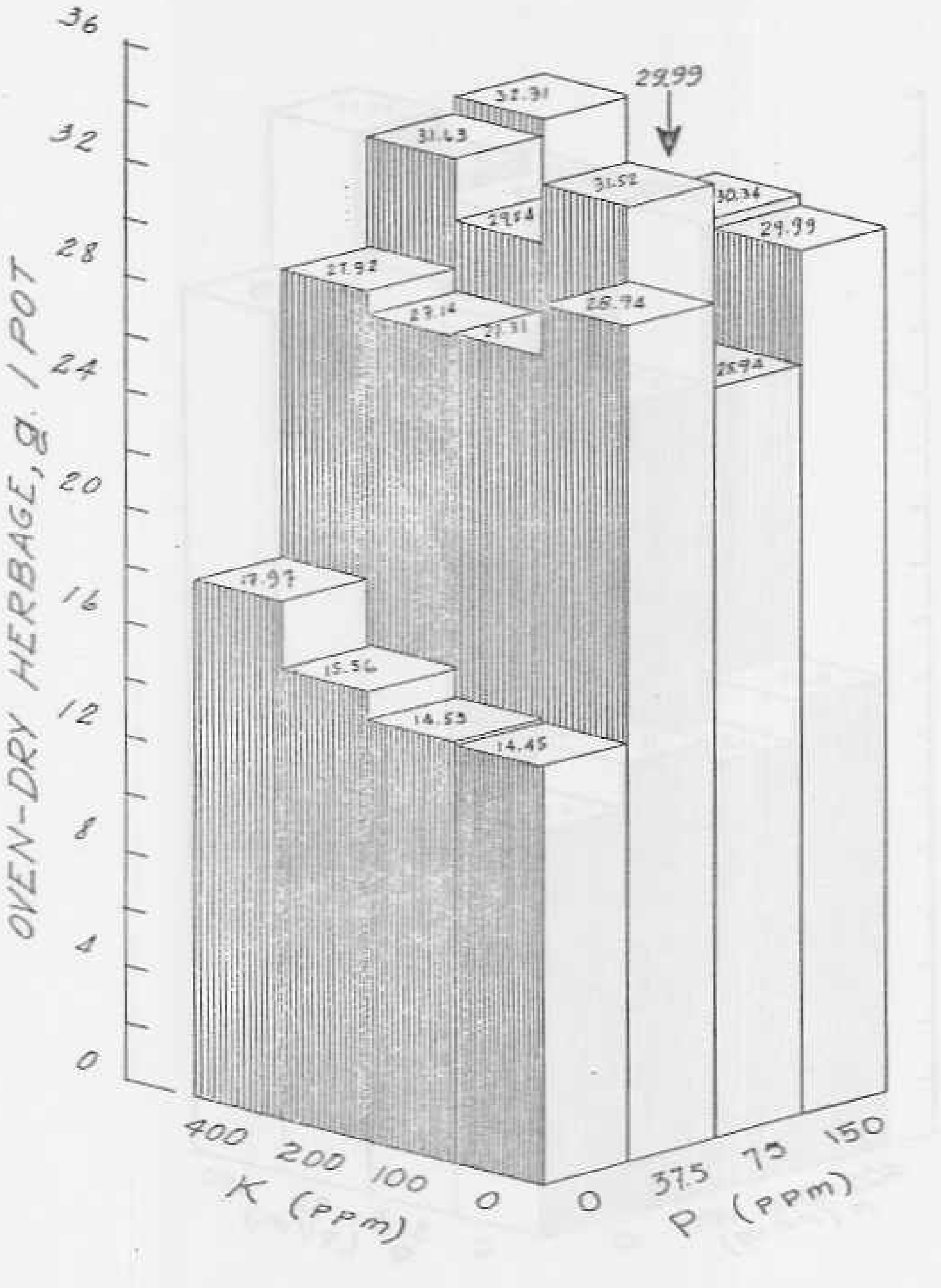


Figure 40.

MEAN EFFECT OF PHOSPHORUS AND POTASSIUM LEVELS ON CORN GROWTH UNDER GREENHOUSE CONDITIONS. SOIL U+V, HIGUERITO.

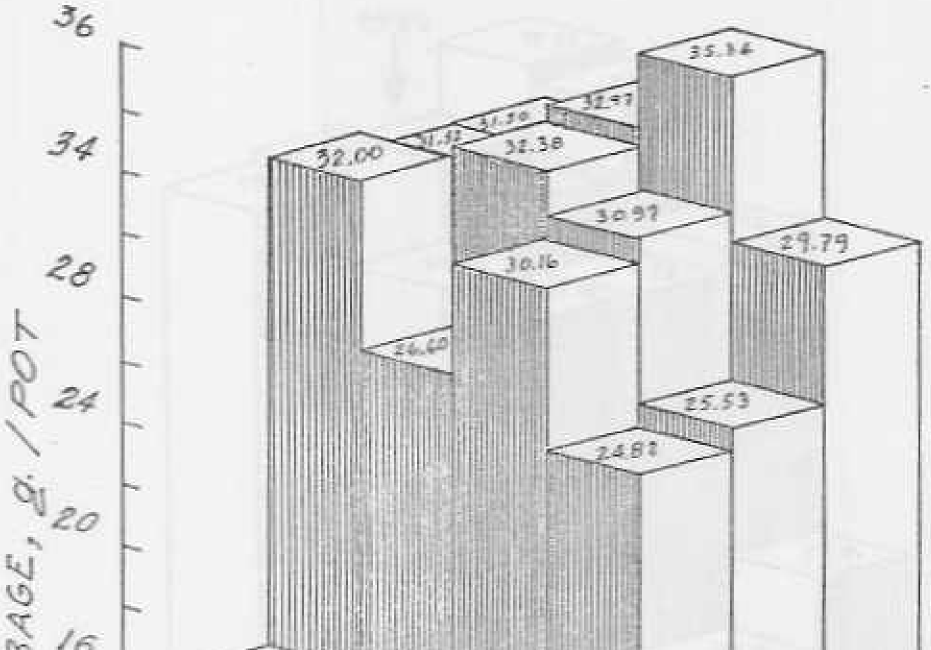


Figure 41.
MEAN EFFECT OF PHOSPHORUS AND POTASSIUM LEVELS ON CORN GROWTH UNDER GREENHOUSE CONDITIONS.
SOIL W+X, HIGUERITO.

Table 119. Effect of phosphorus and potassium application in soils from Honduras on yield of corn herbage in the greenhouse - Phosphorus-Potassium Experiment

Nº	Treatment: Phosphorus	Treatment: Potassium	Soil: U + V	Soil: W + X
			Oven-dry herbage *	
	ppm	ppm	g/pot	g/pot
1	0	0	14.5 e**	14.1 f
2	37.5	0	28.9 abcd	24.8 e
3	75	0	25.9 d	25.5 de
4	150	0	30.0 abcd	29.8 bcde
5	0	100	14.3 e	15.7 f
6	37.5	100	27.3 bcd	30.2 abcd
7	75	100	31.5 abc	31.0 abc
8	150	100	30.3 abc	35.3 a
9	0	200	15.6 e	14.9 f
10	37.5	200	27.1 cd	26.6 cde
11	75	200	29.5 abcd	32.4 ab
12	150	200	30.0 abcd	33.0 ab
13	0	400	18.0 e	16.3 f
14	37.5	400	27.9 bcd	32.0 ab
15	75	400	31.6 ab	31.5 abc
16	150	400	32.3 a	31.5 abc

* Values are total of three harvests.

** Values within a column followed by different letters are significantly different at 0.05 probability level.

Maximum herbage yields in each soil were obtained when P concentration in the above-ground tissue was 0.13% or higher (Table 116). These results agree with those obtained in 1975 when it was found that best sorghum (Sorghum vulgare Pers.) growth was obtained when P concentration in the plant tissue was 0.14% or higher. On the other hand, maximum forage yields were obtained when K concentration in the above-ground plant part was 1.10% or higher. This value was lower than 1.50% found adequate in 1975 for maximum sorghum growth under greenhouse conditions.

Although no pronounced effect of K application on P concentration in the plant was apparent, there was a general reduction in K concentration with the application of P (Table 116). Total P uptake (mg/pot) was increased with each increment in P applied, but no effect of K on P absorption was observed (Table 120). On the other hand, there was no consistant effect of P applied on K absorption, but there was an increase in K uptake with each increment in K applied (Table 121).

There was an apparent reduction in Ca and Mg concentrations as the amount of P or K applied increased. However, P application increased Ca (Table 122) and Mg absorption (Table 123), indicating that the reduction in Ca and Mg concentrations in the plant was caused by dilution due to increased growth with P application. In general, there was no effect of K application on Ca uptake (Table 122), but each increment in K applied caused a reduction in Mg absorption (Table 123).

Results agree with those obtained by other investigators, indicating that some soils from Costa Rica contain relatively small amounts of extractable P and are able to fix high amounts of this nutrient, making it unavailable for plant absorption. No response to P application in banana plantings has been obtained probably because soils containing lower concentration of this nutrient have not been chosen for these trials, or because the banana plant is highly efficient in absorbing P from soils having low content of this element. Nevertheless, the data indicate that P supply is low in some soils and that extreme caution should be exercised in order to detect on time, by foliar analysis, a possible deficiency of this nutrient in bananas.

Solid Versus Liquid Phosphorus

A P experiment was established in the greenhouse with the purpose of comparing the efficiency of P applied in solution prepared from reagent grade materials and solid triple superphosphate in soils N and Q from Golfito.

Corn was the indicator plant. Soils used for this trial were N and Q, both from Coto. Treatments applied were:

1) 100 ppm P in solution.
2) 150 ppm P in solution.
3) 200 ppm P in solution.
4) 250 ppm P in solution.
5) 100 ppm P as solid triple superphosphate.

Table 120. Effect of phosphorus and potassium application in Costa Rican soils on phosphorus absorption in the greenhouse - Phosphorus-Potassium Experiment

	Treatment		Soil			
			C	E	J	M
Nº	Phosphorus	Potassium	Phosphorus uptake *			
	ppm		mg/pot			
1	0	0	2.4 e**	2.5 e	4.1 f	1.9 f
2	75	0	4.9 d	5.2 d	8.6 e	5.4 e
3	150	0	10.5 c	8.1 c	14.6 c	10.0 cd
4	300	0	20.0 a	14.6 a	22.2 b	21.1 a
5	0	100	2.2 e	2.7 e	4.0 f	1.9 f
6	75	100	5.8 d	4.7 d	8.7 e	5.0 e
7	150	100	9.3 c	7.5 c	14.8 c	11.4 c
8	300	100	16.9 b	14.5 a	23.8 a	16.1 b
9	0	200	2.7 e	2.5 e	3.9 f	2.0 f
10	75	200	5.7 d	4.8 d	8.0 e	5.5 e
11	150	200	9.1 c	7.7 c	13.7 cd	8.5 d
12	300	200	19.1 a	13.1 b	23.0 ab	14.9 b
13	0	400	2.4 e	2.7 e	4.3 f	2.2 f
14	75	400	6.3 d	4.2 d	7.9 e	4.9 e
15	150	400	10.1 c	8.6 c	12.9 d	8.4 d
16	300	400	18.3 ab	15.2 a	23.9 a	16.3 b

* Values for the first harvest.

** Values within a column followed by different letters are significantly different at 0.05 probability level.

Table 121. Effect of phosphorus and potassium application in Costa Rican soils on potassium absorption by corn plants in the greenhouse - Phosphorus-Potassium Experiment

Treatment			Soil			
			C	E	J	M
Nº	Phosphorus	Potassium	Potassium uptake*			
	ppm		mg/pot			
1	0	0	74 g**	40 e	126 fg	22 f
2	75	0	60 g	44 e	111 g	20 d
3	150	0	65 g	53 e	110 g	17 f
4	300	0	69 g	48 e	89 h	21 f
5	0	100	101 f	83 d	162 de	59 e
6	75	100	108 f	77 d	149 ef	60 e
7	150	100	99 f	78 d	139 ef	89 d
8	300	100	98 f	89 d	159 de	60 e
9	0	200	144 e	116 c	181 bcd	123 c
10	75	200	157 de	141 b	187 b	161 ab
11	150	200	172 cd	144 b	193 b	158 b
12	300	200	190 bc	148 b	186 bc	114 cd
13	0	400	190 bc	138 b	252 a	166 ab
14	75	400	213 a	155 b	252 a	188 a
15	150	400	215 a	186 a	256 a	178 ab
16	300	400	200 ab	177 a	250 a	173 ab

* Values for the first harvest.

** Values within a column followed by different letters are significantly different at 0.05 probability level.

Table 122. Effect of phosphorus and potassium application in soils from Costa Rica on calcium uptake by corn plants in the greenhouse - Phosphorus-Potassium Experiment

	Treatment		Soil			
			C	E	J	M
Nº	Phosphorus	Potassium	Calcium uptake*			
	ppm		mg/pot			
1	0	0	29 c**	29 cd	57 d	30 de
2	75	0	38 b	38 ab	75 a	45 abc
3	150	0	42 b	41 a	75 a	46 ab
4	300	0	39 b	39 ab	63 bcd	44 abc
5	0	100	28 c	27 cd	48 e	24 e
6	75	100	38 b	33 bcd	66 abcd	45 abc
7	150	100	51 a	35 abc	65 abcd	52 a
8	300	100	43 b	39 ab	70 ab	46 ab
9	0	200	31 c	27 cd	47 e	26 e
10	75	200	40 b	37 ab	61 bcd	43 abc
11	150	200	42 b	40 a	59 cd	51 a
12	300	200	42 b	33 bcd	61 bcd	47 ab
13	0	400	29 c	29 cd	59 cd	26 e
14	75	400	38 b	37 ab	62 bcd	46 cd
15	150	400	40 b	41 a	62 bcd	42 bc
16	300	400	39 b	33 bcd	69 abc	40 bc

* Values for the first harvest.

** Values within a column followed by different letters are significantly different at 0.05 probability level.

Table 123. Effect of phosphorus and potassium application in soils from Costa Rica on magnesium uptake by corn plants in the greenhouse - Phosphorus-Potassium Experiment

	Treatment		Soil C	Soil E	Soil J	Soil M
Nº	Phosphorus	Potassium	Magnesium uptake*			
	ppm		mg/pot			
1	0	0	22 gh**	21 ef	31 f	24 de
2	75	0	36 bc	20 ef	57 b	44 ab
3	150	0	44 a	41 a	64 a	53 a
4	300	0	48 a	39 a	63 a	49 a
5	0	100	20 hi	19 ef	25 g	18 ef
6	75	100	34 cd	28 cd	48 c	37 bc
7	150	100	45 a	33 bc	58 ab	53 a
8	300	100	39 b	36 ab	56 b	49 a
9	0	200	18 ij	16 f	21 gh	15 ef
10	75	200	28 ef	24 de	39 e	28 cd
11	150	200	34 cd	28 cd	40 de	35 bc
12	300	200	36 bc	29 cd	45 cd	38 bc
13	0	400	14 j	16 f	18 h	11 f
14	75	400	26 fg	21 ef	35 ef	23 de
15	150	400	27 ef	29 cd	38 e	30 cd
16	300	400	31 de	29 cd	45 cd	35 bc

* Values for the first harvest.

** Values within a column followed by different letters are significantly different at 0.05 probability level.

6) 150 ppm P as solid triple superphosphate.

7) 200 ppm P as solid triple superphosphate.

8) 250 ppm P as solid triple superphosphate.

Treatments were arranged in a complete randomized block design with five replications. All pots received a basic application of 200 ppm each of N and K. All nutrients were applied three days before the initial planting. Subsequently, 200 ppm of N were applied after each harvest. Following the first harvest, a micronutrient solution to supply 5, 5, 2, 1 and 0.05 ppm of Fe, Zn, Mn, B and Mo, respectively, was applied. Nutrients were supplied by $NH_4H_2PO_4$, KNO_3, $(NH_4)_2SO_4$, $Mg(NO_3)_2 \cdot 6H_2O$, K_2SO_4, $MgSO_4 \cdot 7H_2O$, NH_4NO_3, triple superphosphate, $Fe_2(SO_4)_3 \cdot 4H_2O$, $ZnCl_2$, $MnSO_4 \cdot H_2O$, H_3BO_3 and $(NH_4)_6$ — $Mo_7O_{24} \cdot 4H_2O$.

Texture and chemical characteristics of soil Q are given in Table 115, while those for soil N were given in page 112 of the 1975 Annual Report. Three harvests were obtained from each soil, but since response was similar for the three crops, values shown in Table 124 are the total dry matter produced per pot. Results corroborate findings for the PK factorial experiment, indicating that in these soils the application of 150 ppm of P will be adequate for normal corn growth in the greenhouse.

Similar yields were obtained at equivalent P rates whether it was applied solid or in solution for soil N. On the other hand, lower rates appeared to be necessary for optimum growth when P was applied solid as superphosphate to soil Q.

Results again suggest the importance of observing closely P concentration in the banana leaf to detect on time a drop below the sufficiency levels.

Nitrogen

In order to determine optimum N rates for maximum corn and sorghum growth under greenhouse conditions, a trial was established using soil B from Palmar and soil Z from Copen Farm, Honduras. Sorghum followed corn in the planting sequence. Soil preparation, planting and harvesting procedures were similar to those applied for the previous experiment.

The following N rates were tested:

1) 100 ppm

2) 150 ppm

3) 200 ppm

4) 250 ppm

Treatments were arranged in a complete randomized block design with five replications. A basal application of 75, 300, 25 and 25 ppm of P, K, Mg and S, respectively, was made to all pots. Treatments and the basic nutrients were applied three days before planting each crop. Nutrients were provided by $(NH_4)_2SO_4$, $Mg(NO_3)_2 \cdot 6H_2O$, NH_4NO_3, KH_2PO_4 and K_2SO_4.

Table 124. Effect of solid and liquid phosphorus in soils from Golfito, Costa Rica on yields of corn herbage*

Nº	Treatment Phosphorus applied	Soil N	Soil Q
		Oven-dry herbage	
	--- ppm ---	------------ g/pot	----------
1	100 solution	24.4 b**	37.9 b
2	150 solution	26.4 ab	39.7 ab
3	200 solution	27.6 a	39.1 ab
4	250 solution	28.1 a	42.6 a
5	100 solid	24.4 b	40.2 ab
6	150 solid	26.2 ab	41.4 ab
7	200 solid	26.2 ab	42.7 a
8	250 solid	27.8 a	41.5 ab

* Values are total of three harvests.

** Values within a column followed by different letters are significantly different at the 0.05 probability level.

The effect of N on dry matter yields of corn and sorghum is shown in Table 125. Since growth response of corn to treatments was similar for the first and second harvests, values shown are total of the two harvests. Only one sorghum harvest was made. Differences in yields of corn among treatments were not statistically significant, indicating that 100 ppm of N is probably enough to supply N needs of corn under the conditions of this experiment. On the other hand, maximum sorghum growth on the Honduras soil was obtained with application of 150 ppm of N, but there was a reduction in sorghum yields with N application to the soil from Golfito. This was probably caused by N accumulation from previous crops since there was not water leaching from pots and/or by a decrease in pH at higher N rates.

In general, results agree with present N recommendations for bananas since best growth was obtained with application of 100-150 ppm of N which is equivalent to 225-336 kg per ha (200-300 lb/acre).

Magnesium

An experiment was established with the purpose of determining whether corn and sorghum growth was affected by magnesium applied to one soil from Honduras and four from Golfito under greenhouse conditions. Soil preparation, planting and harvesting procedures were similar to the ones used in the previous experiments.

Two corn harvests were made followed by one of sorghum. The following treatments were applied:

1) 0 ppm Mg

2) 25 ppm Mg

3) 50 ppm Mg

The soils from Golfito used for this trial were: G, I, L and S; the soil from Honduras was collected in Santa Rosa. A basic application of 200, 75, 300 and 50 ppm of N, P, K and S, respectively, was made to all pots. This N rate was applied before planting each crop. Treatments and basal nutrients were applied three days before seeding.

Texture and chemical characteristics of soils from Golfito were described in page 112 of the 1975 Annual Report. Characteristics of the soil from Honduras were given in pages 96 and 98 of the 1975 Annual Report. Magnesium application did not affect corn or sorghum growth, except for the first corn harvest on soil S where yields were significantly reduced from 13.50 to 12.64 g/pot, by the highest Mg rate. Results indicate that these soils supply all Mg required for adequate corn and sorghum growth. These results agree with analytical determinations indicating relatively large amounts of exchangeable Mg in these soils. Low absorption of this nutrient by oil palms in the Coto area may be related to an inefficient mechanism of Mg uptake by the oil palm. On the other hand, banana plants apparently are able to absorb enough Mg from these soils for adequate growth and development.

Table 125. Effect of nitrogen application on yields of corn and sorghum herbage*

Treatment		Copen Soil Z (Honduras)		Palmar Soil B (Golfito)	
		Crop			
Nº	Nitrogen applied	Corn	Sorghum	Corn	Sorghum
	-- ppm --	g/pot			
1	100	19.77 a**	3.84 b	16.58 a	4.37 a
2	150	20.22 a	5.15 a	17.66 a	3.52 a
3	200	21.94 a	5.27 a	17.40 a	2.31 b
4	250	21.27 a	5.18 a	18.12 a	1.47 b

* Values for corn are total of two harvests; while the ones for sorghum are for one harvest.

** Values within a column followed by different letters are significantly different at the 0.05 probability level.

Sulfur - Costa Rica

Preliminary greenhouse experiments conducted in 1975 with soils from Costa Rica showed a pronounced response in sorghum growth to the application of S (1975 Annual Report, p. 127). Since only one rate was tested last year, more experimentation was required in order to determine optimum S rates required for maximum dry matter production under greenhouse conditions.

Soil preparation, planting and harvesting procedures were similar to the ones followed last year. Corn or sorghum seeds were planted in clay pots containing 1 kg of air-dry soil. One week after germination, seedlings were thinned out to six per pot. Two corn and one sorghum harvests were made. Sorghum followed corn in the planting sequence.

The following soils were used for this trial: D, H, I, J, K, L, P and S. The following S rates were tested: 1) Control (no S); 2) 12.5; 3) 25; 4) 50; and 5) 100 ppm of S. Reagent grade K_2SO_4 and $(NH_4)_2SO_4$ were used as S sources. All pots received a basic application of 200 ppm N as KNO_3, $Mg(NO_3)_2 \cdot 6H_2O$, NH_4NO_3 and $(NH_4)_2SO_4$; 75 ppm P as KH_2PO_4; 300 ppm K as K_2SO_4 and KH_2PO_4; and 25 ppm Mg as $Mg(NO_3)_2 \cdot 6H_2O$. After the first harvest all pots received a basal application of 200, 150 and 100 ppm of N, P and K, respectively. Following the second corn harvest, all pots were seeded to sorghum and received a basic application of 200 ppm of N. Treatments were arranged in a complete randomized block design with six replications.

After each harvest, the plant material was dried at 65-70° F and weighed. The data were analyzed statistically by Analysis of Variance, and treatment means were compared by Duncan's Multiple Range Test.

Texture and chemical characteristics of soil J are shown in Table 115, while characteristics of the other soils were presented on page 112 of the 1975 Annual Report. Table 126 shows the effect of S application on corn growth in four soils: D, I, K and S from Golfito. No growth response was obtained in the other soils. The best treatments were 12.5 ppm of S for soils K and S and 50 ppm in soils D and I. Response for the second harvest was similar to the first harvest. Variable response in sorghum growth was obtained. In general, it appears that 25 to 50 ppm, equivalent to 50-100 lb/acre will be enough for optimum corn growth on these soils under greenhouse conditions.

These data indicate that S may become a limiting factor for some crops growing on these soils and, unless bananas are very efficient in absorbing this nutrient, it may limit production of quality fruit. (RODRIGUEZ, GUILLEN)

Soil Fertility Survey

There is a need to characterize the fertility status of soils from all banana-growing areas in Central America in order to better understand plant performance under each specific set of conditions. A soil fertility survey will be also a complement to the foliar analysis program in establishing a comprehensive fertilization program for each region.

Table 126. Effect of sulfur in soils from Golfito on yields of corn herbage

Treatment		Soil			
Nº	Sulfur applied	D	I	K	S
		Oven-dry herbage*			
	--ppm--	g/pot			
1	0	6.6 c**	7.7 b	8.4 c	21.4 ab
2	12.5	7.0 bc	8.2 ab	9.8 a	23.9 a
3	25	7.2 b	8.3 ab	9.0 b	18.4 b
4	50	7.7 ab	8.3 ab	9.6 ab	20.2 b
5	100	7.9 a	8.8 a	9.2 ab	19.3 b

* Values for the first harvest.

** Values within a column followed by different letters are significantly different at the 0.05 probability level.

Since Golfito probably has the most nutrition-related problems, a soil fertility survey was initiated in this Division. This was a very detailed survey; one composite soil sample at approximately 1.22 to 1.52 m from banana plants was taken at a 0-30 cm depth in each cable area. The number of sub-samples making up a sample varied from 25 to 50, depending on the length of each cable. All sub-samples collected in each cable area were mixed together in a large plastic bucket, a 200 to 300 g sample was placed in a polyethylene bag and sent to La Lima to make the following analytical determinations: pH, organic matter, P, K, Ca, Mg, S, Fe, Cu, Zn and Mn. After completing the chemical analysis, maps for pH, P, K and any other nutrient whose concentration in the soil varies considerably will be prepared for each farm.

Phosphorus was extracted by the North Carolina extracting solution (dilute $HCl + H_2SO_4$) and determined by the ascorbic acid method, while K, Ca, Mg, Mn, Zn, Fe and Cu were extracted by a 1N NH_4OAc solution at pH 4.8 and determined by atomic absorption. Phosphorus concentrations were grouped into four categories: very low (<10 ppm), low (10-16 ppm), marginal (17-37 ppm) and high (>37 ppm). On the other hand, K concentrations were tentatively grouped into five categories: very low (<75 ppm), low (75-150 ppm), marginal (151-250 ppm), adequate (251-350 ppm) and high (>350 ppm). These categories are general guides, but even a high nutrient concentration in the soil does not guarantee that a response to the application of such nutrient will not be obtained since there are many factors that affect nutrient availability in the soil.

Tables 127 and 128 show the percentage of samples from each farm in Palmar District in each category for P and K, respectively; whereas these data for farms in Coto District are shown in Tables 129 and 130. Soils from Coto contained less P than the ones from Palmar District. This may be a factor in the lower fruit production in the former District. On the other hand, there was slightly more K extracted from Coto soils than from the ones from Palmar. (RODRIGUEZ, FROMM)

GROUND COVERS

Soil erosion is a serious problem in some Divisions, especially where bare ground is maintained by use of herbicides. This situation is more accentuated in Armuelles and Golfito where 75-80% of their rainfall occurs in 6-7 months of the year. It is suspected that the run-off that is taking place is affecting the upper and richer part of the soil by washing it into the bottom of canals.

A ground cover crop would help control erosion in these areas. This protective cover may be any plant providing an adequate covering of the soil. However, a more suitable cover is a leguminous crop. Undoubtedly, the choice of a ground cover plant must be preceded by a careful screening to guarantee that the selected plant will cause no problems.

A ground cover should cover the soil to prevent erosion, preserve the humus by reducing soil exposure to the effect of direct sunlight, improve structure and aeration of the soil, as well as increase the N level and reduce weed competition.

Table 127. Percentage of samples from Palmar District with phosphorus concentration in each category - Soil Fertility Survey, Golfito, Costa Rica

	Fertility Category			
Farm	Very low (< 10 ppm)	Low (10-16 ppm)	Marginal (17-37 ppm)	High (>37 ppm)
	% of samples			
2	2.56	11.54	55.13	30.77
3	--	--	26.92	73.08
4	--	19.05	68.25	12.70
5	--	--	24.97	75.71
6	--	--	78.75	21.25
7	--	--	11.11	88.89
8	--	--	32.26	67.74
9	24.29	55.71	20.00	--
10	34.33	29.85	25.82	--
11	--	--	71.80	28.21
12	--	26.14	57.95	15.91
13	--	--	1.37	98.63
$\bar{x}$	5.10	11.86	39.53	42.74

Table 128. Percentage of samples from Palmar District with potassium concentration in each category - Soil Fertility Survey, Golfito, Costa Rica

Farm	Very low (<75 ppm)	Low (75-150 ppm)	Marginal (150-250 ppm)	Adequate (250-350 ppm)	High (>350 ppm)
	% of samples				
2	--	60.26	37.18	2.56	--
3	--	13.46	69.23	9.62	7.69
4	--	41.27	50.79	6.35	1.59
5	--	8.57	50.00	28.57	12.86
6	--	35.00	57.50	6.25	1.25
7	--	52.22	30.00	7.78	10.00
8	--	20.43	64.52	11.83	3.22
9	--	40.00	60.00	--	--
10	--	25.37	58.21	16.42	--
11	1.30	24.68	66.23	7.79	--
12	--	47.73	39.77	11.36	1.14
13	--	15.07	68.49	16.44	--
$\bar{x}$	0.11	32.01	54.33	10.41	3.15

Table 129. Percentage of samples from Coto District with phosphorus concentration in each category - Soil Fertility Survey, Golfito, Costa Rica

Farm	Very low (< 10 ppm)	Low (10-16 ppm)	Marginal (17-37 ppm)	High (> 37 ppm)
	% of samples			
41	50.00	48.65	1.35	--
42	46.25	22.50	31.25	--
43	47.06	41.18	11.76	--
44	19.77	63.95	16.28	--
45	9.09	54.55	36.36	--
46	33.33	61.73	4.94	--
47	30.61	48.98	20.41	--
48	17.02	17.02	64.89	1.06
58	0.91	4.55	40.00	54.54
59	1.12	7.87	83.14	7.87
62	21.86	6.25	54.69	17.19
63	9.88	7.41	53.08	29.63
$\bar{x}$	23.91	32.05	34.85	9.19

Table 130. Percentage of samples from Coto District with potassium concentration in each category - Soil Fertility Survey, Golfito, Costa Rica

	Fertility Category				
Farm	Very low (< 75 ppm)	Low (75-150 ppm)	Marginal (150-250 ppm)	Adequate (250-350 ppm)	High (> 350 ppm)
	% of samples				
41		1.35	44.59	50.00	4.05
42		--	61.25	31.25	7.50
43		4.41	58.82	33.82	2.94
44		--	45.35	51.16	3.49
45		1.30	94.81	3.90	--
46		--	66.67	30.86	2.47
47		18.37	80.61	1.02	--
48		19.15	77.66	3.19	--
58		--	57.27	32.73	10.00
59		--	44.44	43.33	12.12
62		--	48.44	43.75	7.81
63		3.70	53.09	38.27	4.94
$\bar{x}$		4.02	61.08	30.27	4.61

A ground cover crop project was initiated in 1975 in Section 6 of San Juan Farm, Honduras to study the behavior of various imported and native plants, mostly legumes, grown under an established banana plantation. Information is being collected from these plants to determine the most suitable ones.

The most important characteristics that must be considered in searching for the ideal ground cover crop are:

Shade adaptation: Species must be adapted to the low light intensity conditions prevailing under banana plantings.

Plant longevity: A perennial plant is preferred to a short-cycle one since it is not practical or economical to establish ground cover every year. Annual plants have been discarded.

Growth habit: Climbing plants are useful because they compete with weeds growing in the same area, but this habit must not be so extreme as to reach the banana bunch. On the other hand, plants with horizontal stem which produce roots at their nodes forming a dense carpet have advantages over climbing type plants.

Plant vigor: Plant vigor and height are important characteristics in the competition against weeds, hence a rapid establishment can be obtained with rapid horizontal growth. However, a very vigorous plant that grows tall tends to reduce labor movement due to its long vines. This is not desirable.

Adaptation to humid conditions: Rainfall in our banana divisions varies between 1,511 mm of water per year in Honduras to 5,209 mm per year in Coto; only species which are adapted to the weather conditions prevailing in each Division should be considered.

Competition with banana plants: Plants that may compete with the banana plant for water and nutrient elements are not desirable. On the contrary, plants which increase the nutritional level of the soil must be sought.

Nitrogen fixation: Determinations of the N content in the soil are being made in order to find out which plants are more suitable in terms of N fixation. There are some subjective indexes to determine the effectiveness of a legume nodule, such as the reddish color of a nodule. The size and number of nodules are not accurate means to judge the N fixing capacity of a legume plant.

Hosts for banana pests and diseases: Species that are hosts to banana pests or diseases will be avoided. For instance, there are some ground cover plants that have been reported as hosts to nematodes.

Resistance to herbicide: For the economical establishment and maintenance of a cover crop, herbicide use is necessary. This factor is even more important with native plants which are naturally growing in some banana farms. Several woody or semi-woody species may excel in this respect. Plants with thick leaf cuticles are showing certain tolerance for some herbicides.

Seed production: Plants producing large quantities of viable seed throughout the year are preferred over plants that produce less viable seeds or those flowering in very specific seasons. It is also important to consider some specific problems like seed dehiscence, very small seeds, seeds with morphological appendixes, etc., which make harvesting of seeds difficult.

Resistance to damage by banana plant residue: When deleafing and at harvest, a large amount of leaves and stalks fall on the ground cover, causing a yellowing of the cover plants, resulting in a serious defoliation of the latter. The cover crop density declines and may be easily invaded by weeds. The degree of recovery is variable from one species to another, but this ranges between 4-6 weeks in the specific damaged sites. Species that spread laterally very slowly are more damaged than aggressive and vigorous plants.

Resistance to attack of pests and diseases: Many ground cover species are attacked by insects or fungi. The extent of the damage varies from poor appearance of the plants to some extreme cases in which some plants are destroyed.

The following species have been planted in the test garden:

1) *Aeschynomene* sp.
2) *Canavalia ensiformis*
3) *Canavalia maritina*
4) *Calopagonium caeruleum***
5) *Calopagonium muconoides**
6) *Cassia lanceolata*
7) *Cassia tagera*
8) *Cassia tora*
9) *Cassia leiophylla*
10) *Cassia* sp. (named *C. maxillare* by our suppliers)
11) *Cassia occidentalis*
12) *Cassia reticulata*
13) *Cassia* sp. (two species)
14) *Centrosema plumierii***
15) *Centrosema pubescens**
16) *Centrosema virginianum***
17) *Chamaecrista stenocarpa*
18) *Chamaecrista* sp.
19) *Clitoria ternatea*
20) *Cracca greenmanii**
21) *Crotalaria incana*
22) *Crotalaria intermedia*
23) *Crotalaria juncea*
24) *Crotalaria lanceolata*

25) Crotalaria maxilaris
26) Crotalaria retusa
27) Crotalaria spectabilis
28) Crotalaria striata
29) Crotalaria tuerckheimii
30) Crotalaria vitellina
31) Crotalaria sp.
32) Desmanthus virgatus
33) Desmodium adscendens**
34) Desmodium affine*
35) Desmodium axillare*
36) Desmodium barbatum
37) Desmodium canum*
38) Desmodium intortum*
39) Desmodium scorpiurus*
40) Desmodium tortuosum
41) Desmodium triflorum
42) Desmodium uncinatum*
43) Derris elliptica**
44) Dolichos axillaris
45) Dolichos lablab blanco
46) Dolichos lablab rojo
47) Dolichos lablab
48) Flemingea congesta
49) Glycine clarence**
50) Glycine javanica Cooper*
51) Glycine javanica Tinaroo*
52) Indigophera hirsuta
53) Indigophera mucronata
54) Indigophera suffruticosa
55) Indigophera sp. (two species)
56) Pectis guyanensis
57) Pectis leptocephala
58) Phaseolus adenanthus*
59) Phaseolus atropurpureus*
60) Phaseolus aureus
61) Phaseolus calcaratus

62) Phaseolus coloratum

63) Phaseolus lathyroides

64) Phaseolus lunatus

65) Phaseolus sp.

66) Pilea microphylla

67) Psophocarpus tetragonolobus U.P.S.-31

68) Psophocarpus tetragonolobus U.P.S.-46

69) Pueraria phaseoloides

70) Rhynchosia hondurensis

71) Rhynchosia minima

72) Stizolobium aterrinum

73) Stizolobium deeringeanum

74) Stizolobium deeringeanum - Gateado

75) Stylosanthes gracilis

76) Stylosanthes gracilis - Guyanensis

77) Stylosanthes humilis

78) Tagetes - Compacta Ursula

79) Tagetes - Dainty Marietta

80) Tagetes erecta - Aztec

81) Tagetes erecta - Guinea

82) Tagetes erecta - Glitters

83) Tagetes erecta - Finest mixed

84) Tagetes - Finest mixed

85) Tagetes - Marietta Hawaii

86) Tagetes - Naughty Marietta

87) Tagetes - Petite mixed

88) Tagetes - (two native species)

89) Tephrosia sp.

90) Teramnus labialis

91) Vigna sp. (named V. marina by our suppliers)

92) Vigna sp. (named V. octubreña by our suppiers)

93) Vigna unguiculata

94) Vigna sp.

95) Zornia diphylla

96) Unknown species (three plants)*

97) Grasses:

Cynodon aethyopus

Digitaria decumbens

Digitaria decumbens - Transval

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* Very promising ground cover.

** Must continue under observation.

The more promising plants are briefly described:

Calopagonium caeruleum - A native plant well-adapted to shade. This is a creeping plant forming a dense mat of 30-45 cm height. Flowering has just started in January. Since it is one of the newest acquisitions, more observation is needed. It has proven to be an important cover crop in rubber plantations in Malaysia.

Calopagonium muconoides - Procumbent growth habit forming a mat of 15-30 cm in height. Since it produces roots easily at the nodes, it spreads very rapidly. Climbing plants with hairy stems and hairy pods. It is not affected by insects and diseases or cold weather. It seems to be favored by a rainy season, but has shown to be a host to Radopholus similis.

Centrosema plumierii - Probably an annual plant that has a procumbent growth, forming a vegetal cover of 30 cm in height. Plant of vigorous and aggressive growth, with abundant leaf falling. Does not reduce the labor movement. Has shown to be middly susceptible to attack by foliage insects. A large amount of effective nodules are observed. Flowering has not yet occurred after 9 months from planting.

Centrosema pubescens - Procumbent growth habit forming a dense mat about 25-30 cm in height. Spreads laterally rapidly. A vigorous and aggressive grower. Considerable leaf fall, hence a carpet of litter is formed between soil and plant. Stems are slender but somewhat woody.

Chlorosis common in Honduras high-pH soil is probably due to an Fe deficiency because when a 0.1% Fe solution was supplied to the foliage, this chlorosis disappeared. It is one of the best adapted cover plants in Honduras and Golfito Divisions. It has shown high adaptability to mixed growth with other plants.

Clitoria ternatea - This is a herbaceous, possibly perennial plant, forming a dense mat of 30 cm in height. A marked tendency to climb the banana mat has been observed. Up to date (one year of age) no insects or fungi have been seen attacking this plant. It does not present impediment to labor movement. It flowers and produces seeds from April through January. More information about the behavior of this plant is required.

Cracca greenmanii - Procumbent growth habit forming a mat of 25 cm in height. Although it has roots at the nodes, it is not a strong competitor with weeds, hence it can easily be invaded; moreover, it is a quite slow plant to spread in a lateral growth. It has semi-woody stems and leaves have thick cuticle. Although it is easy to establish from cuttings, it is difficult to collect seeds due to the dehiscence. Flowering and seed production occurred from January through September. Nodules have not been observed in this plant. It may have considerable potential in a mixture.

Desmodium affine - A very promising dense mat forming a vegetal carpet of 15-20 cm in height. The woody stem roots at the nodes. It is not very aggressive and spreads slowly. It is not a good competitor against weeds. Flowering and seed production occur throughout the year. Reproduction is effective by cuttings and seeds.

Desmodium axillare - A native semi-woody to woody plant, which is very promising for banana plantations. It is one of the more creeping species, forming a dense cover of 15-20 cm. It is quite tolerant to damage by banana residue. It is not attacked by insects or fungi. Flowering and seed production occur throughout the year. Its growth is apparently favored by humid conditions. In spite of the difficulty of seed recollection by hand, some herbicides like Gramoxone and Gesatop may have an important role in the establishment of this plant when natural stands of this species are sprayed with these herbicides.

Desmodium canum - Semi-upright plant, not very dense. Stems thicker and more woody than D. affine. It is not a good competitor against weeds, probably due to poor rooting at the nodes. Defoliation is not abundant as in other plants of this genus. Flowering and seed production occur throughout the year. This plant may be mixed with a more aggressive plant. It is convenient to continue the observations and collection of data from this plant.

Desmodium intortum - Semi-upright growth habit with some stems reaching 1 meter in height. It does not reduce labor movement. Before the plant reaches 1 m in height, most stems lodge and the cover may then have 50-60 cm in height. The nodes produce roots when they are in contact with the soil. Abundant leaf falling occurs; therefore, there is a permanent carpet of litter between leaves and soil. It is easily established from seed and, to a lesser extent, from cuttings. It is not a climber plant. Flowering and seed production occur from January through April. It is slightly affected by the banana residue falling on it.

Desmodium scorpiurus - One of the most promising native creeping plants, forming a mat of 10-15 cm in height. This plant has a large quantity of small, light, green leaves. It roots at nodes extremely easily, hence it has an excellent lateral spread covering the ground within a few weeks. It has been propagated from cuttings and, although flowering and seed production occur throughout the year, the amount of seed produced is quite scarce. The seed is inside pods of 4-7 segments and like many other plants of the genus Desmodium has little hooks in the pods. Neither insects nor fungi attacks have been recorded.

Desmodium uncinatum - Procumbent growth habit forming a mat smaller than D. intortum; it can reach 25-35 cm in height and in general is weaker than D. intortum. Standing water is probably the most limiting factor. The above has been observed in Coto District, Farm 47, where plants germinated successfully but standing water because of poor drainage has eliminated this species. Old plantings are not as dense as young plantings, especially after flowering. This is the main reason to justify a mixture with plants like Centrosema pubescens. Flowering occurs from April to September, and seed production is from December through January.

Derris elliptica - Procumbent native plant which is especially propagated by cutting, it is found growing locally in humid and shaded areas, forming a dense and vigorous mat of long and thick vines 60 cm in height which do not reduce labor movement. Flowering has not been observed in this plant.

Glycine javanica Cooper - A perennial plant of procumbent growth habit and a slight tendency to climb the banana plant and suckers. This plant forms a dense cover of 30 cm with abundant leaves of a light green color. Spreads laterally rapidly due to rooting at nodes. It is a good competitor against weeds by climbing them. It is propagated by seeds or cuttings. It is susceptible to the attack by Rhizoctonia sp. Flowering and seed production occur from November through April. It is also affected by standing water in soil surface. When planted on an open space subject to full sunlight, better ground cover is obtained.

Glycine javanica Tinaroo - Procumbent growth habit, very similar to Glycine javanica Cooper. The Tinaroo variety forms a dense cover of 25-30 cm in height, but it is more susceptible to climatic changes. As G. javanica Cooper, it suffers some declining after flowering, but it takes longer to recover. Insect attacks have not been reported; however, it is susceptible to Rhizoctonia sp. Flowering and seed production occur from February through March.

Phaseolus adenanthus - A native creeping species forming a fair cover 15-20 cm in height. It produces a small number of leaves, hence the cover is not procumbent. However, it is easily established from seed collected in shaded areas where this plant grows well. Flowers are produced from January through April. It is not attacked by insects, but is seriously damaged by the rainy and cold season. It has been observed growing naturally in the Golfito Division. Abundant nodules have been observed.

Phaseolus atropurpureus - A native plant which forms a dense cover of 20-30 cm height. The seed reproduction is more effective. Flowering and seed production have been observed throughout the year. Although almost all species of this genus were seriously attacked by insects, this plant is quite tolerant to this damage.

To date, this plant has behaved like a perennial with some age effect and its degree of recovery is quite good. Lately serious damage, probably associated with waves of low temperature, was observed.

Pueraria phaseoloides - One of the most vigorous species but with a very slow initial growth. A clean ground is generally required for establishment, but after this stage it is a highly aggressive climbing plant, with large vines.

A common oil palm ground cover. In bananas it is now planted in a mixture with Centrosema pubescens, and they produce a cover 20-40 cm in height and the above-mentioned disadvantages were reduced. Large amount of effective nodules are observed in the roots.

Teramnus labialis - A creeping type plant. It is extremely aggressive. A good competitor against weeds. This plant is forming a dense mat of 30-60 cm in height, but does not present any difficulty for labor movement. It is affected by low temperatures. Flowering is observed from November through January.

Unknown-1 - One of the more creeping plants now under observation. It is probably a perennial plant, forming a green carpet of 10 cm in height. A rapid lateral growth occurs due to an excellent rooting at nodes. Although flowers since July through September, no seed formation has been noticed; it seems that the flowers are falling off the plant. Reproduction by cuttings is very effective. It is not affected by climate changes nor by humidity conditions.

About 90 plants have been discarded as ground covers. They exhibited one or several undesirable characteristics which are briefly described below:

Climbing species: The genera Dolichos, Stizolobium and Canavalia have a pronounced tendency to climb the banana plant. Additional labor was needed to remove the long vines from the pseudostem and the base of the banana plants.

Too tall plants: The genera Cassia, Crotalaria and Flemingia are very high, which makes them completely unsuitable in banana plantings.

Unadapted plants: Plants of the genus Stylosanthes did not develop under banana conditions. All the species of this genus had an excellent germination but never reached an optimum growth.

Sun-loving plants: There were also genera like Indigophera, completely unadapted to the shade of banana plantation and, although they had a good initial stage, could not maintain a good appearance.

Short growth cycle: Those plants whose life period is limited from some months to one year have been discarded. They belong mostly to the following genera: Phaseolus, Vigna, Psophocarpus, Canavalia, etc.

Other defects: Some plants belonging to the genus Tagetes had an adequate start, but thereafter were seriously damaged by water fall from the overhead irrigation system.

Importance of Native Plants

About 80-90% of the preliminary chosen cover crop plants are species found locally. These plants were growing mainly in banana plantations. Both propagation by cuttings or seeds have been used. A collection of native plants, preferably leguminous ones must be initiated in Armuelles and Bocas Divisions. This work must also continue in the Golfito Division.

Potential for Mixture of Cover Crop Plants

Since the major number of plants suffer from periodic declines, depending upon their physiology and the climatic conditions, especially the rainy season, it is necessary to consider the potential of some plants for growing in mixtures. Mixtures may also be useful to diminish the damage of fungal attack that occasionally occur.

Some promising mixtures are: Centrosema pubescens with Pueraria phaseoloides, D. intortum, D. axillare, D. uncinatum as well as with plants belonging to the genus Glycine.

Golfito Division Observation Plots

Centrosema pubescens, Desmodium intortum, Desmodium uncinatum and Dolichos lablab were planted in May 1975 at Farm 47, Coto District, Golfito Division. These plants were promising under Honduras conditions.

Dolichos lablab was seriously affected by a combined attack of chrysomelids and Rhizoctonia sp., resulting in the disappearance of this plot.

Standing water is also a factor with detrimental effects, especially in both species of the genus Desmodium. However, D. intortum has shown to be more tolerant than D. uncinatum to poor drainage conditions. Standing water, which is very common in Coto District after heavy rainfall, greatly affects these species. Possibly this situation may be rectified by ground cover mixture with one water-loving plant. C. pubescens has shown, by far, to be the best adapted plant under Coto conditions and the chlorosis observed in the Honduras Division has not been observed there.

It is convenient to start ground cover crop studies under conditions of each Division. Many native and some exotic plants can be planted in a farm to obtain preliminary information before large-scale trials are initiated.

Excluding the Honduras experience, only in the Golfito Division a fair number of species have been observed. In Armuelles there is also a small plot of Centrosema pubescens and some information has been collected from it. Species show pronounced variation in adaptability from one site to another. For this reason, it is necessary that the more important species be observed in each Division.

Experiment with Tagetes sp. for Suppressions of Nematode Populations

A greenhouse trial with Tagetes sp. and parasitic nematodes was conducted. Nine varieties of Tagetes sp., two species of the genus Pectis and one species of the genus Phaseolus were planted in pots filled with nematode-infested soil from San Juan Farm (Honduras Division). The objective of the trial was to determine if growing Tagetes sp. would eliminate banana plant parasitic nematodes from the rhizosphere.

The nematodes considered in this trial were: Radopholus similis, Pratylenchus coffeae, Meloidogyne sp. and Helicotylenchus multicinctus.

Erecta aztec and Erecta glitters Tagetes varieties show some promise as far as reducing number of nematodes in the soil. Growing red beans mixed with Tagetes did not result in any more nematodes than did Tagetes grown alone. Apparently, under the conditions of this trial, these nematodes are going to survive in the presence of Tagetes, and little population suppression can be expected.

Herbicide Use in Establishment of Native Plants

When a native plant is found growing in a banana farm or in other areas, they have the appearance of a heterogeneous stand of natural weeds; the wanted plant may be the dominant one. Some help is needed to reach a complete cover by the desired plant. This has happened with plants like Desmodium axillare, Phaseolus adenanthus, Centrosema pubescens and Centrosema plumierii in the Honduras Division.

A small trial was conducted at Cobb Farm (Honduras) over a natural stand of Desmodium axillare. Several rates of the four cleared herbicides for bananas and three unregistered products were sprayed over the heterogeneous vegetal cover in order to find out whether any of the products under test was able to accelerate the establishment of this native plant.

Gesatop Z at the rate of 2.24 kg/ha (2.0 lb/acre) and Gramoxone at a rate of 1.7 lt/ha (1.5 pt/acre) applied on a monthly basis, 3 or 4 times, resulted in a good cover similar to one obtained by cleaning manually. The area covered by this highly promising plant is being increased.

Seed Germination Trials

A germination trial was conducted in the greenhouse in order to find the best pre-germination treatment to increase germination of each species. A large number of treatments have been tested:

1) Immersing the seeds in boiling water for 1 to 120 sec.

2) Immersion of the seeds in concentrated sulfuric acid (H_2SO_4) for 5-40 sec.

3) Exposure of seeds to low temperature (-7° C) for 1-20 days before planting.

These trials are conducted with the most promising species. Encouraging results for C. pubescens, D. intortum, D. uncinatus and P. phaseoloides have been obtained.

Freezing for 7-10 days has been the best treatment for both Desmodium species; immersion in H_2SO_4 for 5-10 sec is also recommended. With both treatments germination was 90% or higher, but both species appeared susceptible to the immersion in boiling water for more than 15 sec.

Centrosema pubescens had a behavior similar to *Desmodium* genus for both treatments, but its germination was quite lower than in the case of *D. uncinatum* and *D. intortum*. A marked reduction in germination was also observed when using boiling water. Best results with *P. phaseoloides* were obtained when the seeds were treated with hot water (40° C) during half an hour + freezing (-7° C) during 24 hr. However, no more than 39% of germination was obtained.

(RODRIGUEZ, JACOME, MORALES)

FRUIT PROTECTION - GUYING MODIFICATIONS

The present guying system is inadequate for several reasons; namely, improper guying (loose, slippage on anchor plant and choking of young anchor plant caused by slipped knot), variable twine strength, fixed guy length (too long or too short), and cut or broken guys. In addition, with the current strength of twine, even properly guyed plants have little protection against moderate and severe winds. This is especially true of inclined plants bearing heavy bunches.

Our competitors habitually use props of bamboo or other materials. These props have the disadvantages of expense in cultivation and harvest, labor for handling in the field, deterioration and thievery.

A modified system of guying by straightening inclined plants and guying under tension would possibly reduce the considerable field losses experienced with the current system. A simple light-weight tool for this purpose has been developed. The function of the straightening tool is illustrated before (Figure 42) and after (Figure 43) application to the same plant.

The modifications which are suggested for implementation of this revised guying system are outlined below:

(1) Presently, the fruit spray crew searches for the plants with newly shot bunches and the following bagging crew has to search for the same plants. The spray team should carry markers and attach them around the trunk (waist high) of treated plants for subsequent easy spotting by the baggers. These markers are easily made from a strip of bright-colored cloth with a button or hook on one end and a rubber band on the other end. In addition to increased efficiency, this would also prevent missed unsprayed bunches from being bagged during periods of high fruit spot incidence.

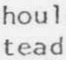
(2) The bagger would continue to bag, dehand and debud, but would not guy. Instead of guying, he would place a much shorter pre-measured string on the plant to be guyed and leave the two loose ends dangling (about 4 ft off ground) opposite the bunch for the subsequent guyer. This string should be three to four times the thickness of current guy string. Instead of tying a knot to attach the guy to the plant as is the current method, the leader guy would be attached with a simple pass-through loop (). This prevents slippage (and aids removal at harvest) and the

Figure 42. Plant straightener at beginning position on inclined plant.

Figure 43. The inclined plant after straightening. Straightener is fixed in position.

thicker twine will not cut the plant. The lead strings would have knots in the ends for ease of tying on of guy string.

(3) The guyer would carry the plant straightener and a spool of twine (on his back). The twine should be twice as strong as that currently used. He would straighten the inclined mats, but not use the straightener on upright mats. Care must be taken that an angle is left for fruit to hang clear of pseudostem upon development. The guyer would then leave straightener in its fixed position and pull string from spool over his shoulder to tie onto one of the lead strings left by the bagger. He cuts only the amount of string needed and pulls it through anchor plant at six inches above ground level with needle carried in disinfectant. Choking of anchor plant is prevented by making a non-slip knot by putting a loop in the string close to anchor plant and running the end of string through the loop for final tie ( ). The second lead string is tied onto and guyed in the same manner. The guyer then removes the straightener and marker that was left by the fruit sprayer before continuing to the next plant.

(4) When the bunch is harvested, the lead rope is removed and taken in for subsequent re-use several times. A segment of guy twine can be left around the knotted ends for recording number of times used.

This system appears to have several advantages:

(a) Less labor required than with propping.

(b) Closer supervision, since guying is one job.

(c) No increase in materials required (the thicker leader guy is re-used several times and 1/2 the amount of regular guy twine is used).

(d) No exertion by guyer (and no loose guys) since the tension is put on the string when straightener is removed.

(e) With needle for anchoring, anchor stays low on plant and will not double the anchor plant as frequently as with higher anchoring.

(f) Stronger twine will give blowdown protection.

(g) Less swaying of plant in wind, since there is no slack in guy or guy attachment on anchored plant.

(h) Reguying of cut or broken guys is easily accomplished by tying onto the stronger leader guy again.

(i) Different colored leader guys could possibly be used for age-grade control.

(j) A considerable reduction in fruit lost.

Disadvantages:

(a) One more job (but bagger should cover a larger area and receive less pay per mat).

(b) Thievery of the stronger lead string.

(c) Lower anchoring will result in less space for carrying harvested bunches under the guys.

(d) The straightener is apparently more applicable to Grand Nain which has more tendency to lean than VALERY.

(e) The system has to be tested. Demonstrations and explanations have been given to Dr. D. W. Funk and Mr. G. E. Donaldson. They plan to test the straightener in their respective areas where props are commonly used (Philippines) and where the highest plant losses are suffered (Armuelles).

(ROWE)

POST-HARVEST HORTICULTURE

SINKERS

In the 1973 Annual Report (pages 215-216) it was reported that sinker fruit did not hold for a significantly longer or shorter time than normal, or floater fruit. It was also found that sinkers had a higher soluble solids content than floaters at all color index stages.

Although sinkers are not identified as a cause of RT problems, they remain a source of loss in production. This is because heavy scarring occurs when the fruit bounce along on the bottom of the delatexing tanks. The phenomenon is perennial and seasonal; fruit harvested soon after the cold winter months contain a high percentage of sinkers. The cold period of 1975-76 was especially long and severe (Table 131).

Table 131. Mean monthly temperature minima (°F) during winter - Honduras Division

Month	Average 1971-1974	Season 1975-1976
December	69	56
January	70	58
February	71	58
March	72	60

In late May 1976, the following statistics were recorded on proportions of sinker fruit in three farms:

	% of dehanded fruit	% of waste fruit
San Juan	0.41	1.72
Corozal	0.77	4.20
Tibombo	2.53	18.03

The high frequency of sinkers in Tibombo fruit was thought to be attributed to comparatively low night temperatures. The following data show monthly average minima for Tibombo Farm between December 1975 and March 1976:

	°F
December 1975	68.4
January 1976	66.9
February 1976	66.5
March 1976	70.1

It is clear that Tibombo minimum temperatures are not low in comparison with the overall means for the Honduras Division. Thus, low temperatures alone are not the cause of the increase in frequency of sinker fruit.

During April and May 1976, a number of analyses were conducted on floater and sinker fruit. Samples from these analytical determinations were collected from La Curva Farm (06). The fingers from floater and sinker clusters of fresh green fruit were sampled on the same day, weighed, and the volume displaced in a graduated cylinder was measured to determine fruit density. Table 132 shows the average results obtained in ten fingers and ten of sinker clusters.

Table 132. Weight, volume displaced and density of sinker and floater fingers

	Sinkers	Floaters
Weight (g)	243.5	189.2
Volume displaced (cm^3)	240.5	190.3
Density (g/cm^3)	1.013	0.996

The specific gravity was also measured with a hydrometer on a solution of 20 g macerated pulp in 1000 ml of water. The average of ten readings on sinkers and same number of floaters was 1.001 and 0.998, respectively. Soluble solids refractometer readings at different color index grades were also measured on both sinker and floater fruit (Table 133). In all cases, sinkers had a slightly higher reading than normal fruit. These data agree with the results reported in the 1973 Annual Report.

Table 133. Average soluble solids refractomer readings on ten fingers of sinker and floater fruit

	Color Index			
	3	4	6	8
Sinkers	14.4	18.9	23.9	24.8
Floaters	14.1	18.9	23.6	24.2

Total soluble solids were also measured with a Brix hydrometer on a juice obtained from fruit with color grade 5+. The macerated pulp was treated with a pectic enzyme (Pectinol 10M) and centrifuged. The Brix hydrometer readings on sinker and floater banana juice was 23.1% and 22.7%, respectively.

The starch analysis confirms the slightly higher content of soluble solids on sinkers, giving an average on ten fingers of 6.62% starch on sinker versus 6.70% on floater fruit.

Ten fingers each of floater and sinker fruit were peeled. The peel on both types of fruit floated 100% of the time, but the pulp did not. Pulp from normal fruit floated 70% of the time on vertical position (with flowering end at the top) and 30% on horizontal position while all sinkers sank 100% of the time.

The pulp of sinker and floater fruit was divided in seven sections (Figure 44). The bananas used in this study were approximately the same length.

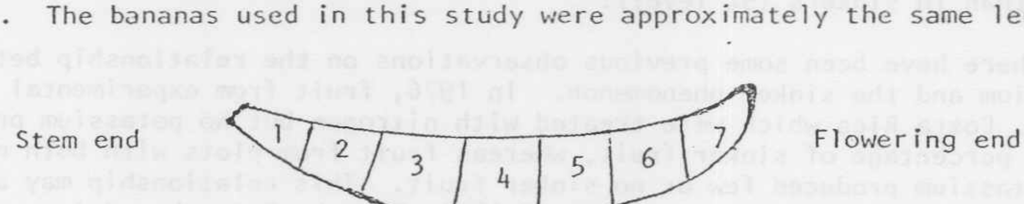


Figure 44. Banana sections used for analytical determinations.

From each section a plug 1.3 cm wide and a variable height, depending on the grade of the fruit, was cut. The density of each plug was measured and it was determined whether they sank or floated. Table 134 shows average density (W/V) and percent of the time that the plugs from sinker and floater fruit sank. It can be seen that in both sinker and floater fruit, the fruit pulp is less dense in the middle sections. In these measurements, the overall mean densities for floaters and sinkers were almost exactly the same.

This may be a reflection of the errors inherent in measuring the density of small pieces of tissue. When it was determined whether or not the various sections floated, however, it became clear that a much higher percentage of the middle sections from sinker fruit sank. In sections 3 to 6, a mean of 92.5% of sinker sections sank compared with only 27.5% in floaters.

The soluble solids refractometer readings per section in color index grades 4 and 5 in both floater and sinker fruit were also analyzed (Table 135). The differences in soluble solids were, on the average, higher in sinkers as already shown in Table 133 above. No clear pattern in distribution amongst the sections emerged, however.

Total soluble solids (Brix hydrometer) were measured on the juice extracted from sections 4 and 5 of floater and sinker fruit. Juice from floater sections 4 and 5 gave a reading of 20.5% and 20.20%, respectively, while on sinkers the percentage was 21.15% and 20.80%. Starch analysis from section 5 confirms these results, giving an average from five fingers of 6.8% starch on floater and 6.20% starch on sinker fruit.

The length and width of starch grains from the whole fruit were measured. Averages for the 20 biggest grains in a microscopic field on sinkers was 54.47 microns length and 39.01 width, while floater grain averaged 43.82 and 36.40 microns, respectively. The same analysis on starch from section 5 from 20 different fingers of sinker and floater fruit gave averages of 59.02 microns length and 42.72 microns width for sinkers and 53.60 length and 47.21 microns width for floaters. These results were confirmed by microscopic observations of tissue of 25 microns width cut with the microtone. Sinker cells had less but larger starch grains than floater cells.

Ten individual fruit samples (peeled) each of sinkers and floaters were subjected to mineral analysis. The results are shown in Table 136.

There appears to be a higher level of both potassium and iron in the floater fruit. However, the iron content was only significantly greater at the 10% level of probability. Potassium on the other hand, was significantly higher in floater fruit than in sinkers (5% level).

There have been some previous observations on the relationship between potassium and the sinker phenomenon. In 1976, fruit from experimental plots in Palmar, Costa Rica which were treated with nitrogen but no potassium produced a high percentage of sinker fruit, whereas fruit from plots with both nitrogen and potassium produced few or no sinker fruit. This relationship may also be reflected in the fact that Sections 29-44 in Tibombo Farm showed low potassium ($<3\%$) by leaf analysis in 1976. It is planned to investigate more fully this relationship during the 1977 sinker season.

<u>The Relationship Between Potassium and Magnesium Status and Holding Properties of Bananas</u>

A preliminary experiment was conducted to investigate the possibility of low potassium and/or magnesium status being a cause of RT. An experiment in La Curva Farm, started in January 1974 in a low soil-K area, has involved treatments of 400 lb actual K/acre/year with some plots receiving supplemental Mg at

Table 134. Mean density of plugs of banana pulp from seven sections of sinker and floater fruit, and the percentage frequency with which they sank in water

Section	Density		Percent frequency plugs sank	
	Sinkers	Floaters	Sinkers	Floaters
1	1.252	1.218	100	100
2	0.995	1.086	100	100
3	0.917	0.920	100	45
4	0.916	0.921	90	15
5	0.879	0.937	90	10
6	0.967	0.954	90	40
7	1.160	1.053	100	90
Means	1.012	1.013	95.7	57.1

Table 135. Average soluble solids refractometer in three readings per section on floater and sinker fruit

Section	Color Grade 4		Color Grade 5	
	Sinker	Floater	Sinker	Floater
1	18.66	14.70	21.13	19.63
2	17.80	14.66	20.96	20.40
3	16.46	15.66	20.80	19.43
4	16.66	16.33	20.96	16.56
5	15.86	16.06	20.40	18.63
6	16.80	15.10	19.26	17.96
7	16.00	14.60	20.60	18.96
Overall Average	16.89	15.28	20.59	18.80

Table 136. Mineral analysis of ten peeled fruit each of sinker and floater (fruit)

Sample No.	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
	Percentage of dry matter					Parts per million			
F1	1.90	0.061	1.66	0.013	0.131	103	3	15	11.3
F2	1.55	0.055	1.23	0.013	0.131	103	5	30	11.3
F3	1.90	0.055	1.66	0.008	0.117	85	5	13	7.5
F4	1.60	0.051	1.45	0.011	0.117	48	3	15	7.5
F5	1.65	0.061	1.27	0.010	0.136	40	5	15	7.5
F6	1.70	0.061	1.05	0.008	0.130	90	8	13	8.1
F7	1.70	0.071	1.35	0.008	0.136	58	8	13	11.3
F8	1.65	0.047	1.31	0.009	0.125	88	5	35	9.4
F9	1.90	0.056	1.92	0.013	0.121	70	3	13	7.5
F10	1.80	0.065	1.67	0.006	0.124	63	3	45	8.8
Means	1.74	0.053	1.46	0.010	0.127	74.8	4.8	20.7	9.0
S1	1.95	0.055	1.17	0.007	0.111	78	3	23	11.3
S2	1.75	0.047	1.43	0.012	0.131	88	3	10	9.4
S3	1.75	0.049	1.37	0.006	0.124	35	3	13	7.5
S4	1.60	0.056	1.7	0.006	0.114	58	5	10	9.4
S5	1.90	0.055	1.15	0.007	0.121	55	5	13	8.8
S6	1.80	0.065	1.27	0.005	0.124	65	5	15	9.4
S7	1.90	0.065	1.27	0.012	0.136	55	5	13	8.1
S8	1.65	0.041	1.27	0.012	0.120	63	8	10	7.5
S9	2.00	0.051	1.17	0.011	0.120	55	5	43	8.8
S10	1.95	0.057	1.27	0.005	0.124	43	5	23	7.5
Means	1.82	0.054	1.25	0.008	0.122	59.5	4.7	17.3	8.8
Significance	N.S.	N.S.	5%	N.S.	N.S.	10%	N.S.	N.S.	N.S.

25 lb/acre/year. In September, potassium rates were doubled. On the 29th December 1976, 20 boxes were taken from each treatment plus an untreated control and, after 48 hr at ambient temperature, were stored at 58° F. Boxes were held until their contents started to turn. Table 137 shows the average number of days held for each treatment and the average grade of the fruit. There was no difference in holding properties between treatments. The experiment will be repeated in 1977.

Table 137. Mean number of days held and average grade of fruit from the potassium-magnesium experiment, La Curva

Treatment	Mean days* held	Average grade
Potassium	20.4	15.3
Potassium & magnesium	19.4	13.9
Control	20.1	15.5

* Each figure is the mean of 20 boxes.

Holding Properties of Bananas in Relation to Hand Position

At shooting, basal hands are exposed 7-10 days before apical hands on the same stem. This difference reflects a difference also in the physiological age of the fruit.

It was decided to cut clean-up fruit on three different harvest dates, to separate the fruit according to hand position and to observe the holding properties of each hand. In two cases 11-hand stems only were cut, while in the third all stems were of ten hands. Each experiment consisted of 20 stems and the hands were grouped according to hand number (i.e. all apical hands - No. 1 were collected together in the same group of boxes and so on up to the basal hands Nos. 10 or 11). All hands were marked with the stem from which they had originated.

The data from each harvest were subjected to an Analysis of Variance and the least significant differences (L.S.D.) between hands computed. The results are shown in Table 138 and Figure 45. In all cases there was a very highly significant difference between hand positions. The range of holding times varied between 10 days and 13 days in the three trials, with the physiologically younger, apical hands holding longer than the basal hands. Thus, the 7-10 day difference in exposure at shooting is maintained, and probably slightly lengthened, during the course of fruit development.

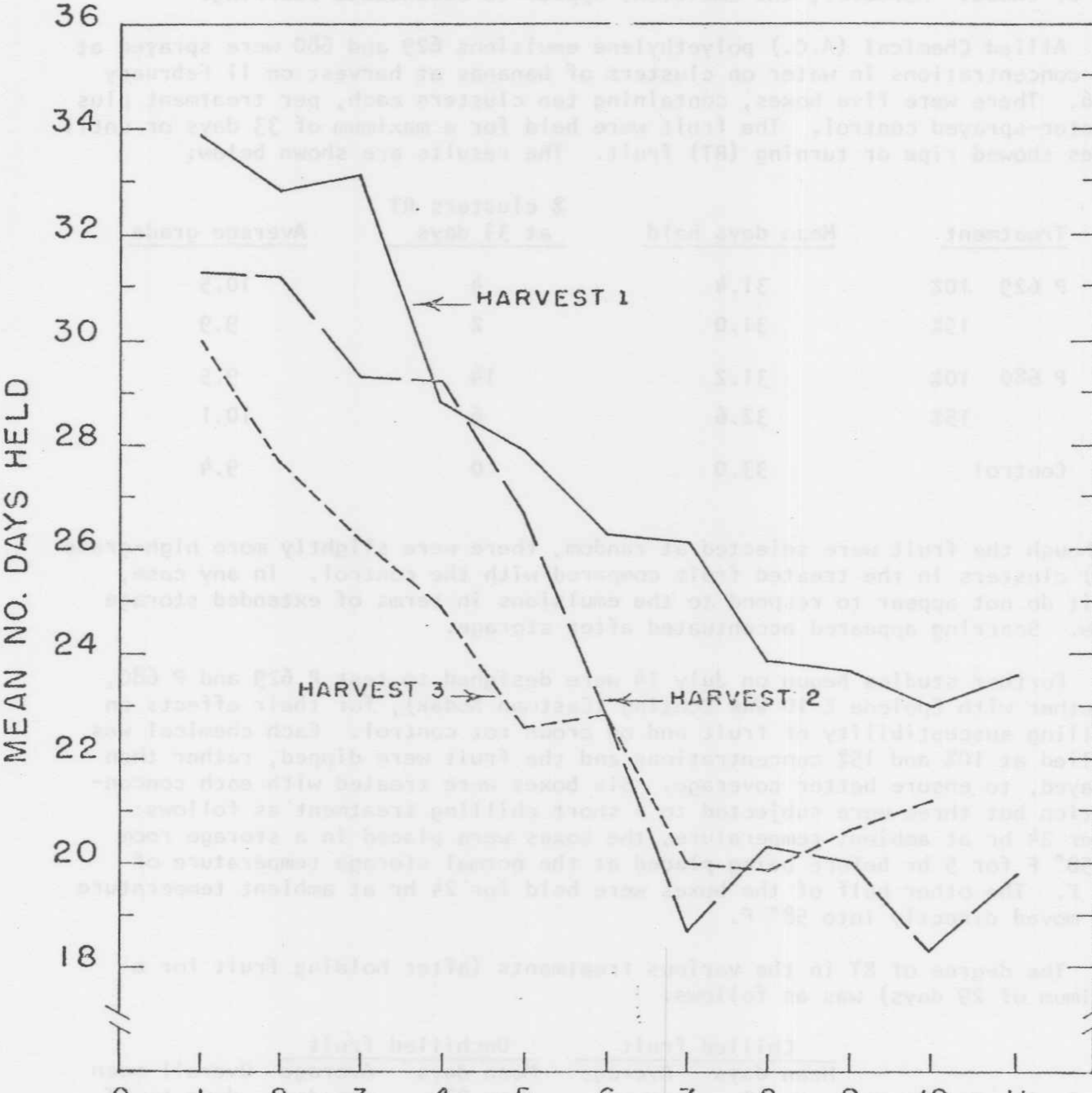
Table 138. Comparison of holding properties and caliper of hands at all positions on the stem

No. clusters	N	1st Harvest July 20		2nd Harvest August 4		3rd Harvest September 9	
		Mean No. days held	Mean grade of hand	Mean No. days held	Mean grade of hand	Mean No. days held	Mean grade of hand
1 (apical)	20	33.9	10.5	31.3	10.0	30.0	11.7
2	20	32.8	11.3	31.2	10.5	27.7	12.3
3	20	33.1	11.9	29.3	11.1	26.2	12.8
4	20	28.8	12.6	29.2	12.3	24.9	13.9
5	20	27.9	13.9	26.7	12.8	22.6	14.0
6	20	26.3	13.8	22.8	13.5	22.8	15.3
7	20	26.1	14.6	18.7	13.9	20.0	15.5
8	20	23.9	14.9	20.3	14.1	19.9	15.7
9	20	23.7	15.6	20.0	14.7	20.6	15.8
10	20	23.0	15.5	18.3	14.7	21.2	15.6
11 (basal)	20	23.6	14.3	19.8	14.0	-	-
Ranges		23.0-33.9	10.5-15.6	18.3-31.3	10.0-14.7	19.9-30.0	
L.S.D. 5%		2.01		6.78		3.90	
1%		2.65	***	8.94	***	5.15	***
F Value		52.2		8.45		12.37	

*** Analysis of variance showed a highly significant difference at the 0.1% level of probability.

Figure 45

THE MEAN NUMBER OF DAYS HELD FOR HANDS AT ALL POSITIONS ON THE STEM (THREE HARVESTS).



* EACH CURVE REPRESENTS ONE HARVEST AND EACH POINT THE MEAN OF 20 HANDS.

Low Molecular Weight Polyethylene Emulsions for Coating Bananas

Tests were carried out to evaluate the effects of these emulsions on the following properties: early ripes and turnings, fruit weight loss, crown rot susceptibility and chilling injury. No large positive effect was observed on any of these. Moreover, the emulsions appear to accentuate scarring.

Allied Chemical (A.C.) polyethylene emulsions 629 and 680 were sprayed at two concentrations in water on clusters of bananas at harvest on 11 February 1976. There were five boxes, containing ten clusters each, per treatment plus a water-sprayed control. The fruit were held for a maximum of 33 days or until boxes showed ripe or turning (RT) fruit. The results are shown below:

Treatment		Mean days held	% clusters RT at 33 days	Average grade
P 629	10%	31.4	4	10.5
	15%	31.0	2	9.9
P 680	10%	31.2	14	9.5
	15%	32.6	6	10.1
Control		33.0	0	9.4

Although the fruit were selected at random, there were slightly more high-grade (13) clusters in the treated fruit compared with the control. In any case, fruit do not appear to respond to the emulsions in terms of extended storage life. Scarring appeared accentuated after storage.

Further studies begun on July 14 were designed to test P 629 and P 680, together with Epolene E-10 Wax Coating (Eastman Kodak), for their effects on chilling susceptibility of fruit and on crown rot control. Each chemical was applied at 10% and 15% concentrations and the fruit were dipped, rather than sprayed, to ensure better coverage. Six boxes were treated with each concentration but three were subjected to a short chilling treatment as follows: after 24 hr at ambient temperature, the boxes were placed in a storage room at 50° F for 5 hr before being placed at the normal storage temperature of 58° F. The other half of the boxes were held for 24 hr at ambient temperature and moved directly into 58° F.

The degree of RT in the various treatments (after holding fruit for a maximum of 29 days) was as follows:

		Chilled fruit		Unchilled fruit		
Chemical	Treatment	Mean days to RT	Average grade	Mean days to RT	Average grade	Overall mean days to RT
P 629	10%	28.0	13.6	28.5	12.6	28.25
	15%	28.5	13.5	29.0	13.2	28.75
P 680	10%	26.0	13.8	24.5	13.8	25.25
	15%	26.5	13.4	23.0	13.6	24.75
Epolene	10%	28.0	14.8	27.0	13.3	27.50
	15%	25.5	13.2	25.5	13.9	25.50
Control		27.0	13.6	29.0	11.0	28.00
Means		27.1	13.7	26.6	13.1	

Again, there was no significant alteration of storage life and scarring was accentuated.

The chilling treatment appeared inadequate since low numbers of chilled fruit were observed and none was severely chilled. The fruit were scored on the basis of a scale from 0 to 4 for none, trace, light, medium, severe, respectively. Maximum score per box of ten clusters was 40, but the highest chilling effect was 7.5:

Treatment		Chilling score (max. 40)
P 629	10%	2.0
	15%	4.5
P 680	10%	2.0
	15%	7.5
Epolene	10%	2.0
	15%	4.0
Control		1.0

The effect of the treatments on crown rot suppression was also evaluated. Sample boxes of fruit were ripened and assessed when at a mean color index of 4, 28 days after harvest. The clusters were scored from 0 (absence of mycelium) to 8 (rotting spread into pulp). Those clusters at or above score 5 (whole crown surface with rot) were counted also:

Treatment		Mean C.R. score (max. 8)	% clusters C.R. 5
P 629	10%	3.70	25
	15%	4.85	60
P 680	10%	4.90	40
	15%	4.95	60
Epolene	10%	4.25	40
	15%	4.65	60
Control		3.00	0

It appears that crown rot organisms are stimulated to more rapid development when fruit are coated in polyethylene or wax emulsions. This may possibly be explained in terms of their ability to function anaerobically; but the host tissue may also be reduced in its resistance to these organisms by the alteration in the constituent gas concentrations in the intercellular atmosphere (the coatings will act as semi-permeable membranes).

A second test begun on July 28 again looked at chilling, using the same methods as in the earlier experiment, except that a period of 48 hr ambient temperature was allowed before the chilling period. Scores, directly comparable with those of the previous test, are shown below:

Treatment		Chilling score (max. 40)
P 629	10%	0.0
	15%	13.5
P 680	10%	6.5
	15%	21.0
Epolene	10%	17.0
	15%	6.0
Control		14.0

Again, scores were low, indicating 5 hr at 50° F was not sufficient. P 629 at 10% showed no chilling in comparison to "trace to light" chilling in the control, but these results were not statistically significant overall. There appears to be a slightly increased incidence of underpeel discoloration (UPD) at the higher concentrations of these coatings; if this is repeatable, it may be that there is a chemically induced UPD, as well as the chilling effect.

A final experiment, commenced on 4 November 1976, was designed to test the A-C polyethylenes for their effect on fruit weight loss by desiccation and also to check further on their effect on resistance to chilling. Fruit were harvested on November 3 and kept 48 hr at ambient temperature. The two emulsions were applied at the same two concentrations (10% and 15%), making 40 boxes + two lots of ten controls. Half the boxes in each treatment lot were subjected to 50° F for 24 hr and then moved to 58° F. The other half were moved directly into 58° F after the period of ambient temperature. All boxes were checked for weight loss at intervals during storage of 21 days and checked at the end of this period for UPD. They were then ripened and checked for further weight loss six days later.

The following table shows that there was no marked difference in weight loss between the treatments (each figure is the mean of ten boxes - 100 clusters):

		Weight Loss (%)	
		After 21 days storage	After ripening
P 629	10%	2.30	4.03
	15%	2.42	4.02
P 680	10%	2.31	3.96
	15%	2.55	4.10
Control 1		2.34	4.06
Control 2		2.41	4.20

The chilling treatment was more severe and resulted in higher UPD scores but there was no significant difference in scores between treatments:

Treatment		$\bar{x}$ Chilling score (max. 40)
P 629	10%	23.0 ± 9.6
	15%	21.0 ± 13.8
P 680	10%	27.6 ± 12.5
	15%	28.4 ± 9.4
Control 1		27.2 ± 11.4
Control 2		34.4 ± 4.9

These data, when considered with previous UPD data, leave a slight doubt whether P 629 is totally ineffective as an anti-chilling agent. However, the overall benefit of P 629, even if slight chilling protection is verified, is little more than P 680 or Epolene. The two A-C polyethylenes consistently high-lighted existing scars on the peel of the bananas.

A further check on P 629 and anti-chilling is planned. Also, it is intended to treat fruit that have already been ethylene-treated in order to observe the effect of the coatings on rapidity of the ripening response.

FOOD TECHNOLOGY

BANANA CATSUP

At the request of the Unimar Division of San Jose, Costa Rica, the development of two prototype banana catsup products was studied: one with artificial tomato flavor and the other with a hot spice flavor.

To develop these two prototype products from banana puree as a starting material, it was necessary to use U.S. certified artificial color and flavorings, beside the common ingredients of catsup: vinegar, salt, sugar and spices. Also, the total acidity had to be raised by addition of extra vinegar.

Analyses were made on a commercial banana catsup from the Philippines, on a commercial Honduran tomato catsup and on the banana puree. A Gardner Colorimeter was used. The "L" value gives a measure of the lightness, the "A" value the redness, and the "B" value the yellowness of the product.

The Bostwick consistometer was used to measure the distance in centimeters that a fixed volume of the product spreads in 30 sec (Table 139).

Total acidity was also determined in the commercial tomato catsup, giving a value of 1.7%, while in the banana puree this value was 0.77%.

Acidity Fixation

Acid in the form of vinegar was used to raise the acidity of the banana

Table 139. Gardner color, pH, soluble solids and consistency values on a banana catsup, tomato catsup and banana puree

Product	pH	% soluble solids	Bostwick consistency	Gardner color "L"	"A"	"B"
Banana catsup	3.7	26.0	6.9-7.5	24.8	17.1	7.3
Tomato catsup	4.1	31.6	4.6	27.2	7.0	8.4
Banana puree	5.2	22.0	2.0-6.0	63.6	3.2	18.6

Table 140. pH* obtained after various levels of vinegar added

Sample #	Volume added (ml)	% by weight of acetic acid in banana puree	pH obtained
1	48	0.42	4.6
2	58	0.50	4.4
3	68	0.59	4.4
4	96	0.83	4.3

* The initial pH of the puree was 3.1.

puree. Vinegar is the principal preserving agent in catsup and constitutes about one-half of the total acidity. Heinz apple cider vinegar with a 50 grain strength $\left(\frac{5\ \text{g acetic acid}}{100\ \text{ml}}\right)$ was used (Table 140).

The addition of large amounts of vinegar to obtain a pH of 4.3 affects the consistency of the product. Good consistency means a flow not more than 9 centimeters in 30 seconds in the Bostwick consistometer.

This high addition of vinegar also makes the addition of more sugar to the product necessary in order to balance the sugar/acid ratio of the product and to keep the flavor in balance.

To overcome the problem of the consistency, a 10% V/V solution of acetic acid was made to use as a 100 grain vinegar. It was found very objectionable because of detection of acetic acid as a flavor component.

Color Fixation

Two dyes: Orange shade and reddish-brown shade manufactured by Warmer-Jenkinson Company were used to give the imitation tomato color.

A 1% W/V dilution of each of these two dyes was prepared and combined in three different proportions.

It was found that the color changed after heating and acidifying the samples. This change was not noticeable in a subjective evaluation. The proportion of 6.5 ml of orange shade per ml of reddish-brown was selected for further formulations.

Flavor

Banana puree contributes predominantly to the consistency of catsup and also an important part of the flavor is derived from it. The banana puree used was from physically damaged puree cans obtained at the La Lima Puree Plant. The rest of the ingredients used are shown in Table 141; the formula was different for the two prototypes.

Table 141. Amount of ingredients (%) used on each prototype

Prototype	Salt	Garlic	Onion	Pepper	Chile	Artificial tomato flavor
Spicy flavor	1.86	0.18	0.22	0.10	0.06	--
Tomato flavor	1.86	0.04	0.06	0.04	--	1.2

An artificial tomato flavor 57.632/BP 05.51 of the Firmenich brand was used in this formulation. With the tomato imitation flavor, the problem was the strong aroma of the banana; even after raising the percentage of artificial tomato flavor, the aroma of the banana remained.

To avoid this problem, the use of puree that had been passed through a flash evaporator was tested. Most of the flavor and aroma components of the puree are driven off during flash-evaporation which makes it easier to achieve an artificial tomato flavor and lessens the use for spice. The evaporating conditions were as follows: The vacuum pressure used was 28 lb and the temperature 142° F in the heating unit and 36° F in the cooling unit.

A check was made on the possible use of flash-evaporated (concentrated) puree to see if any problems would arise from its use.

Table 142 shows a comparison of quality characteristics of a regular banana puree and a concentrated puree. The differences in color were small, but greater on consistency, soluble solids and aroma.

Table 142. Quality characteristics on a regular and concentrated puree

Sample	pH	% soluble solids	Bostwick consistency	Gardner color "L"	Gardner color "A"	Gardner color "B"
Regular puree	5.2	23	6	63.6	3.2	18.6
Concentrated puree	5.2	27.8	2.4	60.9	2.5	15.3

At present, studies on a pilot-scale are being performed in the Corning Laboratories in Iowa.

BANANA BREEDING

Diploid Breeding

The most significant recent accomplishment in diploid breeding is the development of the Sigatoka and black Sigatoka resistant diploid, SH-2989. This hybrid is from the cross IV-9 x SH-2752. Taxonomically, the leaf spot (Sigatoka and black Sigatoka) resistant accession IV-9 is classified as *M. a.* subsp. *burmannica* and has very inferior bunch characteristics (Figure 46). Indeed, SH-2989 was the only hybrid with markedly improved bunch features observed in a population of over 2,500 progenies from crosses of several different advanced diploids

Figure 46. From left: Bunches of the Sigatoka resistant accession IV-9 and advanced diploid SH-2752 and the Sigatoka and black Sigatoka resistant progeny from these, SH-2989.

onto IV-9. During a visit to the Jamaican banana breeding scheme in June, Dr. Shepherd related that their experience using IV-9 as a source for Sigatoka resistance has not resulted in any useful hybrids.

In addition to Sigatoka and black Sigatoka resistance, SH-2989 has many other desirable characteristics. It is vigorous and flowers seven months after planting. The fruit has a good banana flavor and bunches will hold on the plant for six months without ripening. The parthenocarpic fruit set a few seeds when pollinated, and this hybrid is being used as both male and female parent in cross pollinations.

Earlier breeding efforts for Sigatoka resistance were based almost exclusively on accessions of the subspecies *malaccensis*. This was due mainly to the better agronomic qualities of *malaccensis* compared to the other sources of resistance. The resistance of *malaccensis* is controlled by multiple genes, and these accessions still have excellent resistance to black Sigatoka. Before the prevalence of black Sigatoka, hybrid progenies of *malaccensis* frequently exhibited the same level of Sigatoka resistance as the accession. However, now resistance is much more difficult to recover in hybrids. Evidently, all the *malaccensis* genes for resistance must be acquired by the hybrids to impart resistance to black Sigatoka, whereas a few of the genes were sufficient to give resistance against the traditional Sigatoka.

One advanced hybrid, SH-3013, is a derivative of *malaccensis* and has excellent resistance to black Sigatoka. This hybrid is the major parent for this source of resistance in continued hybridization. Crosses have been made between SH-3013 and SH-2989 to produce hybrids with combinations of resistance from *malaccensis* and *burmannica*.

The first progenies from crosses onto the diploid nematode resistant Pisang Jari Buaya (hereafter referred to as PJB) clones were evaluated in the field this year. Many of these hybrids had thick leaves, lacked vigor and never flowered. These abnormalities were expected in view of previous findings that the PJB clones produce chromosomally imbalanced as well as normal ploid egg cells. A total of 13 normal hybrids were selected for further evaluation. Most of these selections had seeds and good pollen, which indicates that the semi-sterile features of the PJB parents are not perpetuated in its progenies. An additional 55 hybrids from this series of crosses were planted in the field and several more are in the seedling stage. This hybridization effort continues with 3000 mats of PJB being pollinated.

The best diploid in the breeding program is SH-2095. A visual evaluation of the diploid breeding stock in the Jamaican program did not reveal any diploids that approached SH-2095 in terms of advanced agronomic features. A comparison of SH-2095 with Lidi, the most widely used diploid accession in the early phases of banana breeding, is shown in Figure 47. A measure of the excellence of SH-2095 is that the second best diploid agronomically in our program, SH-2752 (Figure 46), is a progeny of SH-2095. The three weaknesses of SH-2095 are slight slowness to shoot, poor pollen and slightly watery flavor. These weaknesses are readily corrected upon hybridizing, as evidenced by SH-2752 which is fast to flower, has abundant pollen and good flavor.

In addition to SH-2752, other progenies this year demonstrated the value

Figure 47. Comparison of the diploid SH-2095 (on shoulder) with Lidi, the most widely used diploid accession in the early phases of banana breeding.

of SH-2095 as a parent in hybridization. Four selected hybrids from a small population of the cross, SH-2095 x SH-2733, had bunch characteristics similar to SH-2095. In contrast, crosses of SH-2733 onto several other advanced diploids did not result in any hybrids which merited selection. Of all the advanced diploids which have been the basis of breeding for agronomic qualities, SH-2095 is the only parent which has consistently resulted in a high percentage of progenies with markedly improved agronomic features.

Some 3200 hybrids from crosses of dwarf, agronomically superior and Sigatoka resistant diploids onto SH-2095 were planted in the field this year, and several hundred more will be planted shortly. Of special interest are the seedlings from crosses of the Sigatoka and black Sigatoka resistant SH-2989 onto SH-2095. A total of 5000 mats of SH-2095 are now being pollinated.

The diploid segregating populations evaluated this year resulted in 39 selected diploid hybrids. Aside from the PJB and SH-2095 progenies, the most interesting selection (SH-3041) is from a cross between the black Sigatoka resistant SH-794 and SH-2752. This hybrid is moderately resistant to Sigatoka and black Sigatoka, vigorous and has a nice 18-hand parthenocarpic bunch. Field plantings of segregating diploid seedlings with diverse pedigrees designed to incorporate agronomic qualities, dwarfness and disease resistance amounted to 10,500 plants.

Tetraploid Breeding

The triploids Highgate and Lowgate are the fixed female parents in cross pollinations with diploids to synthesize commercial type tetraploid hybrids. The diploids SH-2095 and SH-2752 were the most intensively used male parents in this breeding endeavor. The Sigatoka resistant diploid SH-2989 was crossed onto Highgate later in the year as pollen became available.

The diploid SH-2095 has poor pollen, and seed set in Highgate was correspondingly lower than when pollinated with more adequate male parents. Nevertheless, these pollinations yielded sufficient seeds for a field planting of 338 hybrids during the year. The earliest of these hybrids will be shooting fruit shortly.

In comparison to SH-2095, the diploid SH-2752 was a more effective pollen parent onto Highgate and yielded larger quantities of seeds with less extensive pollinations. A total of 354 Highgate x SH-2752 tetraploid progenies were planted in the field. The Sigatoka resistant diploid SH-2989 has abundant pollen, and numerous tetraploid progenies derived from this hybrid are in the seedling stage.

Only two progenies from Lowgate x SH-2095 were transplanted to the field this year. This shortest of the Gros Michel dwarf mutants has poorer seed fertility than Highgate, and only a small block of plants was available for pollination. Pollinations are just beginning on a 10-acre increase of Lowgate.

Tetraploid x Diploid Breeding

The various advantages of triploids over tetraploids have been discussed in previous annual reports. Namely, triploids have less leaf doubling, have greater sterility against possible seediness, are more genetically diverse, and additional sources of disease resistance can be introduced in a triploid pedigree.

Some near-commercial triploids have been synthesized by the Tetraploid x Diploid Method. Further testing of this scheme was pursued this year with the pollination of 97 different seeded tetraploids by SH-2095 and SH-2752. Some of the triploid progenies have been planted in the field and numerous others are in the seedling stage.

Greenhouse Operations

The ripening rooms constructed by enclosing frame structures with polyethylene sheeting have given very satisfactory results. Gassing with 1000 ppm (on an empty room basis) acetylene is readily accomplished by adding a measured amount of calcium carbide to a container of water. The standard practice is to apply gas two nights in a row and aerate during the day. A third application of acetylene is sometimes necessary during periods of low temperatures. Seed extraction is now routine and efficient with this system of ripening.

Additional greenhouse space was constructed this year for handling the increased numbers of pollinated bunches. (ROWE)

Publication

Rowe, P. R. 1976. Possibilités d'amélioration génétique des rendements de plantain. Fruits 31: 531-536.

EXTENSION AND TRAINING

During 1976, Extension visits were made to the Central American Divisions, Belize and Colombia, with the purpose of assisting the Agriculture personnel in the various aspects of banana production. The number of trips and duration of the trip in each location is given in the table below:

	Trips	Days
Almirante, Panama	2	20
Armuelles, Panama	3	18
Belize	1	3
East Coast, C. R.	4	27
Golfito, C. R.	2	23
Honduras	Res.	Res.
Isletas, Honduras	1	3
Sta. Marta, Colombia	1	8

Cont'd.

	Trips	Days
Turbo, Colombia	1	13
Boston, U.S.A	1	6
Houston, U.S.A. (Scientific Meeting)	1	6
TOTAL	17	125

A total of eight intensive seminars on Banana Culture were given to Company's Agriculture personnel and Associate Producers in various Divisions during the year. The seminars in Armuelles were also attended by Agronomist from the Panama Ministerio de Desarrollo Agropecuario and the Corporación Bananera del Pacífico; in Honduras the seminars were also attended by Agronomist from the Corporación Hondureña del Banano. The following table shows the statistics of each seminar:

Division & Country	No. of seminars	Attendance	Days	Persons present
Almirante, Panama	1	Assoc. Prod. & Co. Agric. Staff	4	26
Armuelles, Panama	1	Assoc. Prod.	4	31
Golfito, C. R.	1	Co. Agric. Staff	4	63
Honduras	2	Assoc. Prod. & Co. Agric. Staff	6	169
Turbo, Colombia	2	Assoc. Prod.	5	32
-	1	U.F. Co. Management	5	15
TOTAL	8		28	236

A total of 11 Agricultural graduates completed a 38-week training program coordinated by the Divisions and the Agriculture and Training Department. Subsequent to their training, they were assigned to positions in areas where fruit is purchased to provide technical assistance to Associate Producers. Their nationalities are British (1), Colombian (3), Costa Rican (3), Ecuadorian (1), Honduran (1), and Mexican (2).

Assisted by four Agricultural trainees, a section-by-section evaluation of the status of the plantation in 15 farms (approx. 6,900 acres) was made on the East Coast of Costa Rica.

During 1976, soil surveys were made in Belize, Costa Rica, Mexico and Panama. The total area surveyed amounted to approximately 15,578 acres distributed as follows:

Country	Acres
Almirante, Panama	1,195
Belize	964
Chiapas, Mexico	6,567
East Coast, Costa Rica	6,852

Assistance was provided in the design of a series of agronomic studies to be initiated during 1977 in the Central American Divisions. These included studies on production timing, hedge-row planting, harvest systems, and fertilizer trials. (SIERRA)

EXPERIMENTAL DEPARTMENT - ARMUELLES

AGRONOMY

Leaf Sampling for Nutrient Analysis

A total of 1720 composite samples (488 from Associate Producers) were collected this year and sent to La Lima.

Potassium: Levels of this nutrient in Company farms still seems to be adequate with most areas above 3.00% in leaf tissue. Only few areas showed a lower level and were re-sampled. The Associate Producers' farms show typical potassium deficiency symptoms scattered throughout the marginal areas.

Nitrogen: During the year, three cycles of urea were applied, averaging 280.25 lb of nitrogen per acre per year. Foliar analysis results indicated some areas were under the desired N levels.

Production

The production of Company farms amounted to 993 boxes per acre from which 867 were shipped and 126 were not. The latter figure includes blowdowns, overgrade fruit loss due to poor market, Banana II not shipped, and wharf rejects. The Associate Producers averaged 634 boxes per acre shipped.

Drainage

This year a lot of primary and secondary work has been done using draglines and back hoes. Approximately 60% of the primary and 15% of the secondary drainage was completed by the end of the year. More work needs to be done on surface drainage.

Herbicides

Weed control has been accomplished using mainly a combination of Gramoxone and Karmex sprayed with mist blowers. Farms are not completely weed-free, but most of the grasses have been eradicated. Gesapax is being used in conditions where broadleaves, such as *Syngonium*, *Cissus*, etc. become a problem.

Cover Crops

A plot of *Centrosema pubescens* has been established in Section 5 of Majagua Farm. Late this year it was attacked by a fungus (*Colletotrichum* sp.) and almost completely defoliated. Later on, it overcame the infection and new leaves have been produced. A plot of 5 acres has been planted for seed purposes.

Sword Suckers As Material to Replant Within Plantations

A program was initiated later this year using "Colas de burros" to replant open areas within the plantations. At the beginning, results were discouraging due to (a) poor material selection, (b) dry period affecting the planted suckers, and (c) lack of experience of laborers doing the work. Later, most of these problems were solved and very successful work has been accomplished. One of the Associate Producers planted a complete section using this method and obtained very rewarding results.

Liquid Versus Granular Urea

This project started on January 1975 (1975 Annual Report, p. 3), using 250 lb nitrogen/A in solid form vs. 181 lb of nitrogen/A dissolved in water and sprayed in band at the base of the mats. As of December 1975, the liquid form was raised to 250 lb nitrogen. Data collected show a slight reduction in average fruit weights on plots receiving the liquid form (77.8 lb) compared with the granular form (78.9 lb) harvested at the same average grade of 14.5.

Roundup Experiment

An experiment was initiated using glyphosate herbicide. Residues in fruit will be determined for projected E.P.A. clearance. The product is being tested as a weed killer as well as a bananacide. Severe symptoms of phytotoxicity were observed in the treated plots after the second application on young banana plants. Weed control in general has been good so far, except for certain broadleaf weeds.

DISEASES

Sigatoka

Control has been exceptionally good this year due to improved coverage patterns detecting hot spots in time to reduce inoculum, using proper combination of fungicide-oil, and the exceptional dry weather conditions. Number of cycles was as follows:

Dithane Benlate-Oil	9.59
Benlate oil	.4
Dithane oil	.38
TOTAL	10.3

Moko

There were 132 cases in Company farms and 295 in Associate Producers. In the Company area most of the cases were found in plantilla at Aguacate Farm; natural hosts were present. At the Associate Producers' farms, incidence was due to careless control measures.

Figure 48 shows a comparative Moko incidence of three years in Company farms, and Figure 49 shows a comparative Moko incidence of three years in the Associate Producers' farms.

Pitting Disease

The fruit spray program was initiated on April this year using 1 lb Dithane per 5 gal of water. Incidence of the disease has been low. Cobapa had an outbreak during the last months of the year.

Fruit Spot

This trial located in Palo Blanco Farm, Section 21 was designed to try different Dithane-Benlate rates of applications and combinations for fruit spot control.

Table 143 shows the incidence of spots per hand comparing different treatments. No differences could be detected among treatments. All were superior to no control.

NEMATICIDES

Nematode Control

To the end of this year the following have been treated with DBCP (Fumazone):

Acres	No. Cycles
12,245	2
8,060	3
2,775	4
626	5
626	6

DBCP was injected at the rate of 14 cc per mat using the new injection pattern six inches from the base of the mat. The second cycle of Mocap was applied on 1,038 acres.

Higueron Malady

As a result of bromine accumulation in the soil, phytotoxicity symptoms appeared scattered throughout much of the Division. Most of the symptoms were on one or two leaves only and plants recovered. About 5,479 cases were counted but many more cases showing light symptoms were present. These consisted of a brown discoloration at the base of the leaf lamina, or a narrow chlorotic stripe

TOTAL NUMBER OF MOKO CASES

Company Farms

Figure 48

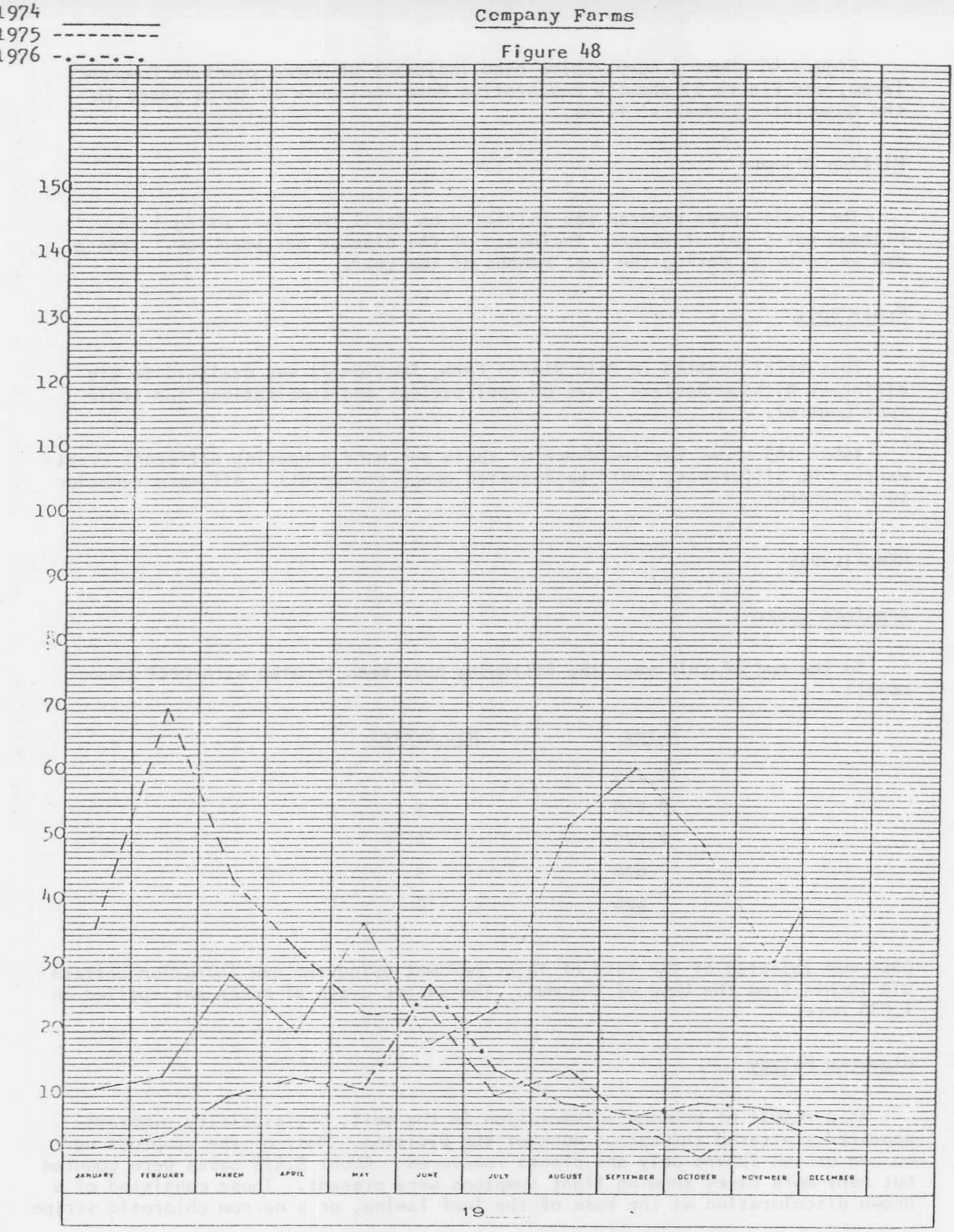


Figure 4c

TOTAL NUMBER OF MOKO CASES

ASSOCIATE PRODUCERS

Comparing 3 year incidence

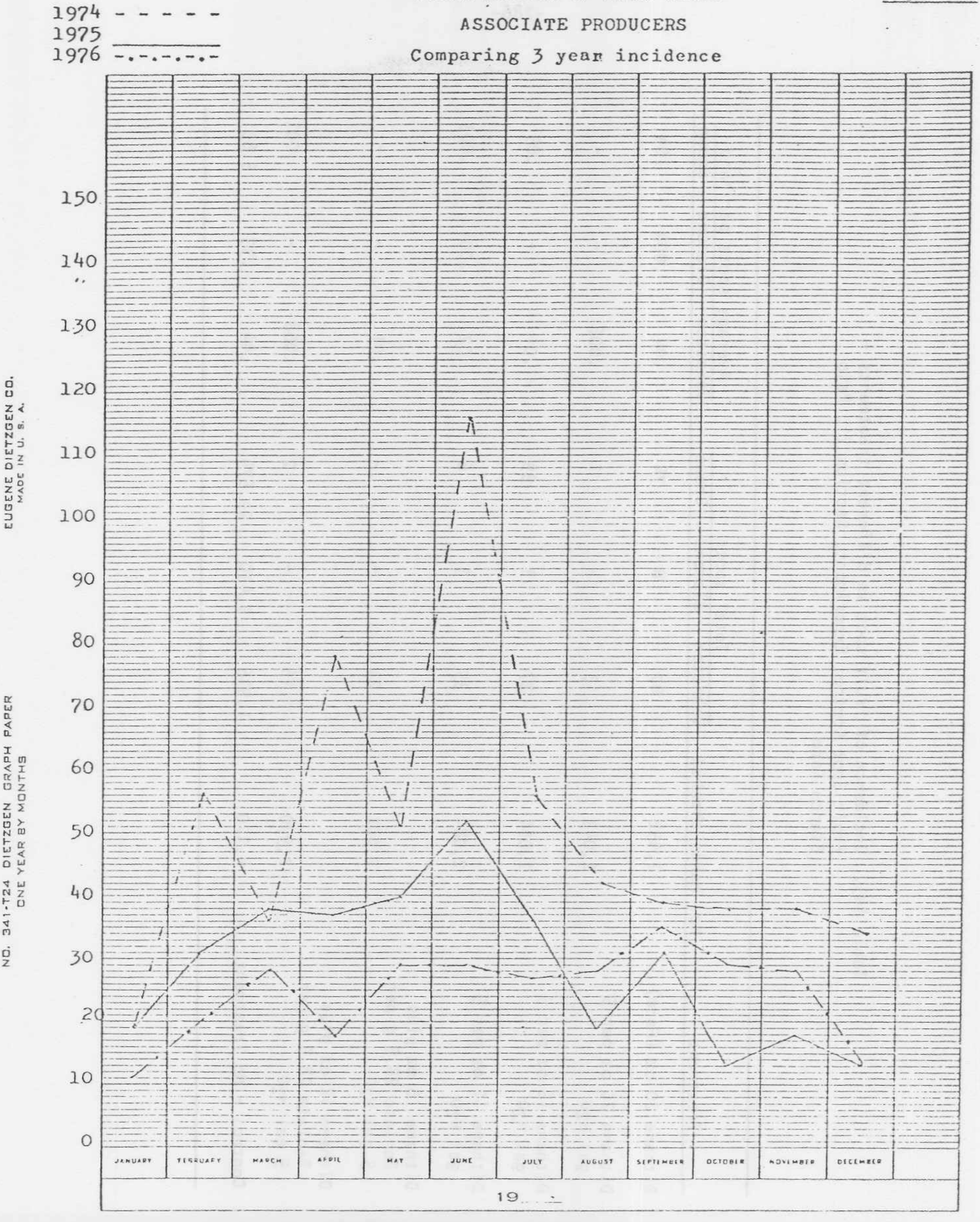


Table 143. Incidence of fruit spot in different treatments - Fruit Spot Control Experiment, Section 21, Palo Blanco Farm

Treatment	No. hands checked	Total spots			Average spots per hand		
		Johnston	Diamond	Brown	Johnston	Diamond	Brown
Dithane 20 oz (Farm)	1,952	87	8	74	.04	.004	.04
Dithane 20 oz per 5 gal H_2O	2,043	13	-	1	.006	-	-
Dithane 16 oz per 5 gal H_2O	2,061	27	1	59	.01	-	.03
Dithane 12 oz per 5 gal H_2O	2,084	35	3	6	.02	.001	.003
Dithane 16 oz plus Benlate 28.5 g per 5 gal H_2O	2,002	23	-	-	.01	-	-
Dithane 12 oz plus Benlate 28.5 g per 5 gal H_2O	1,970	16	-	2	.008	-	.001
Control - No Treatment	4,370	1,936	1,430	24,674	.44	.33	5.65

starting from the main vein going to the margin, close to the basal portion of the leaf. Very little of sucker distortion symptoms due to DBCP toxicity were found.

Nematicide - Fertilizer Experiment

This trial was established in May 1973 using different combinations and rates of nematicides and fertilizers, detailed in previous annual reports.

Table 144 shows the number of stems harvested and incidence of up-roots, and Table 145 shows total losses up to date. Tables 146 and 147 show statistical analyses data.

Losses due to uprooting are much lower than the average in the Armuelles Division (Table 144). However, losses due to "other" causes are high and account for a little over 50% of total losses. The cause of these high "other" losses (Table 145) has not been made clear. The statistical analyses of the data show no difference in stem weight, yield, or losses between nematicide and no nematicide treatments. Also, no consistant trend in potassium fertilizer influence could be detected. Although stem weight and yield tended to be higher in the DBCP than the Nemacur plots, there was too much variability among treatments for statistical significance. The experiment was concluded.

Nematicide - No Nematicide Trial

Nematicide plots received two cycles of DBCP of 14 cc/plant. Results for this trial for one year period are:

1) Plots not receiving nematicide: 2445 stems averaged 72.8 lbs and 8.9 hands

2) Plots receiving nematicide: 2398 stems averaged 75.9 lbs and 8.7 hands.

DBCP Toxicity Plots

A group of plots with different injection distances from the mat was established at Higuito Farm. Injection patterns followed were 2, 4, 6 and 8 in from the mat base on the sucker side. No DBCP phytotoxicity (splitting of sucker leaf sheaths) was present but bromine phytotoxicity symptoms appeared in the sucker leaves.

Mocap Applicator

An applicator has been designed for granular nematicides. Gravity lets the chemical flow through a plastic hose towards a double valve device which opens and closes with a trigger. It gives more protection to workers and will hopefully improve applications. A sample of the device has been sent to every Division for testing.

Table 144. NEMATICIDE - FERTILIZER EXPERIMENT: Number of stems harvested and incidence of up-roots for all crops to December 1976

Fertilizer	Stems harvested	Up-roots	Up-root incidence (%)
		No Nematicide	
0	673	10	1.46
K_2SO_4	686	13	1.86
K_2SO_4 + P	695	15	2.11
KCl + P	683	17	2.43
	2,737	55	2.01
		Nemacur	
0	712	7	.97
K_2SO_4	707	6	.84
K_2SO_4 + P	695	9	1.28
KCl + P	702	4	.57
	2,816	26	.92
		DBCP	
0	723	6	.82
K_2SO_4	747	5	.66
K_2SO_4 + P	738	1	.14
KCl + P	724	6	.82
	2,932	18	.61

Table 145. NEMATICIDE - FERTILIZER EXPERIMENT: Total losses for all crops to December 1976

Nematicide	Doubling	%	Up-roots	%	Snap-off	%	Head rot	%	Blow-downs	%	Others	%	T o t a l
Check	20	5.8	55	16.1	14	4.1	29	8.5	56	16.4	168	49.1	342
Nemacur*	13	5.5	26	11.0	14	5.9	33	14.0	26	11.0	124	52.6	236
Fumazone	11	5.6	18	9.1	11	5.6	23	11.6	12	6.0	123	62.1	198

* Nemacur replaced Furadan in 1975.

Table 146. Means per plot for Nematicide-Fertilizer Test with statistical analysis* for all data through 1976

Plot	Fertilizer Nematicide	Stem weight (lbs)	Number stems	Gross yield	General losses	Up-root losses
	None					
31	DBCP	72.0 wxyz	120.5 a	8678 ab	11.3 xyz	0.8 a
21	Nemacur**	68.0 yz	118.7 a	8079 ab	9.0 xyz	1.2 a
11	Control	66.6 z	112.2 a	7513 b	14.7 yz	1.7 a
	K_2SO_4					
32	DBCP	73.9 wxy	124.5 a	9197 a	6.5 x	0.8 a
22	Nemacur**	68.6 xyz	117.8 a	8117 ab	9.0 xyz	1.0 a
12	Control	68.6 yz	114.3 a	7871 b	12.8 xyz	2.1 a
	K_2SO_4 + P					
33	DBCP	74.9 wx	123.0 a	9218 a	7.8 xyz	0.2 a
23	Nemacur**	71.3 wxyz	115.8 a	8272 ab	10.0 xyz	1.5 a
13	Control	70.9 wxyz	115.8 a	8262 ab	16.2 z	2.7 a
	KCl + P					
34	DBCP	75.6 w	120.7 a	9137 a	7.3 xy	1.0 a
24	Nemacur**	71.7 wxyz	117.0 a	8406 ab	11.3 xyz	0.7 a
14	Control	71.8 wxyz	113.8 a	8171 ab	13.5 xyz	2.8 a

* Means followed by the same letter are not statistically different at the 1% level (w,x,y,z) or 5% level (a,b) by Duncan's Multiple Range Test.

** Nemacur replaced Furadan in 1975.

Table 147. Means per plot for Nematicide-Fertilizer Test with statistical analysis* for all data thorugh 1976

Plot	Nematicide	Fertilizer	Stem weight (lbs)	Number stems	Gross yield	General losses	Up-root losses
34	DBCP	KCl + P	75.6 w	120.7 a	9137 a	7.3 xy	1.0 a
33	DBCP	K_2SO_4 + P	74.9 wx	123.0 a	9218 a	7.8 xyz	0.2 a
32	DBCP	K_2SO_4	73.9 wxy	124.5 a	9197 a	6.5 x	0.8 a
31	DBCP	-	72.0 wxyz	120.5 a	8678 ab	11.3 xyz	0.8 a
14	Control	KCl + P	71.8 wxyz	113.8 a	8171 ab	13.5 xyz	2.8 a
23	Nemacur**	K_2SO_4 + P	71.3 wxyz	115.8 a	8272 ab	10.0 xyz	1.5 a
24	Nemacur**	KCl + P	71.7 wxyz	117.0 a	8406 ab	11.3 xyz	0.7 a
13	Control	K_2SO_4 + P	70.9 wxyz	115.8 a	8262 ab	16.2 z	2.7 a
22	Nemacur**	K_2SO_4	68.6 xyz	117.8 a	8117 ab	9.0 xyz	1.0 a
12	Control	K_2SO_4	68.6 yz	114.3 a	7871 b	12.8 xyz	2.1 a
21	Nemacur**	-	68.0 yz	118.7 a	8079 ab	9.0 xyz	1.2 a
11	Control	-	66.6 z	112.2 a	7513 b	14.7 yz	1.7 a

* Means followed by the same letter are not statistically different at the 1% level (w,x,y,z) or 5% level (a,b) by Duncan's Multiple Range Test.

** Nemacur replaced Furadan in 1975.

INSECTS

Colaspis

A few outbreaks appeared in Palo Blanco, Guayacán and Higuito Farms along the area bordering Rio Cacho. Damage decreased rapidly.

Caligo

This is one of the major pests at present. During the year, 9,321 acres were treated with Toxaphene at 22 oz per acre, and 710 acres were treated with Sevin at 1 lb per acre.

Late in the year a few flare-ups appeared, but were controlled by natural enemies.

Ceramidia

No chemicals were used; natural control is good.

Root Borers

Some 281 acres were treated with Kepone. Since Kepone is no longer available, other products such as Prymicid, Mocap, etc. will be tried on an experimental basis. Table 148 shows the effect of Kepone on the control of root borers and nematodes.

EXTENSION

A) A guide on how to select, dig and plant sword suckers in open areas was distributed to all production personnel in order to reinforce the program.

B) A revision of chemicals used for post-harvest disease was prepared and a circular on amounts required was issued.

C) Data concerning water erosion were gathered and distributed to farm personnel in order to have a better picture of soil losses.

D) Higueron was designated the pilot farm for the Division.

E) Two-acre plots in each of the Associate Producers' farms are going to be used as a guide to show them the benefits of new and improved practices.

F) A list of the most common chemicals, their formulation and application methods was provided to the Associate Producers as a guide for their use.

Table 148. Kepone and its effects on the control of root borers and nematodes

Root Borers - 10 traps per plot (3 plots)

Total borers/plot	Average borers/trap
2 oz Kepone per mat	
24	2.4
40	4.0
25	2.5
89	3.0
Non-treated	
144	14.4
109	10.9
179	17.9
432	14.4

Nematodes - 50 rhizomes per plot (3 plots)

Infection index					Ave. Inf.	%
0	1	2	3	4	Index	infection
2 oz Kepone per mat						
14	1	11	7	17	2.24	72
3	5	5	12	25	3.02	94
5	11	6	8	20	2.54	90
22	17	22	27	62	2.6	85
Non-treated						
1	5	6	10	28	3.18	98
3	6	2	5	34	3.22	94
1	6	5	16	22	3.04	98
5	17	13	31	84	3.15	97

Meetings Attended

1) Proceedings of the Regional Planning Conference of the International *Meloidogyne* Project, University of Panama.

2) Annual Zamorano Graduates Meeting, Guayaquil, Ecuador.

Seminars

A seminar was conducted by Dr. F. A. Sierra assisted by Tropical Research personnel. This seminar was directed to the Associate Producers in order to encourage them to improve their farms.

Weather

A total of 76.67 inches of rainfall was recorded. Most of the meteorological instruments are obsolete or have been stolen. New sets of instruments and evaporation pans have been ordered.

(ESPINOZA)

EXPERIMENTAL DEPARTMENT - BOCAS

AGRONOMY

PK-24

This experiment was terminated on June 30. It was originally designed by Dr. F. A. Sierra in 1973 to determine the influence of potassium and phosphorus application on banana production. The data collected from this experiment were sent to La Lima for analysis and will be reported on by Dr. Sierra.

It was decided by Dr. M. Rodríguez to superimpose additional potassium treatments to the PK-24 plots disregarding phosphorus levels. Potassium chloride is being applied at 450, 675, 900 and 1,125 kg/ha in either two or three applications per year. All treatments are replicated six times. Leaf samples are being taken to relate nutrient concentration in the plant with potassium applied and fruit weight.

The original application of potassium was applied during week 29. One hundred and thirty-nine (139) g of urea per production unit was applied during weeks 34 and 46. The second potassium application was applied during the 46th week according to the respective plot needs. Fumazone applications were made during weeks 50 and 51.

This experiment will be identified as B-76-2 and is entitled Potassium - 24.

Four-Cable Plots

The four-cable plots located in Farms 15, 63 and 64 represent a study to determine the economics of maintaining high concentrations of potassium in the plant. The levels of potassium range from 2.75-4.00% in the lamina. Data obtained indicate a difference between treatments. Data are being collected and potassium leaf levels maintained to obtain the necessary information to determine the economics of maintaining the various levels of potassium in the leaf.

Foliar Analysis

A foliar analysis program for the application of potassium started in November. A series of cableways are surveyed each month from each farm in the Division. Every application of potassium will be based on this foliar analysis when the results are received from Tropical Research. This program should help considerably to utilize in the best way that money budgeted for potassium fertilization.

Plant Loss Survey

A field loss survey using 10% of each farm at random in a biweekly cycle was conducted during 1976. Plant losses were relatively even throughout the year. They ranged from a low of 4.8% during October to 11.0% for August. The higher percentage for August was due primarily to a blowdown in Farms 44 and 45. The causes of field losses are shown in Table 149. Plant losses caused by doubling, up-rooting and snap-offs resulted in 23.3, 58.2 and 11.9%, respectively. Seventy-six percent of the losses reported had fruit on the stem.

During 1976 this division lost, according to this survey, approximately 333,000 stems from the above-mentioned causes. This loss represents, with a box stem ratio of 1.46 for the division, about 486,000 boxes.

NEMATOLOGY

A nematode survey conducted by the Research Department in Farms 47 and 63 was completed in October. This survey revealed an increase in nematode infestation of 80 and 82%, respectively, over the 1975 survey. As a result of this survey, these farms are scheduled to receive DBCP treatment. With the addition of these two farms, all Company production areas are receiving nematicide treatments. All farms are receiving DBCP with the exception of Farm 44 which is being treated with Mocap 5% granules.

The Nema experiments under way in this Division are on their 1st (Nema IX) and 2nd years (Nema VII and VIII) of existence. To date, we have not been able to gather fruit weight data due to low levels of potassium. However, the latest leaf analysis indicated this level is now sufficient to start the harvest data. Up-rooting data from Nema VII for the first 39 weeks were analyzed and no measurable differences were found between the injection of DBCP in the 9x5 or 5x9 pattern. The analysis of up-root data from Nema VIII also indicated that there is no difference between the injection of DBCP at 10 cc or 14 cc per mat, or Mocap at 3 or 4.5 g active ingredient per mat.

Fallow Farm 66

This experiment was originated to determine any preplant fallow methods to destroy existing nematode populations. The original report is found in the 1972 Annual Report. The various fallow treatments were: weeds left in the plots, disc cleaned, rice planted, nematicides and herbicides. Each of the five treatments was replicated five times. Weekly plant loss surveys were conducted by Research personnel. The analysis of these data showed that there were no significant differences between treatments four years after starting the banana plantation in this area.

INSECTS

Antichloris (Ceramidia)

An outbreak of Ceramidia during January on some 600 acres of Farms 2 and 3 necessitated the use of toxaphene to control them. High larval counts, defoliation on young and unshot plants and low parasite required insecticidal control. Throughout the rest of the year populations of this insect have been held at subeconomic levels by parasitic and pathogenic factors.

Table 149. Report of plant losses by month and cause - Bocas Division

Month	Doubling	Up-rooting	Snap-off	Others	With fruit	Without fruit	Total	%
January	684	1691	418	448	2547	694	3241	10.0
February	790	1717	554	263	2618	710	3328	10.3
March	626	1423	395	255	2129	570	2699	8.3
April	451	1417	306	204	1930	448	2378	7.3
May	572	1947	250	220	2399	590	2989	9.2
June	573	1518	222	166	1937	542	2479	7.7
July	554	1746	173	122	1870	725	2595	8.0
August	1057	2055	327	128	2353	1214	3567	11.0
September	490	1574	272	98	1755	679	2434	7.5
October	452	714	298	83	1205	342	1547	4.8
November	741	1713	299	53	2040	766	2806	8.7
December	563	1324	346	78	1825	486	2311	7.1
Σ	7553	18839	3860	2118	24608	7766	32374	99.9
% of total	23.3	58.2	11.9	6.5	76	24	100	

Thrips

Light to medium thrips infestations have been reported in localized areas throughout the Division. Spot treatments of diazinon applied to the pseudostem and fruit gave good control and held costs and environmental contamination to a minimum.

Colaspis

Colaspis still is the principal insect in this Division. Presently, there are about 4,000 acres infested with populations sufficiently high to require premature bagging.

There is a wealth of information on leaf damage caused by Colaspis in the Bocas Division. Before 1973, Colaspis research was conducted by Dr. H. E. Ostmark, Carlos Evers and Clyde Stephens; from 1973-1974 the leaf surveys of T. H. Atkinson (1973-74) and the Research Department (1974 to present) all give excellent descriptions of population limits and relative densities. However, we still did not understand what these figures meant in regards to fruit damage. Throughout March a great deal of time was spent developing a leaf survey that would reduce the subjectivity of this survey. Large unshot plants were selected as the plants to be surveyed. The last two leaves that had completely unfurled were considered as the sample leaves and received a visual rating of 0-4. The rating description is as follows:

0 = No damage evident,

1 = A trace of feeding injury present, less than 1/10 of the leaf damaged,

2 = 25% of the leaf with feeding damage,

3 = 50% of the leaf with feeding damage, and

4 = 75% or more of the leaf with feeding damage.

Research cables were set up in Farm 62 and 65. Ten shot mats per cable did not have the early bag placed to protect the fruit. These racemes were allowed to develop until the 21-25th day at which time they were dehanded, fruit damage by Colaspis assessed and protected with the regular fruit protection bag. Regression analysis of several months data shows that Farm 62 had a regression coefficient of 9.526; while Farm 65 had a regression coefficient of 7.88. Therefore, for every unit increase in the leaf damage index, 9.526 and 7.88% more of the fruit will be damaged in Farms 62 and 65, respectively.

A July survey was taken in farms that had low Colaspis populations to determine if there were farms or sections of farms that could be removed from the costly premature bagging necessary in Colaspis-infested areas. The regression coefficient from Farms 62 and 65 were used as a guide in selecting areas to be removed from premature fruit protection methods. The first area placed under normal bagging consisted of approximately 265 acres in Farm 15; later all of Farm 15 and parts of other farms were removed from premature fruit protection practices. Several months after the change to normal bagging the populations of Colaspis rose and much of the area again was placed under a two cycle per week premature system. Apparently, when large acreages are removed from premature fruit protection, there is a surge in the Colaspis population.

The search for a new fruit protection system was continued throughout 1976. The objectives sought were a reduction in labor expense, reduction in fruit damage caused by clinging bracts and finger rot, and reduction of beetle damage.

Three types of bags were tested against normal bagging. They were: 1) an "apron" bag, 2) an "open" bag, and 3) a "split" bag. All were placed on fruit approximately 8 days old, and all were Poly-D material. The "apron" bag was hung between the raceme and the pseudostem and acted as either a physical or chemical barrier to the beetles. When the fruit was about 21-25 days old the bag was detached and placed on the fruit in a normal manner. The "open" bag was a flat piece of Poly-D hung between the raceme and the pseudostem. This bag was never removed and the fruit was never bagged. The third type, the "split" bag, was a 72-inch Poly-D bag slit along one side. The slit extended 36 inches up the bag. The slit was located away from the pseudostem for maximum fruit protection. The results of this experiment are presented in Table 150.

The analysis of variance of the data for the amount of damaged fingers per stem is given in Table 151.

Table 151. The analysis for the amount of damaged fingers per stem from four different fruit protection methods

Source of variation	df	SS	MS	F
Treatments	3	10875.72	3625.24	92.54***
Replications	68	2663.88	39.17	
Total	71	13539.60		

F .001 (3,68) = 6.13.

As indicated in Table 151, there is a high level of significance between treatments when one compares the three early bagging methods against the normal fruit protection method. However, when one analyzes the means from the four treatments, there are no differences between the "apron", "open" or "split" bags related to damaged fingers.

The analysis of variance of bracts per stem (Table 152) indicates a high level of significance between the three experimental bag types. The number of bracts per stem in the "apron" type is statistically different from the "open" and "split" types when one analyzes the means of each treatment. The premature bagging method presently used in Colaspis-infested areas in the Bocas Division was not included in this experiment because when it is on the fruit at the correct time, eight days after shooting, it offers essentially 100% fruit

Table 150. A comparison of fruit protection methods in an area with high Colaspis populations

	BAG TYPE														
	"Apron"				"Open"				"Split"				Late		
p.	No. of stems	No. of hands	No. of bracts	No. of damaged fingers	No. of stems	No. of hands	No. of bracts	No. of damaged fingers	No. of stems	No. of hands	No. of bracts	No. of damaged fingers	No. of stems	No. of hands	Damaged fingers
1	8	66		16	8	68		38	6	48		3	7	59	104
2	8	60	3	62	10	77	14	50	7	55	6	30	7	56	369
3	5	41	2	21	8	59	11	53	4	26	2	0	7	53	149
4	10	74	13	44	10	77	31	24	10	77	31	8	10	82	362
5	10	81	10	54	10	83	32	30	10	83	19	10	10	91	285
6	8	71	8	35	5	45	20	12	9	67	33	14	9	76	244
7	6	46	3	40	6	52	13	6	5	44	141	0	4	37	121
8	10	85	28	44	9	68	29	20	10	83	23	5	10	87	244
9	10	86	10	66	10	89	17	81	9	78	19	17	9	78	236
0	8	68	7	38	7	62	10	24	9	73	23	6	9	78	325
1	10	79	6	63	10	96	12	85	10	86	6	21	9	81	460
2	8	68	5	80	6	46	10	10	5	42	5	2	7	58	400
3	14	129	21	70	12	107	11	15	14	139	16	32	15	136	270
4	13	114	17	45	14	132	33	86	12	106	25	63	15	136	433
5	12	107	21	39	12	111	22	94	14	115	41	23	12	115	516
6	10	91	23	66	9	84	27	42	9	84	18	9	10	94	307
7	9	77	12	38	8	81	12	25	15	141	31	52	7	72	194
8	10	102	13	34	10	99	12	27	11	109	21	22	9	89	207

protection. However, this method also holds about 100% of the floral bracts as well if they are not dislodged by hand.

Table 152. The analysis for the amount of bracts per stem from four different fruit protection methods

Source of variation	df	SS	MS	F
Treatments	2	11.06	5.53	6.91**
Replications	48	38.38	.80	
Total	50			

$F_{.05\,(2,48)} = 5.09$.

One might assume from these data that "apron" bag gives the most practical Colaspis control. Laborers do not like the bag since it is difficult to open when wet. The "split" bag is easy to handle, also allows most of the bracts to fall naturally and gives good protection against Colaspis; however, the "split" bag should be tested and its fruit protection qualities, such as fruit scarring and thrips injury, determined. To date, there is little indication of these problems existing with the "split" bag.

The use of the "split" bag in Colaspis-infested areas will not reduce the cost of fruit protection because it is placed on the fruit prematurely. However, I feel this bag will increase production due to less damage caused by bracts hanging up in the bag and the reduction of associated finger rot.

Additional experiments to understand the biology of Colaspis ostmarki were started in 1976. Until we know more about the biology of this insect, we will have little success in controlling it in a more economical manner.

MISCELLANEOUS

Critical Age Studies

This project is in its third year of data collection. All data are being sent to Tropical Research in La Lima for analysis.

A study was begun in September to determine if maturity date differences exist in racemes of different sizes. To date, only a small amount of data has been collected and will be reported on at a later date.

To determine if differences exist in maturity dates for the location of the hand on the raceme, an experiment was started in October. Again, due to the small amount of data, this will be reported on in detail at a later date.

Weather

The weather station located in the Research patio consists of rainfall gauges, a sunshine duration recorder, phyheliograph and minimum-maximum thermometers. At the station in Farm 12 there is an evaporation tank, rainfall gauge and piezometers. Precipitation for 1976 amounted to 117.79 inches. This is 18.54 inches more than the same station received in 1975, and 19.6 inches above the 45-year average. Even with the increased rainfall, the piezometer data indicated a water table level generally around five feet. After a heavy rainfall the water table rapidly returned to the 4.5-5.0 foot level.

Visitors

The Research Department hosted 27 official visitors during 1976. The majority of these were scientists from Tropical Research, La Lima, Honduras helping with problems associated with banana production or checking cooperative experiments in progress.

Meetings Attended

I attended the National Meetings of the Entomological Society of America held in Honolulu, Hawaii from November 28 through December 2, 1976.

(HINTZ)

EXPERIMENTAL DEPARTMENT - GOLFITO

AGRONOMY

Fertilization

Three applications of urea were made in 1976 before August with liquid urea sprayed by knapsack around the plant. Spray dosage per plant was not measured. Although farm records showed a rate of 250 lb N/acre, it is believed that accumulated sub-dosages per mat may have resulted in low N readings in leaf analyses. The spray method was abandoned and hand application began again in December 1976.

Potassium chloride was applied twice, totalling 568 g/mat for the year.

Leaf Analysis

Each farm was divided into three blocks for scheduled leaf sampling and K fertilization. Each block will be sampled twice a year. Potassium application will be based on leaf analysis. The current modification is: No KCl above 3% in the leaf, 284 g KCl/mat between 2.8 and 3%, and 568 g KCl/mat below 2.8%.

Phosphorus Trial - Coto 45

On 29 October 1975, six replicates per treatment were fertilized at rates of 0, 548 and 1098 g per mat of triple superphosphate. A leaf analysis from samples taken in May (six months after treatment) showed no difference in P between treatments, nor were fruit weights in 1976 different.

Potassium Chloride Versus Potassium Sulphate - Palmar 10-11

On 20 September 1975, 700 g of K_2SO_4 and 587 g of KCl were applied to each mat in ten replicates each. Stem weights through 1976 are not different between treatments. A leaf analysis from samples taken eight months from treatment showed an average concentration of 2.89% K from KCl plots versus 3.07% from K_2SO_4 plots. However, a second analysis from samples taken 11 months from treatment showed no difference in % K between treatments.

ENTOMOLOGY

Natural Control

For the fourth straight year, no aerial insecticides were sprayed. Insect pests are rarely seen in banana plantations. It was recommended that all insecticides being stored for emergency be transferred out of the Division.

Chalcid Wasp

The last of the Mirex ant bait was used up. A substitute, Kepone, was phased out and there is no longer a control measure against chalcid wasps, except early bagging.

Trial to Study Losses Caused by Root Borers

Duplicated experiments were initiated in Palmar on October 1975 and in Coto on April 1976. Root borers were treated in 6 one-hectare replicates, leaving 6 one-hectare untreated replicates as the control. Losses were recorded weekly.

On 24 August 1976, four months after treatment, heavy field losses were recorded as the result of a blowdown. A statistical analysis showed a highly significant difference between the treated and control plots as shown by the following data:

Ave. Uproots		F. Obs.		
Treated	37.17	Treatments	24.30404	1%
Control	122.67	Blocks	0.47352	NS

Borer counts just before the blowdown averaged 1.4 in treated plots versus 12.9 in the controls. Monthly borer counts continue but weekly loss surveys were suspended until plantings recover.

In Palmar 7, 6 one-hectare plots were treated on 22 October 1975 and 10 November 1976. Since the first treatment, borers remained low with an average of 1.4 per trap in the treated plots versus 14.6 in the control. Trap data were taken monthly. Field losses in each plot were recorded weekly. Losses for the 53 weeks in 1976 were recorded as follows:

Uproots		Total Losses	
Treated	Control	Treated	Control
73.2	114.7	126	170.5

The means of uprooting and total losses are both significantly different at the 1% level and block means are not significantly different as shown below:

	F. Obs.	
	Treatment	Blocks
Uproots	44.56	2.4
Total Losses	33.03	1.39

The Palmar 7 experiment and the duplicate in Coto 48 were designed to indicate effects of root borers on losses. Nematologists now have evidence suggesting that some insecticides may also be nematicidal. If this was the case in the Coto and Palmar experiments, then losses, mostly uproots, may have been reduced in treated plots not only from less borers, but also from partial nematode control. It should be noted that all treated and control plots were injected with DBCP beginning in 1974 through 1976. Also all plots were reguyed weekly to correct poor guying by farm labor.

NEMATOLOGY

Losses

Beginning week 1 of 1976, the line plot method for surveying losses was replaced by the 10% plot survey. Losses are recorded in Table 153.

Bromine Analysis

Three sets of fruit samples from areas mostly with five or more DBCP treatments were sent for bromine analysis as follows:

Date sampled	No farms sampled	Comments on Analysis
June	8	Pulp analyzed. Palmar ranged 4.42-37.18 ppm; Coto 24.7-98.28 ppm. Only one sample above 75 ppm.
October	24	Samples 3-4 months after treatment. Pulp analyzed. Palmar ranged 5.3-33 ppm; Coto 6.2-77.2 ppm. A single sample was over 45.8 ppm.
October	24	Duplicate sample of above sent to Dow Lab who analyzed whole fruit. Coto ranged 9-105 ppm. Only one sample was above 50 ppm. Palmar, 8-56 ppm.

Mocap

Based on the June fruit analysis for bromine, a decision was made to substitute Mocap for DBCP in Coto. Sixty grams of 5% granules per mat were applied beginning in November. Comparative costs were as follows:

Table 153. Losses* (blowdowns not included) - Golfito Division, Costa Rica - 1976

	Per Hectare				
	Double	Uproot	Poor	Other	Total
Coto					
Without fruit	4.02	13.16	.11	.14	17.43
With fruit	31.52	50.06	1.2	.41	83.19
Total	35.54	63.22	1.31	.55	100.62
Palmar					
Without fruit	1.72	5.72	.05	.01	7.5
With fruit	33.96	58.47	.63	.12	93.18
Total	35.68	64.19	.68	.13	100.68

* Ten percent of area planted was surveyed weekly.

Line plot method eliminated end of 1975.

	Dollars per Hectare	
	Mocap	DBCP
Cleaning around mat	11.24	.00
Application	8.20	15.46
Foreman	1.75	1.75
	21.19	17.21
23% Social benefits	4.87	3.96
Total basic labor	26.06	21.17
Nematicide	58.79	53.57
TOTAL	84.85	74.74

Mocap in Palmar 3

Six entire sections previously on DBCP were treated with 60 g/mat of 5% Mocap granules in December 1975, May and December of 1976. Those sections, plus six alternate sections which remained on DBCP, were checked for field losses each week. Losses between treatments for the 53 weeks in 1976 were similar as shown below:

	Ave. per hectare	
Treatment	Uproots	All Losses
Mocap	72.4	99.4
DBCP	82.1	105

Nemacur Versus DBCP - Coto 48

This study was continued in the same ten cableways used in the Furadan Field Trial described in the 1975 Annual Report, p. 259. Five alternate cableways, previously left as the untreated control, received DBCP injections at 14 cc/mat on March and August 1975, February and August 1976. Nemacur granules at 3 g a.i. per mat replaced Furadan in the same five alternate cableways previously with Furadan. Nemacur was applied on August and December 1975; April, August and December 1976.

A blowdown on 24 August 1976 caused minor losses as follows:

	Mean uproots/ha	F. Obs.		
Nemacur	1.98	Treatments	8.10993	5%
DBCP	2.56	Blocks	2.17801	NS

Weekly field losses for 1976 were as follows:

	Mean per hectare	
	Uproots	Total Losses
Nemacur	62.7	90
DBCP	74.8	99.2

Circumference, 1 m high on plants just shot, was measured monthly on 20 plants per plot. The annual mean was 69.5 cm (Nemacur) and 70.1 cm (DBCP). No statistical difference was found between treatments.

Twenty stems per plot, twice a month, were randomly selected and weighed. Though mean stem weights for 1975 were 72.6 lb in DBCP plots versus 64.7 lb in Nemacur, there was no statistical significant difference between treatments (Table 154).

Replant Study with Rhizomes Versus Sword Suckers

On 4 June 1976, 200 VALERY rhizomes and 200 VALERY sword suckers were alternately planted in Palmar 10 to compare growth rates under shady conditions where occasional replants are needed due to nematodes. Central growing points were left on rhizomes. Mocap and KCl were placed in the planting hole. The following data were recorded by the end of 1976:

Treatment	% germination	Height end of Dec.	% shot
Rhizome	94.5	1.62 m	18
Sword sucker	94	1.37 m	2

All plants are highly variable in diameter and height. Fruit is poor and would normally be chopped down by the farm.

A similar study was initiated in Coto 47, but due to irregularities, plants will be observed only.

To observe rhizomes and sword suckers in the open sun, 200 Grand Nain rhizomes and 200 Grand Nain sword suckers were alternately planted in Farm 10 in the open on 10 June 1976. Central growing points were left on the rhizomes. Mocap and KCl were placed in the planting hole. The following data were recorded by the end of the year:

Treatment	% germination	Height end of Dec.	% shot
Rhizome	85.5	1.87 m	60
Sword sucker	93	1.96	65

Table 154. Average bunch weights in pounds from 100 bunches weighed twice a month - Nemacur Versus DBCP - Coto 48, Costa Rica - 1976

Month	DBCP	Nemacur	F. Obs.
January	70.4	70	.05
	68.9	69.8	.05
February	73	72	.03
	71.7	71	.03
March	69.2	71.8	1.91
	69.5	68.2	.30
April	70	68.8	.09
	65.5	65.7	.02
May	66.3	63.3	7.17
	67.5	65.2	5.33
June	70.3	65.4	6.20
	70.5	69.3	.26
July	67.7	68.6	.5
	73.8	76.1	.64
August	75.4	79.9	2.57
	81.6	73	28.15**
September	82.4	75.9	4.17
	79.6	71.6	4.00
October	78.5	70.9	5.25
	76.2	70.5	4.43
November	72.5	71	.17
	74.9	73.9	6.87
December	77.7	70.1	
	78.5	73.6	

Both treatments appear normal and equal. Data will continue through the second crop. A duplicate of the foregoing (Grand Nain in open sun) was initiated in Coto 59. Results to date are similar.

PATHOLOGY

Moko

Less cases were reported than in previous years as shown below:

Year	No. Cases
1973	298
1974	135
1975	82
1976	62

Fruit Spots and Fruit Sprays

Fruit spots were less troublesome than in previous years. Beginning 19 November 1976, fruit spray was suspended in two farms each in Coto and Palmar each week until 11 December when all fruit spraying ceased.

Sigatoka

The disease was not cleaned up during the early 1976 dry season and consequently, a threatening infection appeared in Coto and Palmar when the rains began in May.

Cycles were sprayed as follows:

Rate/acre in 1 gal straight oil	No. applications 1976 Coto	Palmar
1.5 lb Dithane	10.2	10.86
.75 lb Dithane, 2 oz Benlate	4.7	5.29
4 oz Benlate	2.6	1.8
TOTAL	17.5	17.95

Triton was added only to the first mixture each day to protect against water contamination in the plane or mixing plant.

The following observation blocks were established during August in Coto and in July in Palmar:

Rate/acre in 1 gal straight oil	Location
2 oz Benlate	Palmar 13, 416 acres Coto 41-43, 661 acres
3 oz Benlate	Palmar 5, 379 acres
4 oz Benlate	Palmar 9, 635 acres Coto 41, 559 acres
2 oz Benlate, .75 lb Dithane	Palmar 3, 331 acres Coto 41-43, 781 acres

At the end of 1976, Sigatoka infection was low in all treatments.

WEATHER

The Division received about 100 inches of rainfall less than the average (Table 155, Figure 50). A severe drought resulted in constant irrigation totalling 10.9 cycles in Coto and 16.7 in Palmar. Water tables remained low most of the year, except during October.

PHILIPPINE INSECTS

Introduction

Notes on miscellaneous banana insects observed mostly in TADECO VALERY plantations, Davao del Norte, Mindanao, Philippines in January-February 1976 were submitted in a report: "Part I, Miscellaneous Philippine Insects and Other Fauna in Mindanao Banana Farms". A second report, "Part II, Philippine Banana Peel-Scarring Weevils in Mindanao Banana Farms" reviewed weevil pests. Both reports were widely distributed to personnel in Boston, Honduras and the Philippines. Therefore, only a summary of these findings are included in the Annual Report.

Bagworms

Five species of bagworms (Family: Psychidae) were collected from VALERY leaves in TADECO (Figure 51).

Identifications and Descriptions: Bags and male adults of three species (1, 4 and 5, Figure 51) were sent to Dr. Don R. Davis, National Museum of Natural History, Washington, D. C. 20560, who recently collected in Mindanao. Specimens from numbers 2 and 3 were poor and scarce and were not sent. The following identifications and descriptions refer to the mature males numbered in Figure 51.

Table 155. Rainfall in inches in 1976 - Golfito Division, Costa Rica

Month	A Farm 45 Coto	C Farm 59 Coto	D Farm 5 Palmar	Orchard Golfito
January	2.72	2.88	2.10	1.54
February	0.00	.25	0.00	0.00
March	1.00	.21	0.00	4.62
April	7.69	4.78	5.80	8.26
May	21.26	13.61	14.60	11.42
June	10.34	11.59	8.15	12.32
July	6.17	4.67	3.55	6.98
August	14.37	12.23	14.75	13.12
September	15.19	17.29	18.60	12.48
October	30.22	26.00	22.95	13.33
November	13.99	13.59	6.35	9.87
December	6.38	6.81	1.85	7.12
1976 Total	129.35	113.91	98.7	101.06
1975 Total	211.00	190.14	179.15	233.22
1974 Total	208.77	187.26	148.53	248.52
1973 Total	234.50	202.91	191.27	247.06

FIGURE 50

RAINFALL, GOLFITO DIVISION, 1976

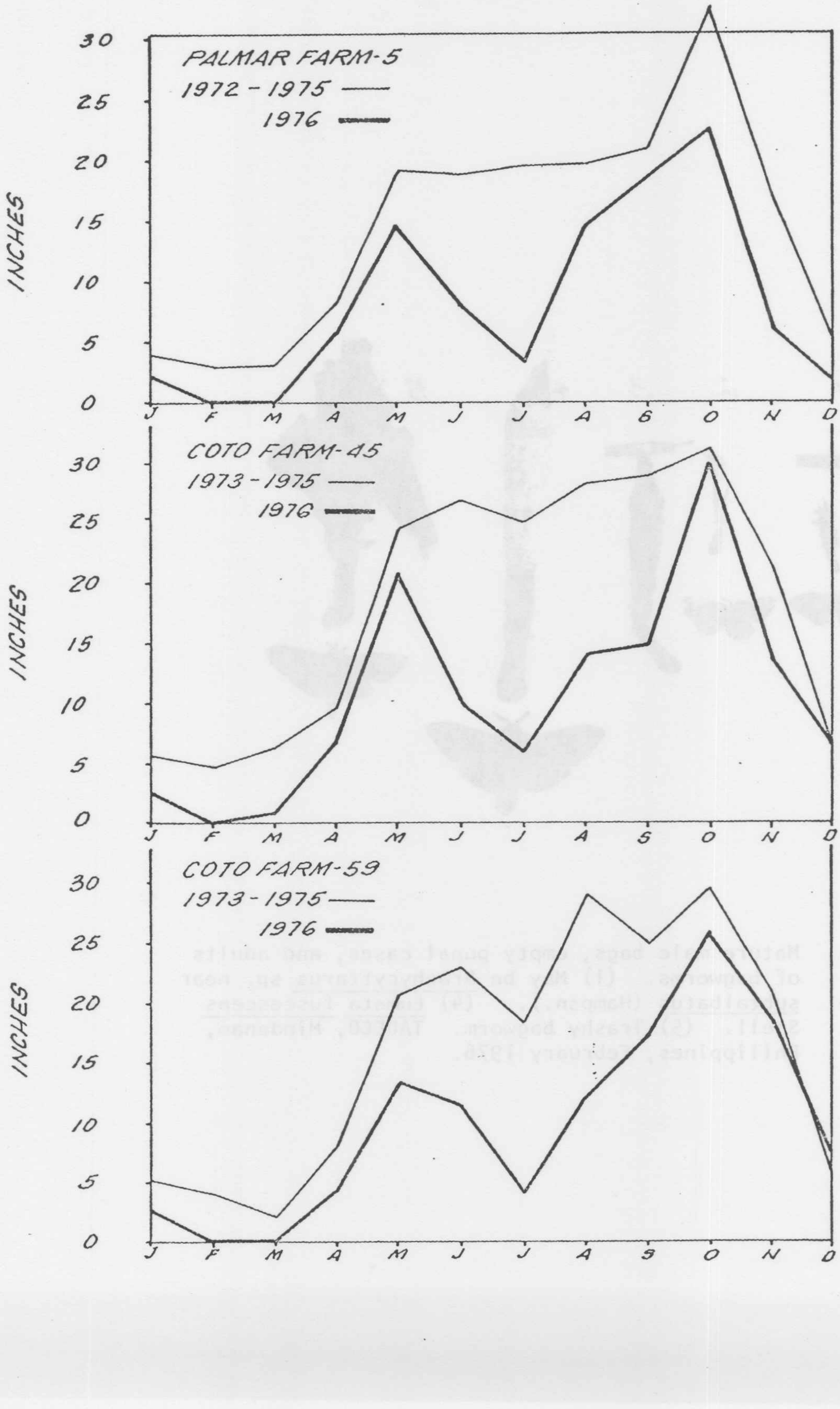


Figure 51. Mature male bags, empty pupal cases, and adults of bagworms. (1) May be Brachycyttarus sp. near subtalbatus (Hampsn.). (4) Eumeta fuscescens Snell. (5) Trashy bagworm. TADECO, Mindanao, Philippines, February 1976.

1. May be <u>Brachycyttarus</u> sp. near <u>subtalbatus</u> (Hampsn.). Bag soft, brown, 8 mm long, attached to leaf by silk thread 8 mm long. Leaf thatch mostly horizontal. Smallest of the banana bagworms. Feeding damage minimal. Common on nutgrass in banana farms. Adult dark gray, fragil. Wingspan 13 mm.

2. Not identified due to lack of good adults. Bag hard, light brown, neat leaf thatch placed flat on surface. Main bag 12 mm with tapering extension 4 mm forming a right angle. Extension made with tiny leaf bits and connected to leaf with silk string 4 mm long which angles back up about 90 degrees. Not common, feeding damage minimal. Adult gray, fragil similar to Nº 1. Wingspan 17 mm.

3. Bag 32 mm, leaf bits placed close to bag, moderately neat thatch, soft bag. Upper bag tapers gradually and has no distinct string attachment as in numbers 1 and 2 . Female bag 1/3 larger. No male moths collected. This species not common.

4. <u>Eumeta fuscescens</u> Snell. Bag 54 mm, thin, papery, smooth, neat, light tan to light brown, made of finely chewed leaf bits and silk. Common and is a potential pest. Large larvae make 45 mm wide feeding holes. Moth light brown, dense setae on thorax and abdomen. Wingspan 32 mm. Figure 51 shows a newly emerged male moth clinging to its bag.

5. Trashy bagworm, unknown to Dr. Davis. Bag 42 mm, large leaf pieces loosely attached. Mature female bag frequently twice the size of the male. A potential pest. Mature larvae chew holes 45 mm in diameter and larger. Adult dark gray. Wingspan 30 mm.

<u>Miscellaneous Species</u>

The following species were discussed in Part 1:

1. A stinging limacodid defoliator similar to Sibine.

2. A slug caterpillar defoliator.

3. A lepidopterous finger tip feeder.

4. Lace bugs (Tingidae) on banana leaves.

5. Red rust thrips identified as <u>Chaetanaphothrips signipennis</u> (Bagnall) by H. E. Ostmark. This pest was not found in TADECO but typical fruit russeting caused by this species was seen on bananas in Desidal and Mabuhay, a few kilometers south of TADECO. Male and female adults were collected between Tugbok and Guianga from banana fruit and suckers with blemishes identical to russeting caused by <u>C. signipennis</u> in Changuinola, Panama.

6. Scale insects on leaves.

   a. Similar in appearance to Diaspis.

   b. Similar to yellow coconut scale.

7. Cosmopolites sordidus

8. Odoiporus longicollis was not seen in TADECO but was collected at higher elevations at Davao Fruit Company plantation near Guianga. This species was observed in banana fruit stalks in southern Taiwan where severe tunnelling in pseudostems and stalks occurs.

9. Termite damage to props in the field. The large termite mound is similar to Coptotermes lacteus of Australia.

10. Bat scratch on young fingers was similar in appearance and intensity to that found in Central America.

11. Giant snail (Japanese snail) not reported as a pest. Snails are highly susceptible to Mocap and Furadan granules. This observation suggests that such pesticides may also control slugs.

Peel-Scarring Weevils

To summarize Part II, three species of flightless curculionid beetles (Figure 52) that feed on banana fruit and leaves were identified by Dr. Charles W. O'Brien, Florida A & M University, Tallahassee.

Philicoptus demissus Heller. This pest (Figure 52) is isolated in the General Santos region, the arid banana zone of Standard Fruit Company where the light sandy soils are irrigated 7-9 months a year. Little is known about the species. The female is 7 mm in length, whereas the male is 6 mm. To the naked eye, adults appear dull white with sparse irregular black markings. Under the microscope, masses of round white scales are seen. Scales overlap on many parts.

Philicoptus iliganus Heller. This insect (Figure 52) is the most economically important banana peel-scarrer. Infestations occur in the South banana zone west of the Davao River Valley (Figure 53). The species is prolific near sea level in Lapanday Farm near Davao City, ranging west into the cool slopes of Mt. Tolomo. High populations are common above Davao Fruit Company's plantation 1 near Guianga at 700 m elevation and in the banana and coffee region of Calinan.

Female adults are 7-8 mm in length, whereas males are 6-7 mm. Both sexes are brilliantly colorful. Although the body is black, the insect appears metallic green. About 3/4 of the body is covered with minute round, metallic green scales which form irregular patterns on the elytra and thorax. Scales also cover parts of the head and abdomen although scales are absent on the caudal 3 abdominal segments of the female. A gold to burnt-orange sheen is commonly reflected. Pink to tan-colored scales are found on the legs and basal segment of the antenna. Scales tend to be green on the interior side of the legs. Scales, anterior to the eye are sometimes blue. All surfaces of the body have hair-like setae.

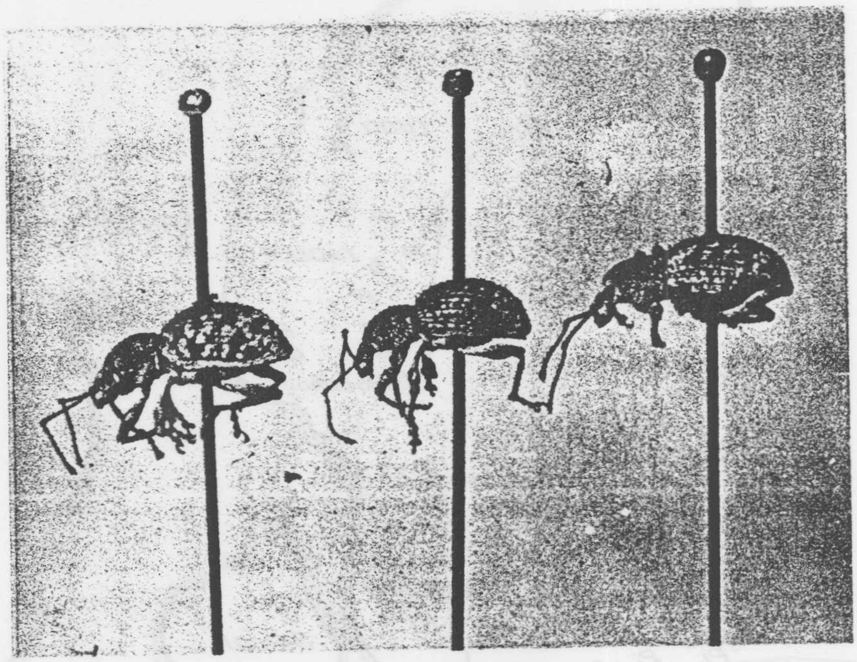
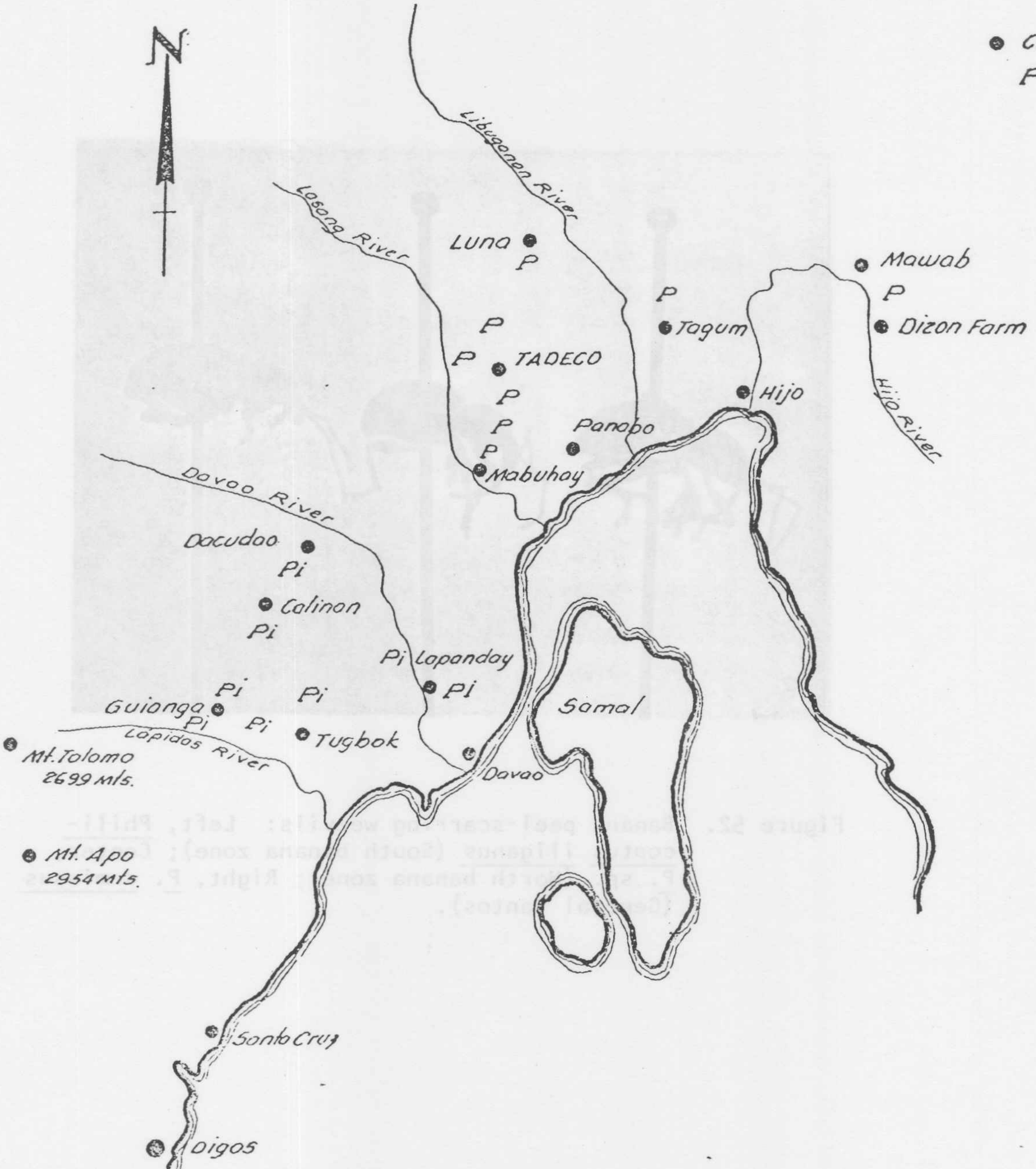


Figure 52. Banana peel-scarring weevils: Left, Phili-
coptus iliganus (South banana zone); Center,
P. sp. (North banana zone); Right, P. demissus
(General Santos).

Figure 53. Distribution of 2 banana peel-scarring weevils, Mindanao, Philippines, 1976.

<u>Philicoptus</u> <u>iliganus</u> = Pi

<u>Philicoptus</u> <u>sp</u>. = P



During recent years, this pest was erroneously identified as Metapocyrtus and P. waltoni Boheman.

The species is strongly polyphagus, feeding on many economic plants, i.e. coffee, avocado, cacao, citrus and pineapple. On bananas, feeding occurs on suckers, mature leaves, banana flowers and mature fruit (Figure 54).

Life cycle studies in the lab by another investigator found that 3-31 eggs deposited in moist soil hatched in 10.2 days. Larvae fed on live mong bean roots. The larval stage required 81-177 days. The newly emerged adult has a pair of black mandibular extensions about .5 mm long which later break off. The new adult is dark, even when exposed to light, but turns metallic green after several days.

Although the larva probably feeds on roots of other hosts, it is strongly indicated that the life cycle is mostly passed on banana roots. During February 1976, of 50 carton drum traps placed over bare soil beside banana plants in Lapanday Farm, 12 traps caught a total of 19 P. iliganus adults (9 males, 10 females). Two traps of 20 placed in the bottom of a moist canal yielded a weevil each. Banana roots were found in soil under both traps.

Control by hand-picking weevils from fruit just shot was only partially effective. Up to 26 adults per bunch were commonly collected. A sticky barrier around the fruit stalk prevented weevils from crawling into the bunch. However, any bridges touching the fruit bunch, i.e. strings, leaf, prop, etc. are almost certain to be used by the insect to enter the bunch.

Insecticide treatments to the soil, weeds, suckers, pseudostem and fruit have been only partially successful in pest control. Bags treated with Diazinon dust have helped to reduce damage.

Philicoptus sp. This weevil (Figure 52) was found only in the North banana zone which extends north and east of the Lasang River Valley to Compostela (Figure 53). The pest was not found in TADECO until February 1976. Previously, weevil damage to fruit was mistakenly identified as caterpillar scar. This insect was mistakenly identified previously as Pyrgops.

The species (Figure 52) is distinctly different from P. iliganus in color and only slightly smaller in size. Females are approximately 6 mm long and males are 5 mm. To the naked eye, the adult of both sexes is a drab green. A black lateral marking on the elytra is visible 1/3 from the posterior of the body. When viewed through the microscope, a colorful display of mostly green mixed with some blue and gold, irridescent, round scales are revealed. These scales cover the basal segment of the antenna, head, thorax, elytra and abdomen, except the caudal 3 segments. Scales on the legs are tan to salmon-colored with occasional gold or orange scales. The body is covered with hair-like setae which are less prominent on the dorsal prothorax. Membraneous wings are lacking and the elytra are fused.

Little was known about the biology of this weevil, but its habits appear similar to those of P. iliganus. Although the species was collected at widely scattered sites, populations in banana farms appear to be limited to low infestations in small localized spots. Farm managers reported little spread in these localized infestations since their discovery soon after bananas were

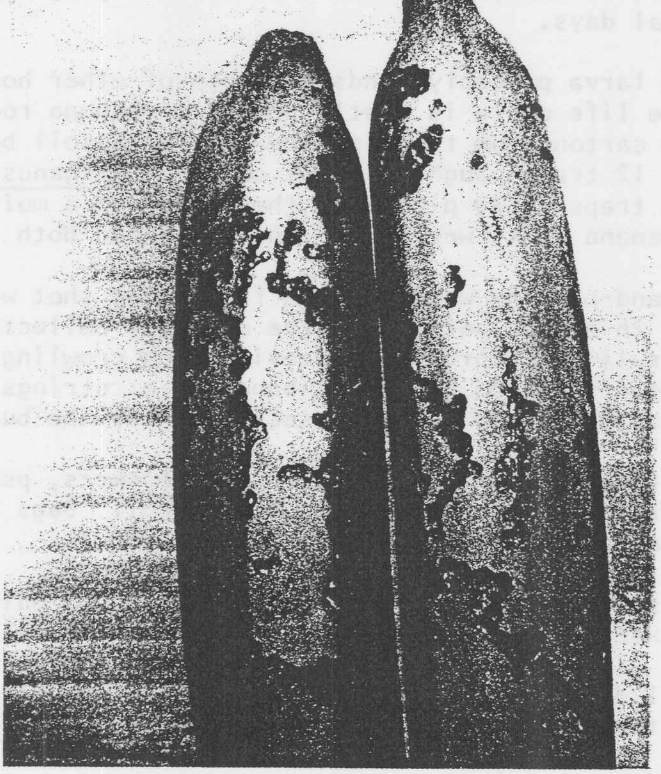


Figure 54. Peel scarring by <u>Philicoptus iliganus</u>, Lapanday, Mindanao, Philippines, 1976.

planted in early 1970's. For example, a known infestation covering 1-2 hectares in northeast Compostela Farm bordered by rice and the Agusan River has reportedly not moved during the last five years. A similar case was reported in La Filipina Farm near Tagum. Although reported previously on a minor scale, no scarring is now known in Hijo Farm.

The insect is polyphagus, feeding on banana fruit and suckers, coffee, a common malvaceous tree, and numerous other plants. Although adults were difficult to find in a small infestation in bananas in La Filipina Farm, numerous specimens were collected only 3 m across the road on the foliage of "madre de cacao" fence posts. Weevils were collected from the bush bordering bananas in Dizon, Diamond and Desidal Farms but no specimens were located on bananas a few meters away. There are indications that beetles in the bush do not penetrate far into the bananas. This may or may not be the result of insecticide sprays in some farms.

In TADECO, the insect was found in Farms 2, 3, 4, 5, 6 and 10. A survey in February revealed that 5% of 1629 stems of fruit had weevil scar. Of the damaged fruit, 90.6% came from Farm 5. Mindanao Fruit Company 1976 monthly reports summarized total stems with weevil scar from all farms as follows:

Month:	March	April	May	June	July	Aug.	Sept.	Oct.
No. stems:	180	389	244	84	196	110	97	75

In August, damaged fruit came only from Farm 5 with an average of 7.7 damaged fingers from an average of two damaged hands per stem. Although beetle populations were high in weeds in Farm 2, no scarred fruit was reported.

Before bananas were planted in 1970-71, some of the Philicoptus-infested areas were in scattered coffee, abaca, ramie and kenaf. It is likely that the weevil was there in its natural state before man settled the zone. The insect has persisted despite drastic ecological changes brought about in recent decades. It is speculated that the species will continue to survive in the present banana habitat and that man should accept the weevil's presence as a permanent part of the banana plantation fauna. Certain manipulations of the habitat based on proven research findings may reduce weevil damage to a tolerable minimum.

Other Weevils

Rumors that other weevils in banana farms are also peel-scarrers appear to be unsubstantiated. To the untrained eye, several weevils are confused with peel-scarring species. A collection of 11 numbered species were deposited in the TADECO lab. Identifications (Table 156) using the collection number will serve as a reference. Dr. O'Brien has a numbered set as well as the USDA collections in Beltsville, MD.

When placed in a 1500 ml jar, six of eight miscellaneous species fed on green banana fingers. Most of the Metapocyrtus species were reluctant to feed during the first few days. However, Philicoptus strigifrons Heller

Table 156. Curculionids in or near Mindanao banana farms, Mindanao, Philippines, 1976

Collection number	Genus	Subgenus	Species	Author	Comments
1	Philicoptus		iliganus	Heller	Banana pest, South zone
2	Metapocyrtus	Trachycyrtus	apoensis	Schultze	
3	Philicoptus				Banana pest, North zone
4	Philicoptus		stringifrons	Heller	
5	Metapocyrtus	Dolichocephalocyrtus	trifasciatus	Schultze	Common
6	Metapocyrtus	Dolichocephalocyrtus	bituberosus	Heller	Common
7	Metapocyrtus	Trachycyrtus	viridulus ?	Chevrolat	Tentative identification
8	Philicoptus		demissus	Heller	Banana pest, General Santos
9	Philicoptus				
10	Philicoptus				
11					Not identified

taken from banana suckers at Guianga feed readily in captivity and may be a suspect peel-feeder.

(STEPHENS)

EXPERIMENTAL DEPARTMENT - HONDURAS

PATHOLOGY

Disease Control

During 1976 black Sigatoka was the disease receiving major attention and we applied 7.79 more cycles to control it than in 1975. Crown mold has been reported in most of the U. S. shipments due to the fact that 40% of the fungi causing the problem are resistant to Benlate or Tecto.

Black Sigatoka

The major disease in Honduras Division is the new race of leaf spot called black Sigatoka and is affecting all the bananas and plantains growing in the Sula Valley.

In the Sula Valley, the area planted with bananas represents 40% and plantains 60%. Most of the banana farms are surrounded by plantains heavily infected with Sigatoka and only in bananas the disease is controlled; because of this we have a high inoculum level in our farms. During December the plantain shipments to U. S. market had been discontinued due to poor quality fruit.

We are controlling this disease with spray cycles of oil plus Benlate and Benlate formulations according to Research recommendations. At the beginning and during the last three months of the year, we had a lot of rainfall and the spray cycles had to be prolonged due to the weather and equipment problems.

In some hot areas (Mopala, Santa Rosa Farms), plants with fruit severely infected and having less than five healthy functional leaves were chopped down to reduce inoculum and help clean up the "hot spots" sooner.

Weekly deleafing cycles to eliminate all infected leaves were made in all the Division starting in July; this also helped to reduce the inoculum of the fungi that caused crown mold, crown rot and fruit spot.

In April CAGSSA farms (2,678 acres) were incorporated to our Sigatoka control program. The area is sprayed using airplane with six micronairs AU 3000. At the beginning the infection was high and spotting was found on leaf number 6. To lower the infection in this area, we were using a nine-day spray cycle of Dithane and Benlate in oil during the first six months. At present, we have good control with no hot areas. On the last survey made on December 30, spotting was found on leaves 8-9.

In the Division the average spray cycles applied this year were 29.39. La Fragua Farm had 33.0 and Guaruma Farm 25.48 cycles. The average length cycle in days is 13, La Fragua having the shortest cycle with 11 and Guaruma with 15 days.

The following is a comparison in number of spray cycles by years:

	1973	1974	1975	1976
Average cycles/ year	13.8	17.2	21.6	29.4

As a result of short spray cycles in combination with the cool weather registered in November and December, bronzing of the leaves is observed in all farms; the problem is heavier at the edges of the farms, along the road ditches and in young plantations (plantilla). Sigatoka control looks better than in 1975.

Crown Mold and Crown Rot

During 1976 crown mold has been reported in most of the shipments sent to U.S. markets, and crown rot only in two or three reports from Europe.

Starting in July, the complete Division was using 200 ppm Benlate or Tecto-40 for the U.S. shipments and 400 ppm Benlate or Tecto-40 for the European markets. This change was done according to Research instructions.

The Agricultural personnel instructed all farm administrators and all packing plant and farm supervisors to improve farm sanitation (weed control, deleafing, plant population, drainage, fruit protection, etc.). At the packing stations all techniques were improved, such as dehanding with enough crown tissue, selecting and cutting the clusters in the right way, giving enough time to spray the fruit with the protective fungicides and packing the fruit in the box correctly.

Mr. James Murphy from the Plumbing Department designed and installed the "Double Line Spray System". This system has been installed in 27 packing plants and is giving us a better protective spray against crown mold and crown rot fungi.

Fruit Spot

The incidence of pitting disease was very low this year due to improved sanitation techniques.

To reduce costs in chemical control, we were spraying the fruit seasonally starting in March through November.

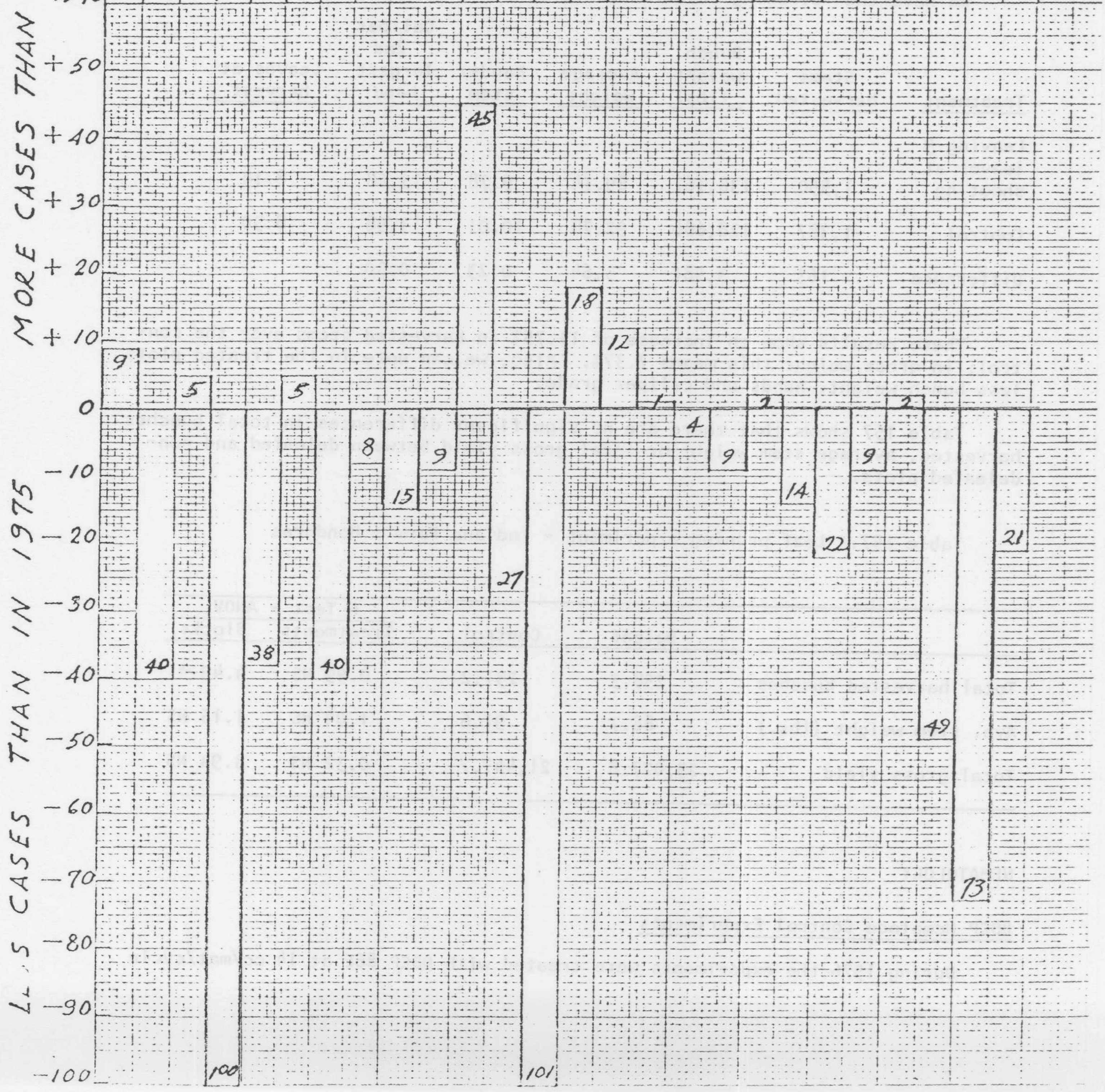
Moko

Moko control was excellent this year with a total of 725 cases in all the Division as compared to 1,206 last year. This means a reduction of 39.9% less cases than in 1975.

San Juan, Guaruma and Omonita Farms in La Lima District have become the problematic ones during the year. We must improve Moko control techniques in these farms (Figure 55).

MOKO INCIDENCE BY FARMS - HONDURAS
COMPARISON BETWEEN 1975 & 1976

	BUENA VISTA	COBB	N. CHINO	LOS INDIOS	PALOS BLANCOS	PALOMAS	LA FRAGUA	T. BOMBO	LAUREL	LUPO	SAN JUAN	LA CURVA	TACAMICHE	GUARUMAS	OMONITA	LIMONES	CAIMITO	INDIANA	CEIBITA	STA. ROSA	COROZAL	MOPALA	BLANCO	GARROBA	BARRANCO	OLIVA	TOTA.
1975	15	67	46	148	52	19	21	53	29	30	85	63	117	—	1	9	7	24	12	29	26	28	50	86	105	74	1206
1976	24	27	21	48	14	24	20	45	14	21	130	36	16	18	13	10	3	15	1-	15	4	19	52	37	32	53	725



Leaf Pruning Experiment

The experiment is located at Indiana Farm and is carried out by the farm administrator, assisted by our Department and Research.

The objectives for this study were presented in the 1975 Annual Research Report.

We have the following results for 1976:

Treatment	Stems harvested	Bunch weight (lbs)	Average weight	Hands/ stem	Caliper 2nd largest hand	Leaves at harvest
Leaving 9 leaves at shooting	1,550	138,167	89.14	9.78	13.68	8.14
Control	1,387	128,686	92.78	10.01	13.98	8.30
Difference	163	9,481	3.64	0.23	0.30	

These results show an increase of 11.75% in harvested stems over the control; in gross weight this means 7.37%. Also, we can note in the treated plots less bunch weight, hands and caliper grade.

Table 157 shows that there are no significant differences in total bunches harvested, average stem weight or total gross yield between deleafed and non-deleafed plots.

Table 157. Leaf pruning experiment - Indiana Farm - Honduras

			F Test - ANOV	
	Deleaf	Control	Treatments	Blocks
Total harvested bunches	258.3	231.2	0.99 NS	4.49 *
Ave. stem weight (lbs.)	88.7	91.6	1.04 NS	1.15 NS
Total gross yield	23,027.8	21,447.7	0.32 NS	3.94 NS

NEMATOLOGY

DBCP Nematode Control Experiments

During 1976 the experiments were treated with DBCP 86E at 14 cc/mat/cycle and two cycles during the year. At the second cycle of the year, the injections were made in the 9 x 5 configuration with the inner circle at 6 in (15 cm) and the outer circle 12 in (30 cm) from the inner circle as per Research recommendations. The cycles applied in 1976 represent the 5th and 6th consecutive cycles of DBCP. These were applied in week 8 and 34 in the Los Limones Experiment, 20 and 51 in the San Juan Experiment, and 15 and 48 in the Barranco Experiment.

Previous data collection has included loss surveys, pseudostem circumference, and nematode surveys. During the year the data collection was increased to include (number of stems), stem weight, number of hands, pseudostem circumference and for the 4th quarter, grade and apical finger length. Summaries by quarter are presented in Tables 158 and 159. Data were collected weekly on random stems from the plots harvested.

In the Barranco Experiment, means for the 3rd quarter were highly significantly (1% level) different from stem weight and significantly (5% level) different for number of hands. During the 4th quarter, stem weight was significant and grade highly significant for mean comparisons. In regard to stem weight in this experiment, two things are happening: the number of hands is increasing and the caliper is higher at harvest. This could indicate an effect of nematode control through better growth and reaching grade faster. Thus, it is going to be necessary to mark mats and keep a closer record of growth and development of the stems. Rainfall in this area during 1976 was 52.56 inches and represents a total increase of 11.62 inches over 1975.

In the San Juan Experiment, data were not available for the 3rd quarter. During the 4th quarter, grade mean difference was the only parameter that was significant. Rainfall during 1976 was 54.13 inches, 27.49 inches greater than 1975.

The Limones Experiment was accidently treated with DBCP in the control plots during 1975. Six additional plots were included to act as controls. Research made counts of nematodes and found no Radopholus in these plots, so at Research recommendation they have been eliminated from the analysis. This area was originally 65% infested based upon rhizome index at the start of the experiment. The area still yields very low nematode counts in the roots. Data analysis shows mean differences only for stem weight in the 3rd quarter which is significant. Rainfall during 1976 was 80.01 inches which is 41.75 inches of the 1975 total.

Up-root losses for the three experiments are presented in Table 160. The losses based upon 650 production units per acre represent 2.1, 2.1 and 0.2% in the areas of Barranco, San Juan and Limones, respectively. The only case where mean differences are significant is in Barranco Farm (1% level), the farm with the highest incidence of Radopholus.

ENTOMOLOGY

We had two insect problems reported in the Division this year:

Table 158. DBCP Experiments - Yield data for 3rd quarter 1976

			F Test - ANOV [2]	
Location[1]	DBCP	Control	Treatments	Blocks
Barranco[3]				
No. stems	132.6	121.4	1.50 NS	2.77 NS
Stem weight (lbs)	89.6	77.4	35.81 **	7.71 *
No. hands	9.5	8.8	10.58 *	1.60 NS
Pseudostem circ. (cm)	72.0	69.1	3.41 NS	1.96 NS
Limones				
No. stems	68.8	45.8	2.98 NS	4.98 NS
Stem weight (lbs)	95.3	91.6	8.79 *	2.70 NS
No. hands	9.8	9.9	0.03 NS	2.49 NS
Pseudostem circ. (cm)	77.8	77.6	0.03 NS	3.42 NS

1 No San Juan data available.

2 ** = 1% level, * = 5% level and NS = Non-significant.

3 Replicate Nº 1 omitted due to harvesting problem.

Table 159. DBCP Experiments - Yield data for 4th quarter 1976

Location	DBCP	Control	F Test - ANOV[1] Treatment	F Test - ANOV[1] Blocks
Barranco				
No. stems	174.7	155.8	0.04 NS	1.62 NS
Stem weight (lbs)	90.8	80.6	8.76 *	3.36 NS
No. hands	9.0	8.7	0.58 NS	0.62 NS
Pseudostem circ. (cm)	72.4	71.4	0.28 NS	1.00 NS
Grade	18.2	17.3	28.26 **	1.44 NS
Apical finger length (in)	8.0	7.9	1.40 NS	0.91 NS
San Juan				
No. stems	66.5	65.3	0.05 NS	3.70 NS
Stem weight (lbs)	94.3	93.1	0.16 NS	1.38 NS
No. hands	10.5	10.3	0.57 NS	0.99 NS
Pseudostem circ. (cm)	75.7	74.6	0.61 NS	1.49 NS
Grade	15.4	15.7	9.14 *	2.89 NS
Apical finger length (in)	7.8	7.7	0.43 NS	1.16 NS
Limones				
No. stems	64.0	50.2	5.30 NS	1.95 NS
Stem weight (lbs)	91.3	88.1	2.68 NS	1.85 NS
No. hands	9.0	8.9	3.08 NS	9.31 *
Pseudostem circ. (cm)	74.2	72.8	5.30 NS	5.32 *
Grade	16.5	16.2	5.45 NS	3.61 NS
Apical finger length (in)	8.4	8.2	2.08 NS	8.02 *

[1] ** = 1% level, * = 5% level and NS = Non-significant.

Table 160. Up-root losses in DBCP experiments in Barranco, San Juan and Limones Farms during 1976

Location	Up-roots/acre	F Test
Barranco		
DBCP	2.8	21.87 **
Control	13.8	
Reduction	80%	
San Juan		
DBCP	8.7	4.63 NS
Control	13.8	
Reduction	37%	
Limones		
DBCP	0.7	0.53 NS
Control	1.3	
Reduction	46%	

** = 1% level.

1) Metachroma variabile - Higuerito District. This was reported on June 18. The small beetle was feeding on young banana fruit. To control the pest all the water suckers were chopped down and the farms cleaned to eliminate weeds, especially camalote grass.

2) Red Rust Thrips - Santa Rosa Farm. The damage appeared at the end of July. The damage apparently was caused because of the poor quality of the plastic bag that did not resist the wind action and rupted (87%), allowing the insects to infect the fruit.

AGRONOMY

Potassium-Magnesium Experiment - Lima and Ulua Districts

The plots are located in poor and good areas in San Juan, La Curva, Copen and Santa Rosa Farms. The objective was to determine if bananas growing in poor and good soil would respond to the application of potassium plus magnesium and potassium alone in soils from Chamelecon and Ulua rivers.

Table 161 shows the results obtained from January through December 1976.

In Lima District, results found through December indicate an increase from 2.6 to 20.5 lb in poor areas and from 2.5 to 14.4 lb in good areas receiving 360 lb of K plus 25 lb of Mg/acre/year.

With 720 lb of K/acre/year, the results show an increase from 5.6 to 21.7 lb for poor areas and from 0.9 to 11.2 lb in good areas.

We have no response in poor areas in Santa Rosa Farm (Ulua District) and a slight increase from 1.4 to 4.5 lb in good areas.

This indicates that most of the farms located along the Ulua River are not actually deficient in potassium. We applied two cycles of 400 lb KCl during this year in Lima District, and during 1977 all the entire Lima District will be treated with potassium.

Table 162 shows significant results in stem weight for San Juan (10% level) and La Curva Farm (5% level) in poor areas. Means for grade are highly significant (1% level) in the poor area in La Curva and slightly significant (10% level) for the good area in Santa Rosa Farm. Number of hands is significant (5% level) only in the poor area of San Juan Farm. Pseudostem circumference is significant in poor areas (5-10% level) in San Juan and La Curva Farms (5% level).

Grand Nain Versus Dwarf VALERY - Laurel Farm

At the beginning of the year, the data showed that 22% of the Grand Nain plants had shot fruit and only 6% in the Dwarf VALERY variety.

The data collected from January through December show the following:

Table 161. Potassium-magnesium experiment - Lima and Ulua Districts

	Poor Area			Good Area		
Location	T-1*	T-2	T-3	T-1	T-2	T-3
San Juan						
Total stems	688	690	644	691	682	700
Stem weight (lbs)	85.8	83.7	75.5	93.6	92.9	91.1
No. hands	10.3	10.0	9.4	10.7	10.8	10.7
Caliper grade**	14.7	14.7	14.8	14.3	14.2	14.1
Pseudostem circ. (cm)	72.9	72.0	67.0	78.2	78.8	76.4
San Juan						
Total stems	648	708	707	729	698	679
Stem weight (lbs)	74.2	77.3	71.6	101.8	100.2	99.3
No. hands	9.3	9.7	8.9	11.1	10.9	10.9
Caliper grade	14.6	14.6	14.9	15.2	15.3	15.2
Pseudostem circ. (cm)	65.3	67.1	62.7	78.9	79.2	78.0
La Curva						
Total stems	679	726	703	616	604	631
Stem weight (lbs)	83.2	90.1	84.5	96.4	93.2	91.6
No. hands	9.0	9.7	9.2	9.8	9.5	9.5
Caliper grade	15.6	15.3	15.5	16.0	15.9	15.9
Pseudostem circ. (cm)	70.6	75.4	71.7	77.4	76.6	74.6
La Curva						
Total stems	749	796	646	552	558	544
Stem weight (lbs)	93.7	94.5	73.2	88.5	90.8	84.8
No. hands	9.8	9.6	8.2	9.6	9.8	9.3
Caliper grade	15.2	15.8	15.8	14.4	14.6	14.6
Pseudostem circ. (cm)	76.4	76.5	64.6	75.4	76.2	71.4
Copen						
Total stems	550	554	620	770	751	671
Stem weight (lbs)	61.2	58.3	69.9	89.1	85.9	74.7
No. hands	7.6	7.5	8.2	9.6	9.2	8.5
Caliper grade	15.2	15.0	15.6	15.2	15.4	15.5
Pseudostem circ. (cm)	57.4	56.6	61.8	74.0	71.8	65.2
Santa Rosa						
Total stems	403	367	395	631	606	611
Stem weight (lbs)	69.3	69.5	70.3	99.4	102.5	98.0
No. hands	8.1	8.0	7.9	10.2	10.4	10.3
Caliper grade	16.1	15.9	16.2	15.3	15.3	14.9
Pseudostem circ. (cm)	64.8	65.0	63.0	81.3	84.2	81.2

* T-1 = 360 lb/acre/year of K plus 25 lb of Mg/acre/year

T-2 = 360 lb/acre/year (starting September 1975, we are applying 720 lb/acre/year.

T-3 = Control.

** Caliper grade = 2nd largest hand.

Table 162. Potassium-magnesium experiment - Lima and Ulua Districts

Location	F Test [1]			
	Poor Area		Good Area	
San Juan				
Stem weight (lbs)	4.24*	3.46**	0.36 NS	1.22 NS
Caliper grade	0.20 NS	0.16 NS	0.14 NS	0.23 NS
No. hands	3.28 NS	8.67**	0.84 NS	2.27 NS
Pseudostem circ. (cm)	4.74*	11.98***	2.68 NS	2.39 NS
La Curva				
Stem weight (lbs)	1.20 NS	7.36**	1.60 NS	0.88 NS
Caliper grade	0.45 NS	13.35***	0.05 NS	0.03 NS
No. hands	1.28 NS	9.09**	1.08 NS	1.61 NS
Pseudostem circ. (cm)	1.81 NS	9.17**	3.18 NS	2.12 NS
Copen				
Stem weight (lbs)		0.71 NS		0.71 NS
Caliper grade		0.44 NS		1.42 NS
No. hands		0.78 NS		3.90*
Pseudostem circ. (cm)		0.83 NS		4.07 NS
Santa Rosa				
Stem weight (lbs)	0.04 NS		0.72 NS	
Caliper grade	0.52 NS		4.29*	
No. hands	0.32 NS		0.41 NS	
Pseudostem circ. (cm)	1.07 NS		1.43 NS	

[1] * = 10% level, ** = 5% level and *** = 10% level.

Variety	Stems harvested	Bunch weight	% CHIQUITA	Caliper basal hand	Apical finger length (inch)
Grand Nain	1,142	81,667	64.9	15.5	7.9
Dwarf VALERY	993	68,445	68.4	15.5	7.8

Grand Nain produces more fruit than Dwarf VALERY, but less percent of CHIQUITA fruit.

Selective Pruning Experiment - Laurel Farm

The experimental area was planted on February 10 through 19, 1976 with peeled but not heat-treated Grand Nain "seed". Plant spacing is 9' x 9' hexagonal (621 units per acre). The rhizomes planted ranged from 6 to 8 inches in diameter with the center growing point removed prior to planting.

The objective of this trial is to evaluate the effect of different sucker selection methods on yield, bunch weight, stem size and finger length.

Treatments are arranged in a randomized complete block design and are replicated six times. Each replicate consists of 280 to 301 production units, but production data are collected from the center 56 mats.

Treatments are:

1) Select the first sucker regardless of position.

2) Select the most vigorous sucker regardless of position.

3) Select vigorous, well-located suckers.

4) Leave first two suckers and select best located one when direction of shooting is known.

Data collected from November through December give the following:

Treatment	Stems Shot	Stems Harvested	Stem weight (lbs.)	Hands/ stem	Caliper basal hand
1	246	87	59.5	7.7	15.6
2	243	89	66.4	8.2	15.6
3	246	72	60.7	7.8	15.5
4	249	84	63.0	8.0	15.7

Nitrogen-Potassium Experiment - Laurel Farm

The experiment is located at Laurel Farm. The objective is to determine the response of Grand Nain to two rates of Nitrogen in combination with five rates of potassium sulphate, using 621 production units per acre.

Table 163 shows some differences in bunch weight, number of hands per stem when comparison is made between the two rates of nitrogen using all potassium combinations at each nitrogen level.

Table 163. Effect of nitrogen and potassium fertilization of Grand Nain - Laurel Farm - Data collected from January through December 1976

Pounds/Acre/Year Nitrogen	Pounds/Acre/Year Potassium	Stems harvested	Stem weight (lbs)	Hands/ stem	Apical finger length	Caliper basal hand
200	0	414	71.0	8.4	7.7	15.2
200	200	413	70.5	8.3	7.7	15.4
200	400	462	76.0	8.7	7.8	15.1
200	600	445	78.4	8.9	7.8	15.1
200	800	438	78.3	8.9	7.8	15.2
300	0	425	71.7	8.4	7.7	15.1
300	200	432	75.5	8.6	7.8	15.1
300	400	441	73.5	8.7	7.7	14.9
300	600	450	78.4	8.9	7.8	15.1
300	800	452	79.3	8.9	7.8	15.0

Potassium Experiment - La Curva Farm

The experiment was initiated in August. The objective of this trial is to know the optimum potassium concentration in the leaves, source of potassium (K_2SO_4 and KCl), rate and frequency of application more efficient to obtain maximum yields in our conditions. Using the foliar analysis, potassium concentration in the leaf will be correlated with stem weight and total production.

Phosphorus Experiment - La Curva Farm

The objective of this experiment is to know if phosphorus application has an effect on fruit weight and if there is any beneficial effect to determine which is the best level of application to obtain maximum production.

In both experiments (potassium and phosphorus), the information collected will be evaluated by the analysis of variance and means will be compared using Duncan's Multiple Range Test.

Banana Production Estimating Project

The project was started during February 1975 with the assistance of Mr. E. Schons and Dr. Yñiguez. The purpose is to determine the feasibility of estimating three-week banana production by using maximum and minimum temperatures, bud farm counts, weekly fruit growth, ribbon color and field losses. To run this trial, a total of 38 sampling plots (0.5-acre plot) were laid out in a randomized fashion, one in each section of Santa Rosa Farm.

Each week we send a radiogram to Dr. Stier in Boston which includes all information collected.

This information has been helpful to the Agriculture Department when planning weekly fruit estimation, especially during November through February when the climatic conditions changed due to cold fronts.

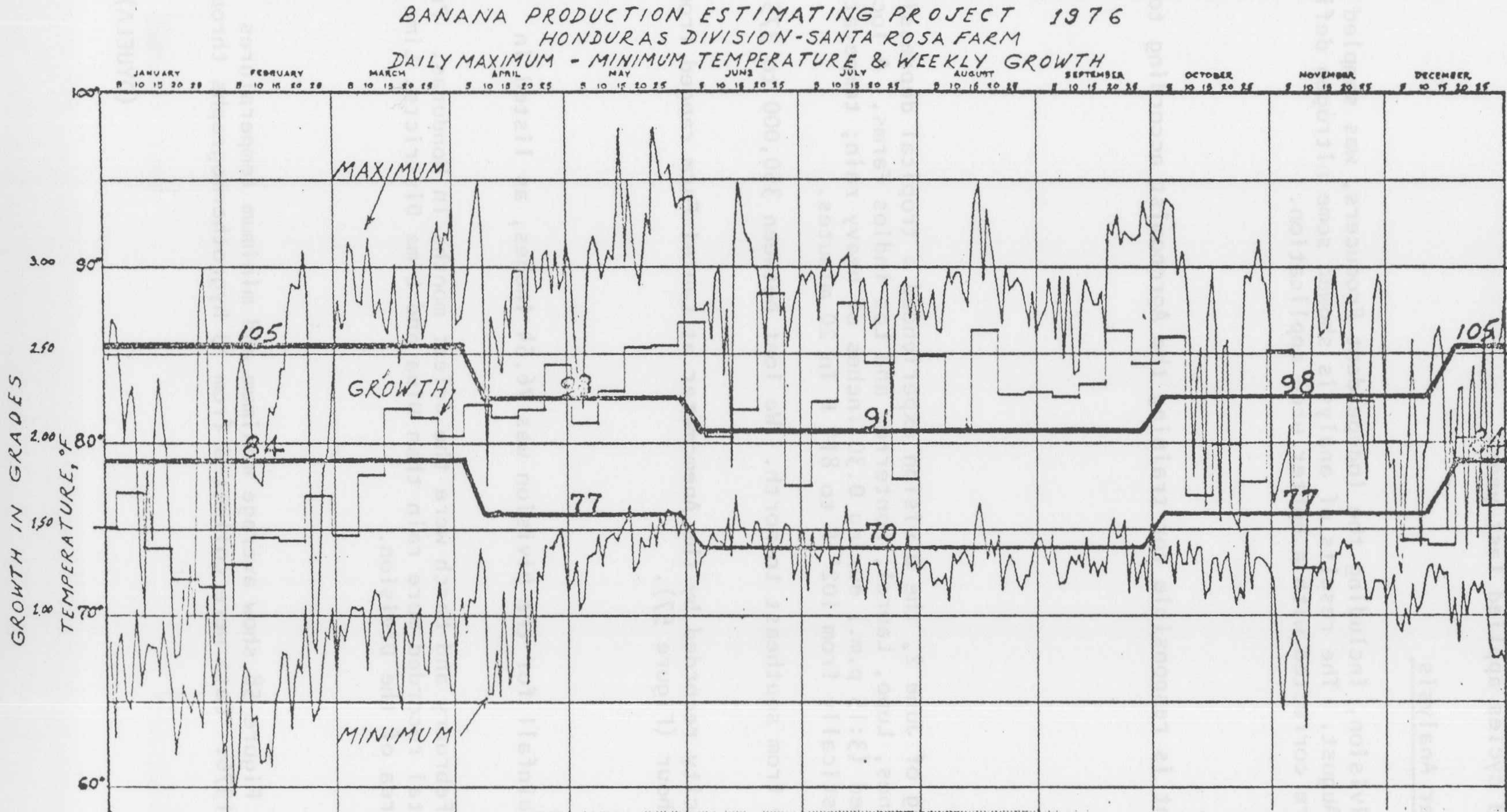
Figure 56 shows the information for 1976 recorded in Santa Rosa Farm. Dr. Sierra's Harvest Program Age/Grade Control showing four harvest periods for Honduras Division, according to our weather conditions, is as follows:

		Harvest					
		Days			Weeks		
Nº	Harvest periods	Min.		Max.	Min.		Max.
1	From Dec. 11 to Apr. 3	84	to	105	12	to	15
2	From Apr. 3 to May 28	77	to	98	11	to	14
3	From May 28 to Sept. 28	70	to	91	10	to	13
4	From Sept. 28 to Dec. 11	77	to	98	11	to	14

This means that for period Nº 1 any ribbon in areas with good growth must be calipered for the first time in week 12, second calipered in week 13, and swept in week 14. For areas with less growth, the first caliper must be in week 13, second calipered in week 14, and swept in week 15. This is done to optimize grade, try to obtain the maximum box/stem ratio, and avoid ripe and turning during transit.

Water Requirement

The Experimental Department gave assistance to the Agriculture personnel in this matter. Weekly soil moisture readings with tensiometers were initiated starting in January and continued according to the dry periods experienced during this year. Readings were taken at 6" and 12" below soil surface in most of the farms.



AVERAGE MEDIUM TEMPERATURE BY WEEK DURING 1975 & 1976

WEEK Nº	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1975	76.2	76.3	73.2	78.5	78.4	77.5	78.7	78.1	75.1	77.0	77.7	77.1	82.8	82.2	81.2	81.0	81.1	84.0
1976	75.3	72.4	69.2	72.8	70.9	72.2	74.9	73.8	76.3	79.9	77.8	78.1	80.1	80.6	76.5	79.4	81.7	79.5

WEEK Nº	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1975	86.3	84.7	84.6	84.0	84.8	84.5	84.4	82.7	80.6	82.9	82.7	82.2	83.0	82.1	83.5	82.5	82.7
1976	82.4	83.4	82.8	84.8	80.8	81.9	81.7	81.1	81.4	81.8	80.2	80.2	80.3	80.5	82.7	81.3	80.3

WEEK Nº	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1975	83.8	82.5	83.3	80.2	81.5	81.2	83.3	78.5	78.5	79.9	79.1	75.2	76.8	76.5	75.3	76.1	73.1
1976	80.3	80.1	82.0	82.5	83.1	79.8	78.2	77.6	77.5	71.8	80.0	79.2	77.7	74.2	77.2	75.2	76.0

AVERAGE GROWTH IN GRADES RECORDED BY WEEK DURING 1975 & 1976

WEEK Nº	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1975									1.91	1.66	1.97	2.08	2.46	2.23	2.41	2.08	2.28	2.52
1976	1.71	1.98	1.21	1.16	1.28	1.45	1.43	1.68	1.46	1.81	2.19	2.14	2.04	2.21	2.14	2.18	2.44	2.11

WEEK Nº	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1975	2.56	2.65	2.65	2.87	2.60	2.71	2.04	2.45	2.25	2.41	2.25	2.36	2.18	2.28	2.37	2.39	2.32
1976	2.29	2.34	2.55	2.68	2.05	2.79	2.85	1.75	2.23	2.80	2.45	1.79	2.49	2.07	2.64	2.27	2.28

WEEK Nº	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1975	2.41	2.44	2.11	1.81	1.92	2.30	2.31	1.86	1.82	2.00	1.58	1.49	1.56	1.70	1.36	1.51	1.51
1976	2.26	2.33	2.64	2.45	2.60	1.69	1.98	1.77	2.52	1.27	1.60	2.24	2.00	1.44	1.41	2.03	1.64

Figure 56

In 1976 we had 76.54 inches of rainfall in comparison with 30.33 inches during 1975. Because of this, we applied only 33.4 irrigation cycles during this year vs. 60.3 cycles applied last year.

Sampling for Foliar Analysis

The entire Division, including the Independent Producers, was sampled from February through August. The results of analysis showed some nitrogen deficiencies which were corrected with a better urea application.

Training Program

The Department is responsible for training the Agronomist according to the program.

METEOROLOGY

Blowdown Losses

On the evening of June 2, the Division experienced a tropical depression that affected Limones, Lupo, Laurel, Monterrey and Los Indios Farms. A local windstorm was formed (3:15 p.m.) during 0.30 inches of heavy rain; temperature dropped 21° F, drastically from 102° F to 81° F in 20 minutes.

The wind blew from southeast to north. We lost between 350,000 to 375,000 production units.

The wind velocity recorded by the Anemometer at Laurel Farm ranged from 36 to 6 miles per hour (Figure 57).

Rainfall

The average rainfall for the Division was 76.54 inches, as listed in Table 164.

During 1976, February and March were the driest months in Honduras. Progreso and Guanacastal recorded more rain than Ulua and Lima Districts, Lima being the driest area of the Division.

Temperature

Table 165 and Figure 58 show average maximum and minimum temperatures which occurred in 1976. Data were collected from 13 hygrothermographs throughout the Division.

(OYUELA)

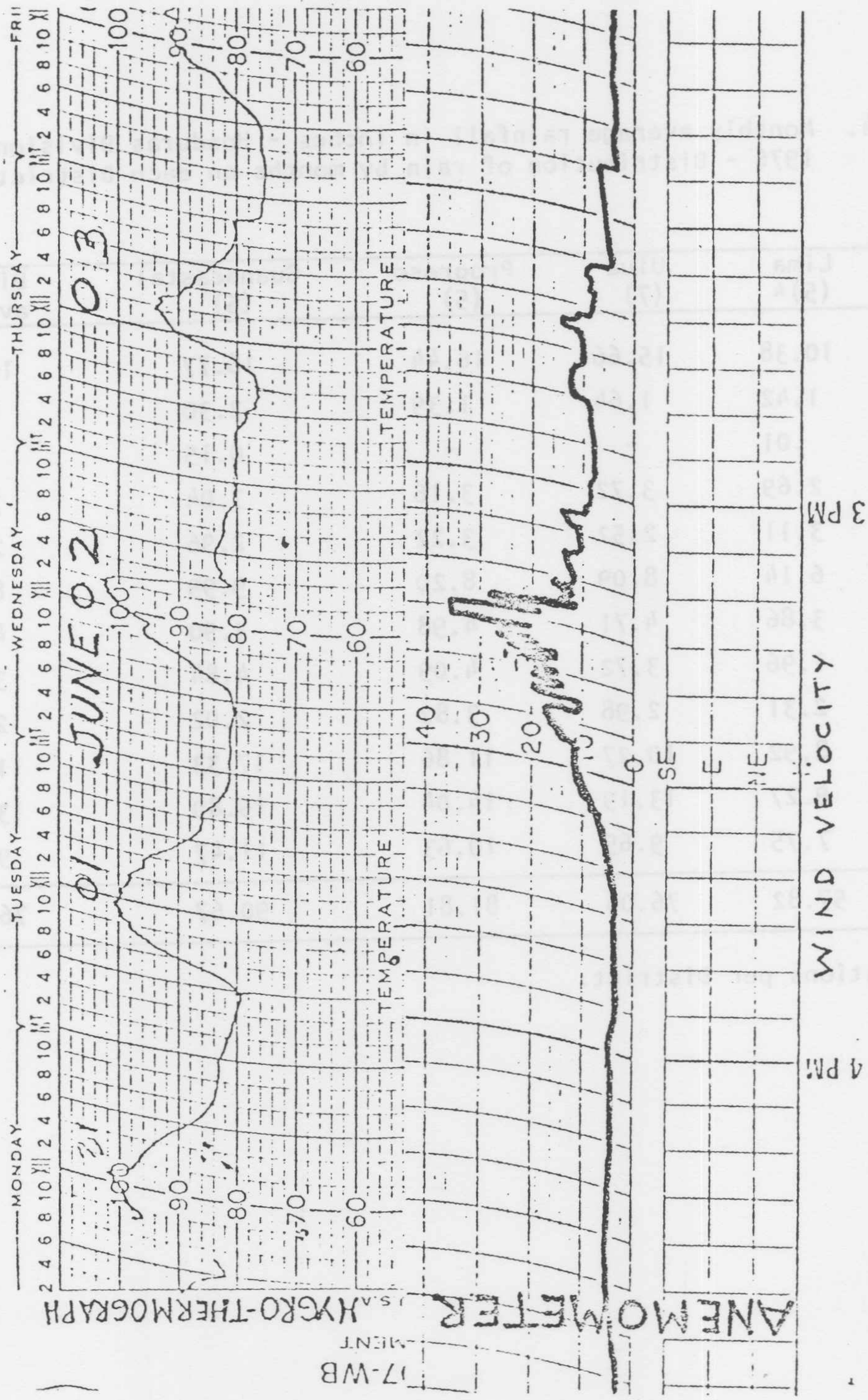


Figure 57. Wind velocity recorded by Anemometer at Laurel Farm.

Table 164. Monthly average rainfall in inches - Honduras Division 1976 - Distribution of rain by months on each District

Month	Lima (5)*	Ulua (7)	Progreso (5)	Guanacastal (5)	Division average
January	10.38	15.66	16.44	16.77	14.89
February	1.42	1.64	1.39	2.30	1.66
March	.01	-	-	0.15	.01
April	2.69	3.72	3.16	3.04	3.20
May	3.11	2.52	3.22	2.96	2.91
June	6.14	8.09	8.20	9.99	8.11
July	3.86	4.71	4.98	3.90	4.40
August	1.96	3.72	4.09	4.84	3.66
September	2.31	2.98	3.82	2.02	2.80
October	8.92	10.27	11.86	17.33	11.92
November	9.27	13.19	14.04	15.89	13.10
December	7.75	9.65	10.63	11.47	9.86
	57.82	76.06	81.81	90.67	76.54

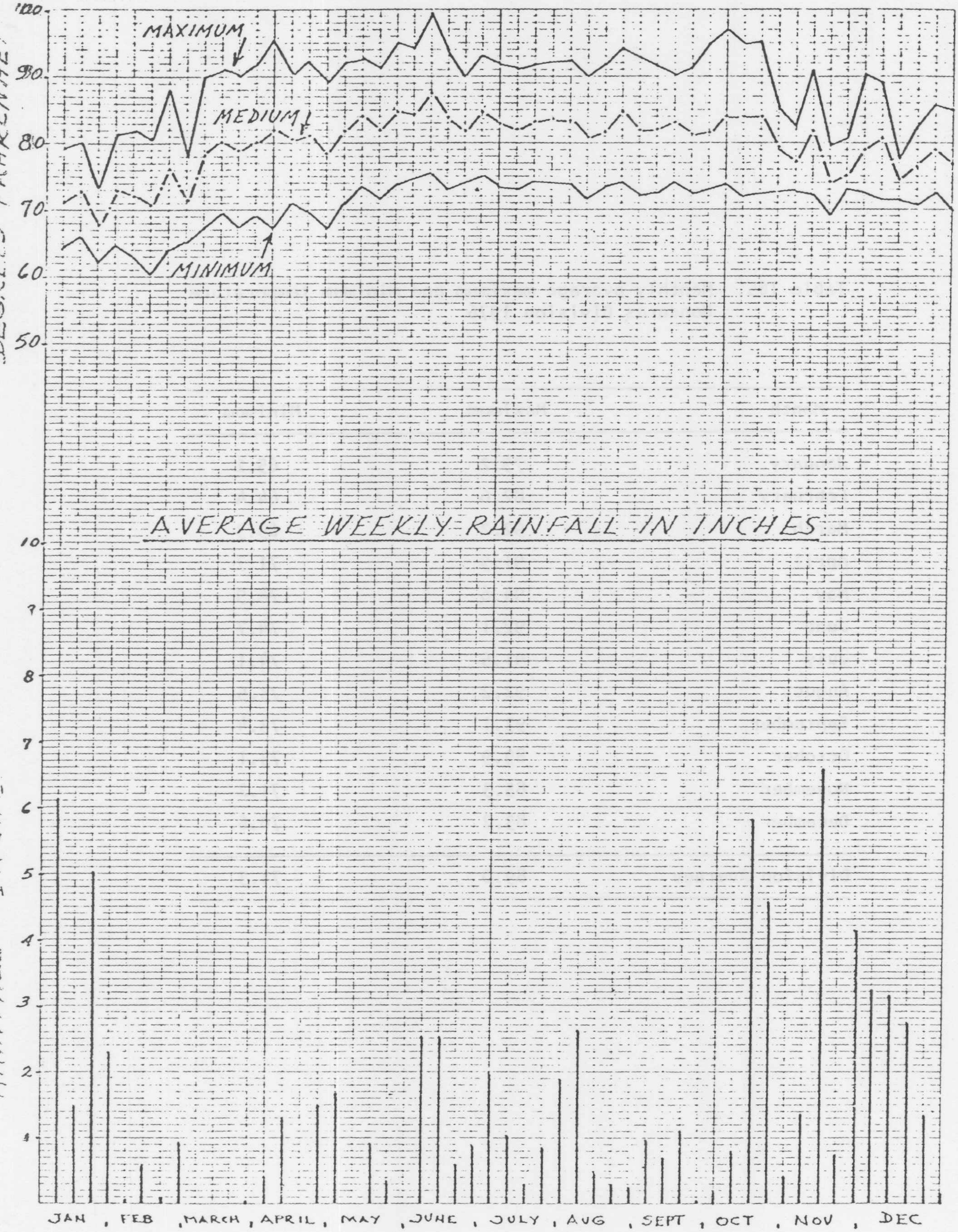
* Number of stations per District.

Table 165. Monthly average maximum and minimum temperature Honduras Division 1976

Month	Maximum	Minimum
January	79.2	65.2
February	82.6	64.4
March	92.2	69.3
April	91.5	71.7
May	94.6	74.9
June	92.1	74.7
July	91.5	74.1
August	92.2	73.5
September	93.1	73.4
October	89.9	73.1
November	85.3	71.2
December	83.2	70.6
Division Average	89.0	71.3

HONDURAS-DIVISION

AVERAGE MAXIMUM-MINIMUM WEEKLY TEMPERATURE



PROFESSIONAL STAFF AT END OF 1976

Dr. R. H. Stover	Director Vining C. Dunlap Laboratories
Dr. D. L. Richardson	Director Crop Development
Dr. F. A. Sierra	Director Agricultural Ext. & Training Services
Dr. H. E. Ostmark	Director Entomology/Nematology Department
Dr. P. R. Rowe	Director Banana Breeding Program
Dr. T. J. Johnson	Associate Horticulturist
Dr. Le Da Ton	Associate Horticulturist
Dr. M. Rodríguez	Associate Agronomist
Dr. J. G. Pinochet	Associate Nematologist
Dr. P. L. Taylor	Associate Nematologist
Dr. L. C. Darlington	Associate Pathologist
Dr. W. R. Slabaugh	Associate Pathologist
Dr. M. D. Grove	Associate Pathologist
Mr. J. D. Dickson	Associate Botanist
Mr. J. E. Romero	Associate Geneticist
Mr. H. J. Lizárraga	Associate Scientist
Mr. G. E. Donaldson	Manager Pest Control Extension - Panama
Dr. J. A. Salas	Principal Pathologist - Costa Rica
Mr. R. Escobar	Research Associate - Costa Rica
Mr. G. Alpízar	Senior Research Assistant - Costa Rica
Mr. G. Quesada	Senior Research Assistant - Costa Rica
Mr. M. R. Bustamante	Research Associate
Mr. C. Evers Q.	Research Associate
Mr. G. Manzanares U.	Research Associate
Mr. M. T. Palao	Senior Research Assistant - Nicaragua
Mr. A. A. Bueso	Senior Research Assistant
Mr. R. A. Fromm	Senior Research Assistant
Mr. J. R. Gómez	Senior Research Assistant
Mr. E. O. Jácome	Senior Research Assistant
Mr. J. A. Alfonso	Senior Research Assistant
Mr. O. A. Barrigh	Senior Research Assistant
Mr. J. R. Hernández	Senior Research Assistant
Mr. J. A. Padilla	Administrative Assistant

PROFESSIONAL STAFF AT END OF 1976 (Cont'd)

Mr. J. C. Guillén	Research Assistant - Agrónomo Veterinario
Mr. C. Joya	Research Assistant - Agrónomo Veterinario
Mr. M. A. Lara	Research Assistant - Agrónomo Veterinario
Mr. R. Lanza	Research Assistant - Agrónomo
Mr. C. Martínez	Research Assistant - Agrónomo
Mr. R. Beltran	Junior Agronomist
Mr. V. M. Guerra	Senior Soil Surveyor
Mr. L. A. Ware	Research Mechanical Supervisor
Mr. J. R. Arriaga	Office Head
Mr. A. Maldonado	Scientific Programmer

MEETINGS ATTENDED BY STAFF - 1976

"Food Storage Seminar" - Agency for International Development, San Pedro Sula, Honduras. January 25-30. A. A. BUESO

Plantain Work Shop - International Institute of Tropical Agriculture, Ibadan, Nigeria. January 27-29. R. H. STOVER

Interamerican Course on Soil Microbiology, San Jose, Costa Rica. May 31-June 24. E. O. JACOME

17th Annual Meetings of the Society for Economic Botany, Urbana, Illinois. June 13-16. T. J. JOHNSON

The Malaysian International Agricultural Oil Palm Conference, Kuala Lumpur, Malaysia. June 14-17. D. L. RICHARDSON

XII Annual Meetings PCCMCA, San Jose, Costa Rica. July 26-29. H. J. LIZARRAGA

73rd Annual Meetings American Society for Horticultural Science, Baton Rouge, Louisiana. August 11-14. P. R. ROWE

15th Annual Meetings Society of Nematology, Daytona Beach, Florida. August 15-19. P. L. TAYLOR and J. G. PINOCHET

XV International Congress of Entomology, Washington, D. C. August 19-27. H. E. OSTMARK

4th International Colloquium on the Control of Plant Nutrition, Ghent, Belgium. September 6-11. M. RODRIGUEZ

68th Annual Meetings American Society of Agronomy, Houston, Texas. November 28-December 3. F. A. SIERRA

DAYS WORKING AWAY FROM LA LIMA AND LOCATION
1976

Place	Ph. D.	Others	Total	%
Tapachula, Mexico	-	9	9	0.6
Mexico (FAO Banana Course)	10	-	10	0.7
Quepos	2	6	8	0.5
Golfito (Coto, Palmar)	132	146	278	18.4
Costa Rica (various locations)	63	107	170	11.3
Bananera, Guatemala	6	-	6	0.4
Nicaragua	15	90	105	7.0
Belize	17	10	27	1.8
Changuinola	283	40	323	21.4
Armuelles	54	7	61	4.0
Panama (Oil Palm)	16	28	44	2.9
Colombia	75	19	94	6.2
Ecuador	7	-	7	0.5
U. S. A. (various locations)	51	19	70	4.6
Taiwan	6	-	6	0.4
Philippines	49	-	49	3.2
Asia (other countries)	12	-	12	0.8
West Indies	5	27	32	2.1
Puerto Rico	5	-	5	0.3
Scientific Meetings	72	6	78	5.2
Seed Technology, Zamorano	-	16	16	1.1
London	-	8	8	0.5
Surinam	17	-	17	1.1
Honduras - PATSA	11	31	42	2.8
Panama - PATSA	11	-	11	0.7
Nicaragua - PATSA	11	-	11	0.7
U. S. A. - PATSA (Meetings)	6	6	12	0.8
	936	575	1511	100.0

Above does not include soil surveys as follows: 66 days Mexico; 63 Colombia; 8 Belize; 28 Changuinola; 48 Cobal; 7 Isletas. Total = 220 days.