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About the Institute
The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

Research Department
La Lima, Honduras
January 15, 1940

Mr. J. F. Aycock:

We submit herewith annual report of the Research Department for the year 1939.

W. C. Dunlap

CC: Mr. W. E. Turnbull
Dr. Wilson Popenoe
Mr. P. H. Myers
Mr. W. C. MacLouth
Mr. E. M. Cobb

OUTLINE OF REPORT OF RESEARCH DEPARTMENT

TELA RAILROAD COMPANY

1939

V. C. Dunlap

I. GENERAL

II. DISEASE AND PEST CONTROL

1. Sigatoka
2. Experimental Tests of Fungicides
3. Thrips or Red Rust
4. Experimental Tests of Insecticides
5. Banana Scale
6. Panama Disease
   - General
   - Surveys
   - Seed Disinfection
   - Soil Disinfection and Replanting
   - Flooding Experiment

III. SOIL INVESTIGATIONS

1. General
2. Surveys

IV. FERTILIZERS

1. Complete Fertilizer Experiment
2. Urea-Bordeaux Mixture Experiments

V. MISCELLANEOUS RESEARCH

1. Bordeaux Mixture
2. Bordeaux Toxicity Tests
3. Rubber Fruit Slings and Shoulder Pads

VI. Lancetilla Experiment Station

REPORT OF RESEARCH DEPARTMENT

TELA RAILROAD COMPANY

1939

V. C. Dunlap

I. GENERAL

During the past year, 1939, Sigatoka control work has been continued by this department, especially in connection with further investigation of cycles, concentrations and preparation of Bordeaux Mixture, the testing out of new sprays, dusts, spreaders, stickers and appliances used in spray operations.

Experiments have been carried on and promising results obtained with control methods for Red Rust thrips and banana scale. These two insect pests have become progressively injurious during the past two years and the former already occasions serious fruit losses.

Panama Disease surveys covering 6796 acres have been carried out in Honduras over several complete company farms, the independent rehabilitation areas, and seed beds.

Extensive soil surveys totalling 14,630 acres and including all areas recently planted or proposed for planting have been made in this division. Soil surveys made by this department in Guatemala totalled 4000 acres while reconnaissance surveys in Costa Rica in which a member of this department collaborated, included some 12,286 acres.

The large scale experiments with nitrate, potash, and phosphate fertilizers started in 1936 have been continued for over three and a half years. This year, for the first time, we have obtained definite beneficial results from the complete fertilizers.

In the laboratory, analyses of soils for texture and pH, experiments

on effect of heavy applications of Bordeaux to the soil and tests on various methods of preparing, effect of settling, agitation and heat on Bordeaux mixture have been conducted.

Among experiments recently commenced are the Naranjo Chino flood fallowing experiment for Panama Disease Control and the application of Urea through the stationary spray system in La Lima Farm.

During the year, members of the department have spent considerable time in other divisions in connection with Sigatoka control and soil examination. Mr. Bowman spent several weeks in the Chiriqui Division assisting in the installation of stationary spray system, nearly two weeks in the Costa Rican West Coast for the same purpose and made three trips to Guatemala in connection with Sigatoka control and Panama Disease surveys. Mr. van Diepen made two trips to Costa Rica in connection with airplane dusting and soil surveys and during August and September made an inspection of Sigatoka infection in Eastern Cuba. Mr. Lungwitz spent November in Guatemala carrying on soil surveys on the North Coast.

Dr. M. F. Morgan of the Connecticut Agricultural Experiment Station spent a month in the division advising us on improved methods of soil analyses, laboratory methods, etc.

Personnel: G. F. Bowman has been in charge of investigations of stationary spray system installations, spraying methods, materials, etc.; Wm. van Diepen in charge of field experiments with sprays, dusts and fertilizers; D. J. Lungwitz in charge of chemical work, soil surveys, and Panama Disease surveys; W. J. Schwarz and J. A. Stuart, assistant chemists; C. E. Bergquist, I. C. Hubbard, C. A. Bennaton, C. Von Der Goltz, Wm. Pena, G. J. Cappel, and F. Casenove, research assistants; and Mrs. L. C. Jewett in charge of files, materials and clerical work.

II. DISEASE AND PEST CONTROL

1. Sigatoka Control

Spraying for Sigatoka control by means of stationary spray systems has now become a part of ordinary farm routine in this division. Practically every acre of bananas included in the cultivated area is under spray. The chief additions to sprayed area during the year have been the new rehabilitation projects amounting to 2143 acres of independent farms. The entire division now has 38,623 acres of spray system installed.

This year stationary spray installations have been extended to cover practically all of the Company's producing acreage in Honduras, Guatemala, Costa Rica, and Panama and brings the total spray installation up to 103,000 acres requiring more than 5200 miles or nearly 28,000,000 feet of pipe.

Control of Sigatoka in Honduras has been good all year in spite of very difficult spraying weather during part of October, all of November, and most of December. The application of spray has been better than in previous years because of experience gained by all those connected with the mechanical and field operations.

Considerable reductions in cost have again been made. The total cost per project acre, including depreciation, dropped to $40.13 for 1939 compared to $51.08 for 1938 and $62.97 for 1937. The reductions in concentration and lengthening of cycles account for most of this economy but some part of it must also be credited to increased efficiency of operation. The acres sprayed per gang per day has been increased from 4.5 in 1937 to 5.3 in 1939. The average number of acres under different cycles and concentrations for the year are given in the following tables.

Average Acreages Under Different Cycles and Concentrations - 1939

	3-3-50	4-4-50	5-5-50	Total
14 day	527.7	382.8	6353.4	7263.9
21 "	639.5	758.3	3004.8	4402.6
28 "	8104.6	5028.5	8496.2	21629.3
42 "	234.6	63.5	1229.8	1527.9
Total	9506.4	6233.1	19084.2	34823.7

The average costs in this division for the various cycles and concentrations are as follows : (per acre)

	2-2-50	3-3-50	4-4-50	5-5-50
14 day	$33.47	$40.89	$48.30	$55.72
21 "	23.40	28.59	33.71	38.95
28 "	18.37	22.44	26.51	30.57
42 "	13.33	16.29	19.24	22.19

The cost of spray operations, without depreciation, for this year was under $.116 per count shipped and $.145 with depreciation.

The following comparative figures are given for the last three years:

	1937	1938	1939
Number of project acres	18124	32565	37043
Cost per acre application (not including depreciation)	2.54	2.20	2.10
Cost per acre application (including depreciation)	2.92	2.45	2.53
Cost per project acre per year (not including depreciation)	57.96	45.99	38.22
Cost per project acre per year (including depreciation)	62.97	51.08	40.13
Gals. per acre	258.8 Tela 267.0 Cortes	264 Tela 262 Cortes	263 Tela 266 Cortes
Acres per gang day	4.5 Tela 4.9 Cortes	4.8 Tela 5.1 Cortes	5.3 Tela 5.3 Cortes

No changes of any consequence were made during 1939 in method of spraying, type of nozzle, or layout of systems. The average number of gallons applied per acre increased slightly, from 261 to 263. An improved gun cut-off was developed, steel nozzle tips were replaced by longer wearing, cheaper, porcelain tips, more durable hoses were found, and various other refinements were made in accessories.

One serious difficulty, water supply, was partly overcome in 1939 by a method of acidizing deep wells to restore their output. When the well at Guaruma III became inadequate, it was determined in the laboratory that hydrochloric acid was not dangerous to the casing and locally made strainers , but would remove incrustations which had plugged the strainer slots. Enough concentrated acid was added to the well to bring the entire content of the casing to 20% strength and this was left to work overnight. Next day the well was pumped out with an acid resistant pump until the water was neutral. The capacity was then found to be greater than when the well was new. The same treatment has been used successfully on a number of other wells and has been improved by adding pressure to force acid into the water-bearing strata.

An interesting development in Chiriqui has been the use of the spray system with weak Bordeaux as a repellant against caterpillars even in places where Sigatoka has not appeared.

The beneficial effect of Bordeaux spraying on banana weights is becoming more and more marked. This increase is apparently due to reduction in transpiration from the banana leaves, thus enabling the individual leaf to supply more food to the bunch and causing each leaf to function for a longer period before dropping.

Weights of all fruit cut from two acre check plots in widely separated farms have been kept for over three years. No fertilizer has been applied

at all and only usual farm care and spraying have been received. Below is given the actual weights and the pounds increase in weight per stem.

	Average Weight Per Stem				
	1936	1937	1938	1939	Increase in Lbs.
Guaruma II	30.25*	44.89*	56.04	58.26	19.01 (4 years)
Tecumseh	45.79	49.17	58.48	55.00	9.21 (4 years)
Los Indios	-	-	61.04	80.36	19.32 (2 years)
Farm 12		57.64*	64.53	72.22	14.58 (3 years)

* Weights affected to some extent by Sigatoka.

In Guaruma III, the weight of all fruit cut in three sections has been kept for the past three years. In this case, ordinary farm applications of cyanamid have been made and all other routine farm treatment followed:

	Average Fruit Weights			
Guaruma III	1937	1938	1939	Increase in Lbs.
Section 21	59.34	75.60	88.26	28.92
" 33	61.01	80.19	88.25	27.24
" 29	65.59	76.40	93.15	27.56

The above sets of figures would seem to demonstrate that on good soil without nitrate applications Bordeaux spray will add considerable weight to fruit and that combined with our usual farm fertilizer program it is raising fruit weights rapidly each year.

2. Experimental Tests of Fungicides

During the past four years, field tests have been carried out with all fungicidal sprays and dusts which seem to offer possibilities in "Sigatoka" leaf spot control. From time to time new fungicides are received for trial and these that give little or no control are eliminated. In our Guaruma III experimental plots several of the fungicides have been under test since the first of 1936.

In June 1939 an additional 23 acres in Guaruma II was allotted to the Research Department for fungicide experiment purposes. In this section there are nine plots of approximately 2.59 acres each. The entire area is sprayed from a stationary Bean pump reduced down to capacity of 15 gals. per min. powered by a 10 H.P. electric motor. The layout of pipe and system of spraying in all our experimental spray plots is very similar to that of the regular farm installations.

All fungicides are compared with Bordeaux 5-5-50 and 3-3-50, both from a control and cost standpoint, in evaluating efficiency.

The fungicidal sprays and dusts which are still under test as well as those that have been tested and eliminated during the past year 1939, fall into two groups.

Copper Group	Sulfur Group
1. Bordeaux Mixture	1. Lime Sulfur
2. Bordeaux Mixture and potassium permanganate	2. Flotation Sulfur Cream
3. Ammoniacal Copper Carbonate	3. Sulforon
4. Bayer Concentrate	4. Sulfur Dust
5. Basic Copper Sulfate	

Copper Group

6. Tri-Basic Copper Sulfate
7. Fungicide "26"
8. Yellow Cuprocide
9. Cuprocide 54-Y (Improved)
10. Perenox
11. Copper Oxychloride
12. Copper Lime Dust

Cycles are shortened or lengthened depending upon the season of the year and the virulence of infection. Most of the fungicides are effective during the dry seasons of the year on a twenty one day cycle; but differ markedly in their effectiveness during the wet months of the year.

During the past wet season, the Cuprocide sprays were very effective on a biweekly and 21 day cycle. Bayer, Copper Oxychloride, Fungicide "26", Basic Copper Sulfate, and Tri-Basic Copper Sulfate were not as effective in the more prolific growing areas, where virulence of infection generally is more marked. Up to the present time no fungicide has equalled 5-5-50 Bordeaux Mixture in Sigatoka control under Honduran conditions.

Fungicides - Sprays and Dusts - Sigatoka Control

Name	Composition	Proportions Used	Spreaders, Stickers, if any	Manufacturer	Material Cost	Lab.	Field	Length Trial	Cycle	Spreading	Sticking	Advantages	Disadvantages	Control	Comments
Bayer Copper Concentrate	Modified Copper Oxychloride Metallic copper 49.89	2.5#-100 gals.	Sticker present	I.G. Farbenindustrie A.G.	$1.06 per acre application	N.Y.	9/37 Guaruma III 6/39 Guaruma II	2 yrs. 3 mos. 7 mos.	Biweekly 21 day and monthly	Good	Good	Easy to prepare. Keeps well. Alkaline. pH of 7.4 Material is very fine	Residue not as pronounced as Bordeaux Some leaf burning during the wet season	Very fair	Light blue residue on the leaves. The only objection raised is the fact that the weaker concentrations of Bordeaux are cheaper and just as effective. During the rainy season cycles must be shortened.
Copper Fungicide "26"	50% Basic Copper Sulphate and 50% $CaSO_4$. Metallic copper 26%	3#-100 gals.	-	Tennessee Copper Co.	$.44 per acre application	-	7/6/38 Guaruma III 6/39 Guaruma II	18 mos. 7 mos.	"	Good	Good	Easy to prepare. Cheap	None	None	Light bluish residue more like Bordeaux than any of the other copper sprays. Good control during the dry season but during this past wet season showed poor control. An increase in the concentration might be more effective.
Copper Oxychloride	Oxychloride of copper. Metallic copper 52.15%	6#-200 gals.	Recent Shipment contains Grasselli SS-3 incorporated in it.	DuPont de Nemours & Co.	$1.35 per acre application	N.Y.	9/37 Guaruma III 6/39 Guaruma II	2 yrs. 3 mos. 7 mos.	Biweekly and 21 day	Fair	Fair	Easy to prepare	Residue on the leaves not as pronounced as Bordeaux	Fair	Light Bluish residue on the leaves. This fungicide is quite similar to Bayer Concentrate. The weaker concentrations of Bordeaux are cheaper and more effective. Infection increases during the wet season in areas with rapid growth.
Copper Zeolite	Aluminum Silicate Salt of Copper Metallic copper 25%	3#-100 gals.	-	Nichols Copper Co.	$1.66 per acre application	N.Y.	4/37 Guaruma I and III	2 yrs.	Biweekly and Monthly	Poor	Poor	Easy to prepare	Inconspicuous residue Too costly	Does not control Sigatoka	Very fine bluish powder. The least effective of all copper sprays tested.
Bordeaux Mixture	Copper Sulphate and Chemical Hydrated Lime Metallic copper 25.6%	5-5-50	-	Locally made. Materials from open market	$1.15 per acre application	N.Y.	2/36 Guaruma III and II	3 yrs. 10 mos. 7 mos.	Biweekly 21 day and monthly	Very good	Very good	Conspicuous residue on leaves increasing ease of supervision	Difficult to prepare Deterioration on standing Fruit discoloration objectionable	Excellent	Excellent fungicide. As yet our most effective spray even in weaker concentrations. Easily seen on leaves making spray supervision a simple task. Residue removed with weak acids.
Bordeaux Mixture		3-3-50	-	Locally made. Materials from open market	$.69 per acre application		2/36 Guaruma III	3 yrs.	Biweekly 21 day and monthly	Good	Good	Cheap. Conspicuous residue	-	Good	This concentration is used chiefly during the dry months. Also used during the rainy season in non-virulent Sigatoka areas.

Name (Sprays)	Composition	Proportions Used	Spreaders, Stickers, if any.	Manufacturer	Material Cost	Lab.	Field	Length Trial	Cycle	Qualities: Spreading	Qualities: Sticking	Advantages	Disadvantages	Control	Comments
Basic Copper Sulphate	$CuSO_4 \cdot 2\,Cu(OH)_2 \cdot 2\,H_2O$. Metallic copper 51%	5# - 100 gals.	-	Sherwin Williams Co.	$1.37	N. Y.	7/36 Guarnus II and III 9/38	3 yrs. 7 mos.	Biweekly and 21 days	Fair	Fair	Easy to prepare	Is more expensive than Bordeaux	Fair	Light bluish residue on the leaves similar to Meyer and Copper Oxychloride. Not very effective where there is virulence of infection.
Tri-Basic Copper Sulfate	Basic copper sulfate. Metallic copper 53%.	2# - 100 gals.	No	Tennessee Copper Co.	$.698 per acre application		7/14/39	6 mos.	14 day	Fair	Fair	Cheap		Poor	A cheap but sparsely xxeffective fungicide during the rainy season. Increasing the concentration might show to some advantage.
Semesan	Organic Mercury compound	1# - 50 gals.	-	Dupont de Nemours & Co.	$2.25 per lb.	Yale 1936	Farm 19 Guarnus I Section 31 11/22/35	2 mos.	10-14 Day	Poor	Poor	-	Poisonous. Too costly. Leaf burning	None	Inferior to Bordeaux Mixture and not as cheap and convenient to use in the field. Small amount of residue on the leaves.
Shirlan	Sodium Salicylanilide	2 oz. per gal.	-	Dupont de Nemours & Co.	Not quoted	Yale 1936	"	"	"	Poor	Poor	-	Ditto	"	Ditto
Funtrogen	Copper and nickel	1 - 60	-	Rose Manufacturing Co.	$6.00 per gal.	Yale 1/9/36		2 das.	-	Poor	Poor	None	Too costly	Non-effective	The high cost of these products and their lack of outstanding fungicidel xvlue has obviated further field tests with them. Efficiency of spray or dust can only be determined when tests are conducted from plant material sprayed or dusted under field conditions. Tested in laboratory by Dr. Reinking in 1936.
Sulfocide	Sodium polysulfides and thiosulphates	1 - 200	-		$1.50 per gal.	Yale 1/9/36		2 das.	-	Poor	Poor	None	Too costly	Effective	
Copper Solution	Proprietary	1 - 80	-		$4.60 per gal.	Yale 1/9/36		2 das.	-	Poor	Poor	None	Too costly	Partially effective	
Fungine	Sulfur Compound	1 - 40	-		$3.00 per gal.	Yale 1/9/36		2 das.	-	Poor	Poor	None	Too costly	Non-effective	
Dowicide "A"	Sodium Orthophenyl phenate	1#-25.	-	Dow Chemical Company	$.50 per lb.	Yale				Poor	Poor	None	-	None	Too expensive
Blood Albumin Wettable Sulfur	90% Superfine Dusting sulphur 7% wetting and spreading agent 3% Blood Albumin	10# - 100 gals.	Contains wetting and spreading agent	Stauffer Chemical Co.	$1.31 per acre application	-	8/37	9 mos.	weekly	Fair	Fair	None	Like lime sulfur residue. Cannot be removed from fruit	None	During rainy season, it is non-effective in disease control.

Name (Sprays)	Composition	Proportions Used	Spreaders Stickers, if any	Manufacturer	Material Cost	Tested Lab.	Tested Field	Length Trial	Cycle
Potassium permanganate with Bordeaux 2-2-50	Oxidizing agent plus Bordeaux 2-2-50	12 oz. Pot. Perman. to 100 gals. of spray	No.	Carus Chemical Co.	$.807 per acre application		10/24/39 Guayama III		Biweekly
Ammoniacal Copper Carbonate	$CuCO_3$ and Ammonia Metallic copper 55%	5 oz. $CuCO_3$ 3 pts. NH_4 (26°B) 50 gals.	-	Nichols Copper Co.	$1.28 per acre application	-	9/37	2 yrs. and 3 mos.	Biweekly and 21 day
Cuprocide "54"	Red Oxide of copper Metallic copper 49.6%	4#-100 gals. and 2#- 100 gals.	-	Rohm & Haas Co.	$2.26 and $1.63 per acre application		1/20/38	13 mos. 3 mos.	Biweekly
Yellow Cuprocide	Red oxide of copper Metallic copper 51%	2# - 100 gals.	-	Rohm & Haas Co.	$1.60 per acre application		5/8/39	8 mos.	Biweekly and 21 day.
Cuprocide 54-I	Red oxide of copper Metallic copper 51%	3# - 100 gals.	Yes	Rohm & Haas Co.	$2.40 per acre application		7/14/39	5 mos.	21 day
Perenox	A cuprous oxide 50% copper	2.25# - 100 gals.	Yes (goulac)	Imperial Chemical Industries	$1.056 per acre application		8/29/39	9 mos.	Biweekly
Copper Hydro "40"	Neutral copper hydroxide	4# - 100 gals.	-	Chipman Chemical Co.	$.74 per acre application	-	1936	3 mos.	Biweekly

Qualities Spreading	Qualities Sticking	Advantages	Disadvantages	Control	Comments
Good	Good	Potassium Permanganate is supposed to increase the toxicity of Bordeaux Mixture.	The potassium permanganate changes the color of the Bordeaux to a wine color which is not easily seen on the leaves	?	Five applications have been made to date. Insufficient time has elapsed for any conclusive evidence of increased effectiveness in Sigatoka control.
Poor	Poor	None	Harmful effects to labor from ammonia. Very little residue on leaves. Difficult to prepare	Fair	Less effective as a fungicide than Bordeaux.
Poor	Poor	Easy to prepare	Settling rate is very fast. Too costly. Not easily seen on the foliage	The stronger concentration gives only poor control. Doubtful if weaker conc. will be effective	The stronger concentration costs $0.26 for material per acre application as compared to $1.23 for Bordeaux 5-5-50. Burning has been noticed using the stronger concentration.
Poor	Good		Expensive, difficult to mix, and settles quickly necessitating constant agitation	Fair to good	Has given good control on a biweekly and 21 day cycle through the wet season. More expensive than Bordeaux 5-5-50 and difficult to mix or get into suspension. Poor spreading qualities.
Poor	Fair	Easy to mix	Expensive. Settles quickly necessitating constant agitation. Leaf burning during rainy season.	Fair to good	Has given good control on a 21 day cycle. Is double the Price of B 5-5-50. Poor spreading qualities. Has possibilities - cost being important factor.
Poor	Fair	Forms a good suspension. Does not settle very fast. Cheap.	Some leaf burning during the wet seasons.	Fair to good	Has given to date fair to good control on a biweekly and 21 day cycle throughout the year. Not as expensive as Bordeaux. Poor spreading qualities.
Poor	Poor	Easy to prepare and cheap		Ineffective	Light bluish residue necessitating removal by weak acids.

Name (Sprays)	Composition	Proportions Used	Spreaders, Stickers, if any.	Manufacturer	Material Cost	Lab.	Field	Length Trial	-12- Cycle
Lime Sulphur 1-20 " " 1-40	Unslacked lime and Flowers or Ground Sulphur made up to lime sulphur concentration of 32° Be	1-20 1-40	-	Home-made	$.94 .47 per acre application	-	2/36	3 yrs. and 10 mos.	Biweekly and Monthly
Flotation Sulphur Cream	By-product of coke manufacture. Finely divided sulphur in suspension	10# - 100 gals.		Camden Coke Co.	$.89 per acre application	-	7/36	3 yrs.	Biweekly
Sulforon	A colloidal wettable sulfur	6# - 100 gals.	No	Dupont Chemical Co.	$.84 per acre application		6/12/39 to 11/6/39	6 mos.	21 day and 14 day
Magnetic Wettable Sulphur	Sulfur and a wetting agent	10#-100 gals.	-	Stauffer Chemical Co.	$.73 per acre application	-	9/36	9 mos.	Biweekly
Burgundy Mixture	Copper Sulphate and Sodium Carbonate	5-5-50	-	Home-made	$1.84 per acre application	-	6/36	1 Mo. Guarumo II	Biweekly
Anhydrous Copper Sulphate (Calispray)	Anhydrous copper sulfate and lime	1# - 3 gals.	-	Los Angeles Chemical Co.	$7.99 per acre application	-	1/36	1 mo.	Biweekly
R. T. 50	Colloidal phenolic fungicide	1-400 parts and 1-600 parts		Merck Chemical Co.	$12.00 per gal.	-	11/15/35 Los Indios Farm 18	6 mos.	7-day Biweekly

Qualities Spreading	Qualities Sticking	Advantages	Disadvantages	Control	Comments
Fair	Good	Inexpensive	Residue on fruit insoluble in weak acids	Lime sulfur 1-20 partiaddy effective Lime sulfur 1-40 Ineffective	Lime sulfur 1-20 gives fair control during dry season but this spray is ineffective during rainy season in virulent areas on a biweekly cycle.
Fair	Fair	Inexpensive. Easy to mix.	Non-removal of residue from the fruit	No	It gives satisfactory results on a biweekly cycle during the dry period of the year but control not effective during the rainy season. This fungicide has been eliminated from our plots.
Fair	Poor	Cheap	Residue easily washed off by rains	No	Definitely ineffective in controlling Cercospora Leaf spot. Greatest weakness is lack of adhesion.
Fair	Poor	Inexpensive	Non-removal of residue	No	Like all sulphur compounds, the residue on fruit cannot be removed.
Fair	Poor	Slightly less residue	Whitish residue	No	Residue easily removed by weak hydrochloric acid. Weak fungicide.
Fair	Poor	None	Not as effective as Bordeaux	No	Similar in composition to commercial Bordeaux
Very Good	Poor	None	Colorless - no residue on leaves	No	Production of this spray has been discontinued.

Name (Dusts)	Composition	Proportions Used	Spreaders, Stickers, if any	Manufacturer	Material Cost	Tested Lab.	Tested Field	Length Trial	Cycle	Qualities Spreading	Qualities Sticking	Advantages	Disadvantages	Control	Comments
Copper Hydro "40" Dust	28% copper hydro 72% bentonite	75# per acre	-	Chipman Chemical Co.	$3.10 per 100#	-	Farm 19 1936	4 mos.	Biweekly	Poor	Poor	None	Too expensive	Ineffective	Copper Lime dust cheaper and more effective
Copodust	Copper-lime dust	75# per acre	-	Niagara Sprayer and Chemical Co.	$6.90 per acre application	-	Farm 19 1936	4 mos.	Biweekly	Good	Fair	None	Too expensive	Ineffective	Freshly prepared copper lime dust cheaper and more effective
Copper Resinate Dust	Copper and resin Metallic copper 9.5%	75# per acre	Resin as sticker	Wood Chemical Products Company	$10.60 per acre application	-	Guaruma III 2/38	10 mos.	Biweekly	Poor	Poor	Soluble in Acetone Used for mildew proofing of fabrics	Highly insoluble in water. Very Expensive	No	Anhydrous precipitate - chemical combination of copper sulphate and abietic acid as exists in rosin and rosin oil. Fluffy powder-light green color-sticky feel.
Micronized Copper Lime Dust	Copper Lime dust 20-80%	75# per acre	-	Micronizer Processing Co. Inc. N.J.	$2.58 per acre application	-	Guaruma III 11/37	1 yr.	Biweekly	Fair	Fair	None	Tendency to flocculate and form small balls on the leaves, giving an uneven coverage. Too costly.	No	Two kinds of micronized dust were tested. (1) Copper and lime micronized seperately, then mixed. (2) Copper and lime mixed and micronized together. Not as effective as ordinary copper lime dust. The former was easiest to handle.
Copper Lime Dust	Copper 20% Lime 80%	75# per acre	-	Home-made Sherwin Williams Co.	$1.17 per acre application $3.55	-	Guaruma III 2/36	3 yrs. and 10 mos.	Biweekly	Fair	Fair	For small plots cheaper than Bordeaux	Must be applied early in the morning while dew is on the leaves. Subject to washing off during rainy season.	Fair in small areas. Not as efficient as Bordeaux in large areas	Airplane dusting discontinued in favor of spray. Weather conditions play an important part in dusting operations. Good control during dry season but poor during the wet seasons. Ineffective on a monthly cycle.
Kolodust	Bentonite and sulfur	75# per acre	Bentonite as sticker	Niagara Sprayer and Chemical Co.	$6.87 per acre application	-	Farm 19 1936	3 mos.	Biweekly	Fair	Poor	None	Too costly	No	Washes off to a large extent even during light rains.
Sulfur Dust	Superfine sulfur	75# per acre	-	Stauffer Chemical Co.	$2.25 per acre application	-	Guaruma III 2/36	3 yrs. and 10 mos.	Biweekly	Fair	Fair	Easily applied	Residue on fruit insoluble in weak acids. More expensive than Bordeaux	Fair to good	Has given best control of any of the dusts used. Residue on fruit cannot be removed. Ineffective on a monthly cycle.
Potassium Permanganate plus Sulfur Dust	Oxidizing agent and sulfur	1#-100#	-	Carus Chemical Co.	$2.375		Guaruma III 11/19/39		1 day	Fair	Fair	Increases toxicity	Increases cost of dust	?	Found effective when used with sulfur dust as a control for C. sacchari and H. ocellium on sugar cane. Possibility of increasing effectiveness of sulfur and Bordeaux in controlling Sigatoka
Calispray Dust	Anhydrous copper sulphate	75# per acre	-	Los Chemical Co.	$6.92 per acre application		Guar. III Farm 19 1/35	6 mos.	Biweekly	Fair	Poor	None	It is poisonous and causes sickness if inhaled	No	Very inefficient dust for Cercospora control

Stickers and Spreaders - Sigatoka and Thrips Control

Name	Composition	Manufacturer	Material Cost	Tested Lab.	Tested Field	Length of Trial	Concentrations Used	Qualities Spreading	Qualities Sticking	Advantages	Disadvantages	Comments
Sugar				N.Y.	With Bordeaux 1937	6 Mos.	4 oz. to 50 gal. or 1/2-1/4% - 100	Fair	Poor	None	Does not increase spreading and sticking qualities of Bordeaux	It is difficult to distinguish leaves sprayed with and without this material either immediately after or two weeks following spraying. Stained fruit, when used with Tartar Emetic as a spray for thrip control.
Molasses					With Bordeaux 1936	2 Mos.	2 qts. per 100 gals.	Fair	Poor	None	Ditto	Like sugar, there is no discernible difference
Powdered Skim Milk		Dairyman's League	$.06 to $.10 per lb.		With Bordeaux 1937	6 Mos.	1/2% per 100 gals.	Poor	Poor	None	"	Added to Bordeaux as a tension breaker. It failed to exert any appreciable spreading qualities or did not increase the suspensary qualities of the spray solution.
Fish oil soaps	Sodium and potash fish oil soaps	Interstate Chemical Manufacturing Co.	$.566 per gal.	N.Y.	With Bordeaux 1937	4 Mos.	1# per 100 gal.(Fung.) 4# " " " (Insect.)	Fair	Poor	None	"	Spreading increased but no beneficial sticking qualities detected when used with Bordeaux. Used in insecticidal sprays. Chiefly as an emulsifier in oil sprays.
Palustrex	Pine oil base	Southern Pine Chemical Co.	$1.14 per gal.	N.Y.	Sept. '36	1 Mo.	1/2 gal. to 100 gal.	Fair	Fair	None	"	Used with Bordeaux as penetrant
Penetrol	Sulphonated petroleum hydrocarbon	Kay-Fries Chemical Co.	$.99 per gal.	N.Y.	Feb. '39	1 Mo.	.846 pts.-500 gal.(F.) 1 pt.-100 gals. (I.)	Good	Fair	Gives slightly more even film over the leaf surface	Does not increase sticking Qualities of Bordeaux. Too costly.	Its added cost does not warrant its use with Bordeaux used with Tartar Emetic as a spray for thrips control.
Aresket - 240	Sulfated phenyl compound	Rubber Service Laboratory		N.Y.	Sept. '36		1 - 400 parts	Poor	Poor	None	Ditto	Used with Bordeaux as penetrant and spreader. No increased efficiency detected
Grasselli SS-3		DuFont de Nemours & Co.	$4.11 per gal.	N.Y.	April '38	6 Mos.	3-6 oz. per 100 gal. .625 pts.to 200 gal.	Fair	Fair	Breaks down surface tension of spray to some degree	"	Breaks down surface tension of Bordeaux somewhat giving a slightly more even distribution over the leaf. The added efficiency of this spreader is not enough to warrant continued use because of the added expense.
Sandovit		Fabriqus de Products Chemiques - Suisse	Not quoted sample		La Lima Feb. '39	1 Mo.	1.85 pts. to 200 gal.	Fair	Fair	Seems to increase the spreading qualities of Bordeaux	No comments	Breaks down surface tension of spray, giving a more even distribution over the leaf surface but in no way increases the sticking qualities of Bordeaux Mixture
Lethane Spreader		Rohm & Haas Company	$1.80 per gal.		July 18, '39	1 Mo.	1% by weight of Cupreocide present	No increased spreading or sticking qualit		None	Did not increase wetting qualities	An experiment was conducted (using 10% by weight based on amount of Cupreocide present with some success. It takes some twenty minutes to wet yellow Cupreocide employing 10% Lethane spreader and even then all of the fine particles do not go into suspension. Rohm & Haas' recommendation to use 1% by weight of Cupreocide does not increase wetting qualities.

Name	Composition	Manufacturer	Material Cost	Tested Lab.	Tested Field	Length of Trial	Concentration Used	Qualities Spreading	Qualities Sticking	Advantages	Disadvantages	Comments
R 1956 emulsifier used with Celel		Rohm & Hass Company	$.45 per lb.		9/9-12/20 with Cuprocides	3½ Mos.	10% Conc. used at conc. of ¼% in finished spray	Fair	Fair	None	Does not improve settling qualities of the Cuprocides	This emulsifier is made up using 10gals. R1956 to 90 gals. Celel and used at a concentration of ¼% in the finished yellow Cuprocide and Cuprocide 56-Y spray. There is a slight increase in spreading qualities but does not improve the sticking or settling properties.
Agral	Contains goulac	Chemical Industries Co.			12/27		2 oz. per 100 gal.					Agral is at present under test in the field. At this early date we cannot predict the results.
Moytol	Water soluble oil sticker and spreader	Standard Chemical Products Inc.	$1.147 per gal.		11/21/39		½ pts. and 1 pt. to 200 gals.	Good	No added sticking qualities	More uniform. Deposit free of spots or blotches	Added cost	When used with Bordeaux there is no noticeable increase in sticking qualities but there seemed to be a more uniform coverage free of spots. It was also found that 1 pint per 100 gals. was just as effective as the stronger concentration.
Dexed Dispersing Agents		Dewey and Almy Chemical Co., Mass.	Sample, no price		7/18/38		5% and 25%	Did not increase spreading and sticking qualities of Bordeaux 5-5-50				Used as a dispersing agent in Bordeaux. Concentration percentages figured on the dry weight of the Bordeaux Mixture to be dispersed. Found an improvement of 1.1% to 3.6% in favor of Bordeaux 5-5-50 and Dexed. There is so little improvement, it appears that the use of this material with Bordeaux on a large scale would not be justifiable.
Kayso (Calcium Caseinate)	Casein 20% Hydrated Lime 80%				With Bordeaux 1939	1 Mo.	1% per 100 gals.	Poor	Poor	None	No better than Bordeaux alone	The object is to improve sticking qualities of Bordeaux especially during the rainy season. There is the possibility that Kayso lessens the toxicity of the fungicide without improving its sticking qualities. No desirable results.

From field observations using various stickers and spreaders with Bordeaux, we have found in some cases added coverage on the new leaves and in other cases there is no noticeable difference. The possibilities of spreaders and stickers rests on their ability to increase adherence of Bordeaux to the three top youngest leaves of the plant. Because of the excellent control Bordeaux has given thus far in Sigatoka control without the use of spreaders and stickers, it is assumed that complete coverage of the very new leaves is not necessary; and, therefore, does not warrant the added cost of a spreader or sticker. If they are to pay for themselves, this must be done through lengthening of spray cycles, at least during the dry seasons.

5. Thrips or Red Rust Control

Red Rust, the discoloration of the skin of the banana fruit caused by a species of thrips - (Scirtothrips signipennis) has increased in this Division during the last three years to such an extent as to render a large amount of the fruit harvested during the rainy season unmarketable. On young stems of fruit, the first trace of thrips damage shows up as areas with a water soaked appearance, slightly reddish brown in color. This is followed by a gradual darker discoloration until finally the red color of the typical rust appears. The color change is apparently due partly to the reaction of the fruit to continued feeding by this insect and partly to advancing maturity. In addition to this red discoloration, cracking of the epidermis may occur in severe cases, later becoming deeper and ultimately resulting in the splitting of the skin in the more mature or full fruit.

From continued inspection of red rust fruit, the butt-end hands of the emerging stem are the first to become infested with the thrips, and are normally the most severely affected. Frequently there is a decrease in intensity from the butt-end to bud end of the stem. Rust injury is usually most prevalent between the fingers on the first and second hands of the butt-end. In severe cases injury appears also on the backs and outside of the fingers.

On the fruit, thrips are found primarily at, or near, the points of contact between fingers. During the rainy season on overcast days, they can be seen crawling around on the outside of the fruit. This insect is found on fruit in larval and adult stages throughout the year in Honduras. Though there is no cessation of reproduction during the rainy season, there is a decline in infestation. It is claimed that its life cycle is completed in from 29 to 36 days and that maximum duration of the whole life cycle is about three months. The greatest development of rust takes place during the early stages of the

life of the fruit, the injury being accentuated by the growth and expansion which takes place during development or maturity of the stem. Thus the more mature the fruit harvested, the greater the severity of red rust. Thrips population appear to reach its peak during the months of July, August, and September. Thus the incidence of red rust on fruit harvested during the months of October, November, December, and January.

Shade might be a factor affecting the population in some areas. A point of interest here is the fact that large areas cut down in 1937 for Sigatoka control, e.g. Guanchia farms, show much less Red Rust infection as compared to those areas left standing.

Experiments were started in July for the control of thrips causing Red Rust injury. Various insecticides and protective devices have been tested out most of which are still in the experimental stage.

Insecticides

1. Nicotine sulfate spray (with and without soap)
2. Volck oil Emulsion spray
3. Calol Spray oil (Spray)
4. Sulferon "
5. Lethane '440' "
6. Loro "
7. Tartar Emetic "
8. Cube Root "
9. Naphthalene (Soil Treatment)
10. Paradichlorobenzene
11. Roto dust
12. Nicotine dust

Protective devices

1. Bagging
2. Banding with Oakum
3. " " Creosoted Burlap

There was a steady increase in severity of red rust infection recorded from August through to November, with a marked decrease during the month of December. The results obtained from the various insecticidal sprays and dusts tested out are discouraging in most cases.

Reviewing the percentage of red rust severity in the plots, there is no evidence of control using oil emulsions, Lethane, Naphthalene, Paradichlorobenzene, and Rote and Nicotine dusts. Those showing promise and recommended for continued trial are Nicotine sulfate, Loro, and Tartar Emetic.

In early October, banding of the pseudo-stem of each plant was started in two four acre plots, one was banded using Oakum and the other using burlap painted with creosote.

Fruit bagging was also commenced during the first week in October. The results to date are very promising. From observations recorded to date, bagging should be started the first week in July and continued through October. Bags should be applied when the fruit is two weeks old or as soon as the first two stem-end hands begin to curve upwards. Banding was started later and as yet has shown no evidence of control.

Percentage of Severe Red Rust in Insecticidal Plots (July - December 1939)

Plot #	July	Aug.	Sept.	Oct.	Nov.	Dec.
1. Check				1.9	20.7	16.4
2. Nicotine Sulfate and Soap 1#-4#-100 gals. - 4 acres. Spray biweekly Ten applications	-	-	.9	.9	4.8	2.5
3. Fruit bagging - started Oct. 6 Formerly nicotine sulfate and soap 1#-4#-100 gals. biweekly cycle - 7 applications. Bags removed when fruit is English grade.	.2	.7	-	4.0	-	
4. Fruit bagging started Oct. 5. Formerly Nicotine sulfate and Soap 1#-4#-100 gals. Monthly cycle - 7 applications. Bags removed when fruit is American grade				1.7	20.3	8.1

Plot #		July	Aug.	Sept.	Oct.	Nov.	Dec.
5.	Nicotine Sulfate and Soap 1#-4#-100 gals. Spray monthly and naphthalene 4 oz. per plant (soil treatment) monthly cycle. Five applications each	-	-	.8	8.2	8.4	1.8
6.	Volck oil spray (2-100 gals.) yielding 1-2/5% actual oil dilution. Biweekly cycle. Ten applications	-	18.0	2.5	16.1	30.9	18.6
7.	Check	-	1.2	-	1.9	7.1	-
8.	Ockum (banding) Formerly Volck oil spray, biweekly. 7 applications	3.0	2.7	2.5	16.2	22.1	5.6
9.	Burlap-creosote (banding) Formerly "Sulforon" Spray, biweekly. 7 applications.	-	-	-	4.9	3.5	4.3
10.	Lethane "440" (1-300 gals. Biweekly spray - 10 applications	-	-	-	-	1.6	6.8
11.	Loro (1 pt.-100 gals.) Biweekly spray 10 applications	-	-	-	4.4	3.6	2.6
12.	Tarter Emetic and Brown Sugar 4#-16#-100 gals. Spray biweekly 7 applications. Panetrol 1 pt.-100 gals. substituted for brown sugar - 3 applications	-	-	-	-	-	-
13.	Check	-	-	-	3.5	15.0	10.3
14.	Naphthalene - 4 oz. per plant (soil) 10 applications biweekly	-	1.1	1.5	3.8	26.2	19.2
15.	Naphthalene - 4 oz. per plant (soil) monthly - 5 applications	-	-	.7	2.0	21.9	19.7
16.	Paradichlorobenzene - 1 oz. per plant biweekly, 10 applications (soil)	-	-	2.2	-	22.4	11.9
17.	Paradichlorobenzene - 1 oz. per plant (soil) monthly - 5 applications	-	3.6	1.4	-	25.5	7.6
18.	Check	1.0	-	1.8	3.8	30.1	12.6
19.	Check	-	-	-	2.6	18.9	14.3
20.	Check	-	2.1	-	20.0	25.9	6.4

Plot #		July	Aug.	Sept.	Oct.	Nov.	Dec.
21.	Calol Spray Oil and Blood Albumen 2 gals. - 4 oz. - 100 gals. Biweekly - 10 applications	3.0	7.4	4.4	11.3	24.8	31.4
22.	Calol Spray oil and Blood Albumen 2 gals. - 4 oz. - 100 gals. Biweekly - Sprayed fruit only. 7 applications	2.0	4.4	10.2	11.0	20.3	16.4
23.	Cubé root 4#-100 gals. and Blood albumen 4 oz. - 100 gals. Spray Biweekly - 10 applications	8.0	2.0	3.3	8.5	18.0	19.4
24.	Rote Dust 15# per acre Biweekly - 10 applications	6.0	3.7	1.1	5.1	18.1	2.6
25.	Nicotine Dust 15# per acre Biweekly - 10 applications	-	4.0	1.9	3.0	21.3	2.7
26.	Check	-	1.9	-	1.9	23.2	-
27.	Nicotine Sulfate 2#-100 gals Sprey, biweekly - 10 applications	-	.1	-	-	4.1	-

Severe red rust injury refers to the general red discoloration over the fruit, disfiguring it so much as to render it unsaleable. Fruit showing severe injury is either rejected on the farm or at the port of embarkation.

The following is a detailed report of all insecticides tested for thrip control.

Insecticides - Sprays and Dusts

Thrips Control

Sprays	Manufacturer	Composition	Proportions Used	Material Cost	Field Test	Applications	Cycle	Emulsifiers Spreaders and Stickers	Control	Comments
Nicotine Sulphate	Tobacco By-Products and Chemical Corp.	Tobacco extract 40% nicotine sulphate	1#-100 gals. water 2#-100 Gals.	$.748 per acre Applic.	6/27/39	10	14 da. 28	Soap 4#-100 gals.	Fair	Results warrent further trials
Volck's Oil Spray	Calif. Spray Chem. Co.	83% highly refined mineral oil and emulsifier.	2 gals.-100 gals. water	$1.26 per acre applic.	6/28/39	10	14 da.	-	None	30.9% infestion red rust recorded in Nov.
Sulforon	Dupont Company	Colloidal wettable sulfur.	6#-100 gals.	$.84 per acre applic.	6/28/39	7	14 da.	-	None	Easily washed off by rains
Lethane "440"	Rohm & Haas Co.	Aliphatic thiocyanate	1-200 gals.	$2.275 per acre applic.	6/28/39	10	14 da.		Fair	This spray is similar to Lore but more expensive
Carbon Bisulphide	E. I. Dupont Co.		Stock Emulsion (7 gals. CS_2,-.6 Soap - 40# Naphthalene-2.4 gals H_2O) dilute 1-200 2 qts. per plant			Upon diluting for application as a spray the emulsion broke down leaving the naphthalene crystals deposited in strainers, pipes, and pump. It is only a matter of a few minutes before the pump is completely clogged. As a result, this spray was abandoned.				
Naphthalene	E. I. Dupont Co.	Coal tar derivative	4 oz. per plant	$2.61 per acre applic.	6/7/39	10 5	14 da. 28 "		None	Seven applic. to soil of 4-8 -12 ozs. per plant were made. That is a max. of 5#/ was added to one plant without it showing any detrimental or chloretic effects

Names	Manufacturer	Composition	Proportions Used	Material Cost	Field Test	Applications	Cycle	Emulsifiers Spreaders and Stickers	Control	Comments
Paradichlorobenzene	Dow Chemical Co.	Coal Tar derivative plus chlorine	1 oz. per plant	$2.10 per acre applic.	6/7/39	10 5	14 da. 28 "		No	7 applications to soil of 2-4-8 oz. per plant were made. Max. of 32# was added to one plant without it showing any detrimental or chlorotic effects.
Tartar Emetic	Rohm & Haas	Potassium Antimonyl Tartrate	4#-100 gals.	$1.32 per acre applic.	7/7/39	10	14 da.	Penetrol 1 pt.-100 gal.	Fair. This insecticide gave the best control though not completely effective	Brown sugar (16#-100 gals. left a dirty brown residue on the fruit which would not wash off, thus Penetrol was substituted.
Cubé Root	Chipman Chemical Co.	Rotenone active agent	4#-100 gals.	$.085 per acre applic.	6/20/39	10	14 da.	Blood Albumen 4 oz.-100 gal.	No control	Though highly recommended for thrips control, this insecticide did not produce satisfactory results.
Roto Dust	Sherwin Williams Co.	.75% Rotenone	15# per acre	$1.05 per acre appli.	7/17/39 to 12/31/39	10	14 da.	-	No control	Besides giving little or no control. Dusts are not practical for our purposes. Residue not easily washed off the fruit.
Nicotine Dust	Sherwin Williams Co.		15# per acre	$ 1.50 per acre appli.	7/16/39 to 12/31/39	10	14 da.	-	Ditto	Ditto
Cabol Spray Oil	Standard Oil Co.		2-100 gals.	$1.39 per acre appli.	8/30/39 to 12/31/39	10 7	14 da. " "	Blood Albumen 4 oz.-100 gals. Penetrol 1 pt-100 gals.	No control	In December 31.4% Red Rust infection recorded

Sprays	Manufacturer	Composition	Proportions Used	Material Cost	Field Test	Applications	Cycle	Emulsifiers Spreaders and Stickers	Control	Comments
Lorc	Dupont Company	Aliphatic thiocyanate	1 pt. - 100 gals.	$.67 per acre applic.	6/29/39 to 12/31/39	10	14 da.		Fair	Results warrent further trial.
Oakum	Wall Rope Works N. Y. City	Fibrous material containing creosote		$9.60 per acre.a[illegible]	10/11/39	Each plant banded			Banding was started too late to arrive at any definite conclusions at this time.	
Creosote-Burlap	Wood Preserving Co., Charleston, S.C.	Burlap painted with creosote		$2.40 per acre applic.						
Bagging	Arkell Safety Bag Co. N.Y.C.	Waxed paper		(26 x 57-.025 (26 x 26.5-.0125	Oct. 6					Bagging was started too late in the present experiments to definitely state its effectiveness as a control measure for red rust. Results to date indicate that (1) bagging should be started around the first week in July; (2) fruit should be bagged approximately two weeks after shooting or as soon as the fingers begin to curve upwards. Experiments are under way to test the feasibility of protecting the top four or five hands nearest the butt-end with paper bags (26"x30"). Also the possibility of removing all bags at English grade without any discernible increase in Red Rust. Cloth bags are not practical. The laborers steal them for sundry purposes. Results of previous tests during 1936-1937 indicate marked control but red rust injury at that time was not severe
	Locally made	Cloth		26 x 57 -.245 26 x 36 -.129	Oct. 17					

Percent of Severe Red Rust Injury on Various Observation Plots - February - December 1939

Farm and Section		Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Guaruma III	4-24	-	-	-	-	-	.3	.3	.9	1.1	2.8	2.5
" "	23	-	2.8	-	-	-	-	.9	.7	.0	.0	5.4
" "	21	-	8.9	-	-	-	4.1	16.1	14.5	12.2	24.1	22.9
" "	29	5.9	4.9	-	-	.2	4.1	21.7	9.6	15.2	34.1	17.6
Guaruma II	19	-	.5	-	-	-	-	.8	-	6.4	5.9	16.9
" "	50-51	-	-	-	-	-	-	1.6	2.3	4.1	9.3	14.3
Tacamiche	35	2.6	-	-	-	-	-	-	-	-	-	-
San Juan Sulfur Dust	63		-	-	-	-	6.7	40.3	15.1	45.3	37.2	25.3
San Juan 5-5-50	63		-	-	-	-	1.8	13.2	9.9	11.9	11.0	19.3
La Lima Sulfur Dust	4			-	-	-	-	3.2	8.3	-	20.0	16.7
La Lima 5-5-50	4			-	-	-	-	-	-	-	-	-
San Juan	64						1.3	1.1	.4	1.7	1.1	4.8
Los Indios	18	2.5	2.1	.4	.3	.7	1.9	13.5	16.7	10.3	25.0	26.0
Farm 12	56	2.0	.7	.5	-	.9	-	3.3	20.4	39.1	34.9	27.7

5. Banana Scale

The banana scale, Aspidiotus destructor, has become increasingly prevalent in this division during the past three years. Since it was first noticed shortly after the introduction of Bordeaux spraying, it is believed the natural enemies, insect or fungus, are being killed by this practice. Such a condition was brought about in Florida citrus groves a few years ago after the prolonged use of Bordeaux. It was found necessary there to use oil sprays to counteract the increase in scale infestation.

Heavy infestation of scale causes pronounced yellowing of the leaves while the margins turn yellow and then black. Such severely attacked leaves show the entire surface covered with the closely packed yellowish scale insects. These leaves drop down and cease functioning prematurely and the ultimate effect on the plant is much the same as with Sigatoka. On growing plants usually the four youngest leaves are free but all other leaves infested, in an area severely attacked. Severest infestation appears to occur in July, August and September.

Fruit infested with scale has a decidedly unattractive color, both green and ripe. Fortunately the scale attacks the fruit only when present on the leaves in extremely severe infestation. The infested fruit shows mottled yellowish areas over its surface which on ripening present a pale whitish appearance against the normal yellow background.

Scale infestation has apparently made slowest progress in small areas not sprayed at all. It has been more severe in areas sprayed with lime sulfur or dusted with sulfur than in areas controlled with Bordeaux or other cuprous fungicides. At present there are some 100 acres of severe infestation in the Cortes Division.

Control work up to date indicates that oil emulsion sprays are

effective against scale infestation. Various emulsions have been tested and though effective in scale control the oil injures the fruit both when used alone or in combination with Bordeaux Mixture.

It is probable that bagging would be a necessity to protect the fruit should wholesale spraying for scale become effective. From information gained up to the present time, it appears that three sprayings on a biweekly cycle will give control for several months.

The most efficient spray to date from the standpoint of cost and control appears to be Bordeaux 2-2-50 to which is added an oil emulsion spray made up of 3% Diesel oil, 4 pounds Fish Oil Soap, and 100 gallons of water. The Bordeaux Mixture definitely increases the sticking and spreading qualities of the spray.

The following oil sprays and combinations with Bordeaux have been field tested. Cost of each per 100 gallons of spray is given.

1. Bordeaux 2-2-50 plus 2½% Diesel oil - 100 gals. water $.343 per 100 gals of spray
2. 2% Calol Spray plus 4# Fish oil soap - " " " 1.66 ditto
3. "% Diesel oil plus 4# Fish oil soap - " " " .2472 "
4. Bordeaux 2-2-50 plus 3% Diesel oil plus 4# soap 100 gals. water .4994 "
5. 2% Velck emulsion - 100 gals. water 1.26 "
6. Diesel oil stock emulsion - N.Y. Laboratory
   Tela diesel 44-23 gals.
   Red oil - 4-30 gals.
   Triethanolamine 1.45 gals. - 50 gals. water.

   4.5 gals. stock emulsion - 100 gals. water gives 2% Diesel oil spray Cost per 100 gals. .339
7. Kerosene stock emulsion - N. Y. Laboratory
   Kerosene 47.6 gals.
   Red oil 4.23 gals.
   Triethanolamine 1.36 gals.
   Water 46.81 gals.

4.5 stock emulsion - 100 gals. water gives 2% Kerosene spray Cost per 100 gals. .409

8. 3% Diesel oil plus 3 pints B 1956 plus 4# fish oil soap - 100 gals water .4795

6. Panama Disease

The spread of Panama Disease has become more and more pronounced during the past three years in both Tela and Cortes Farms. Abandonments for 1939 amounted to 1958 acres and this figure will doubtless be exceeded in 1940.

One of the outstanding features of its spread of late has been the fact that heavy clay areas, formerly considered most resistant, in many cases show more rapid spread than lighter river bank soils. Certain areas that have had a few cases for many years with but slight increase are now becoming honeycombed with abandonments.

Diesel Oil Treatment - Treatment of diseased mats in most of the cultivations with diesel oil has been carefully carried out up to the end of the year. From now on it is doubtful if such treatment is justified with the exception of the cleanest sections in old farms, all new plantings, and in seed beds. Where infection has become severe the mats are simply cut down and piled over the stumps. Cost of this process is $.02 per mat as against $.05 for oil treatment.

Panama Disease Surveys - Extensive surveys of Panama Disease have been made of all areas used as seed beds, all old plantations in proposed rehabilitation projects, and in several old company farms. The surveys in this division have been carried out by Mr. Lungwitz.

A survey of Panama Disease in Alsatia Farm, Guatemala, was carried out by Mr. Bowman in April.

Following is a list of all areas surveyed for Panama Disease by this department during 1939.

1.	Campin	900 acres
2.	Seed bed area along the river in Kele Kele and Monacalito	100 "
3.	La Fragua	1078 "
4.	Mezapa	400 "
5.	Areas in Tela Farm	125 "

6.	Palomas and La Fragua Seed beds	100 acres
7.	Melcher Bolsa	160 "
8.	Villanueva and La Venta tracts	1800 "
9.	San Juan Farm	1206 "
10.	Oro property	250 "
11.	Palomas	500 "
12.	Las Margaritas	175 "
	Total for Honduras	6796 "
Guatemala		
1.	Alsacia Farm	900 "
	Total for Honduras and Guatemala	7696 acres

Seed Disinfection - All seed used for planting in this division has been treated with formalin for disinfection purposes. The heads were first washed with water under pressure, then dipped in tanks filled with disinfecting solution, and then cut up into bits. At first 5% formaldehyde(12.5% commercial formalin) with 10 minute immersion was used. In dry soils, this was found to retard germination definitely and to cause rotting of the seed. Under moister conditions such injury was much reduced. Tests with various strengths of formaldehyde from .5 to 5 percent were subsequently run with different periods of immersion from 1 to 10 minutes. Under the very dry soil conditions prevailing at that time, it was concluded that a 1 percent solution of formaldehyde (2.5 percent commercial formalin) with five or ten minutes immersion could be used safely.

Disinfection and Replanting of Panama Diseased Spots - There has been considerable discussion in the past concerning the feasibility of treating sites of diseased mats in resistant soils with formaldehyde, copper sulfate, or other disinfectants and later supplying with healthy seed. In view of conflicting data in this connection the following tests were started in March of this year.

In San Juan Farm nine sections were selected, three on light soil,

three on clay loam, and three on heavy clay. In each of these a close disease survey was made and then all infected mats were cut down, killed out with Diesel oil, and the remaining stumps treated with copper sulphate crystals. One fourth pound of crystals per mat was placed on top of the stumps in the hope that the solution would penetrate and kill some of the fungus in roots and rhizomes. Following this, 500 gallons of 1% formaldehyde were applied around each diseased mat in one light, one medium, and one heavy section. The area treated was about 18 feet square for each mat. Three similar sections were treated with 500 gallons of 5-5-50 Bordeaux per mat. The three remaining sections received no fungicide. About one month later supplies were planted in all nine sections, about 3 feet away from the site of each diseased mat. The methods used and results to date may be summarized as follows:

Method

1. Mats first killed out with Diesel oil.
2. Application of copper sulphate crystals to diseased stump- 1/4# per mat.
3. March 3 and 4. Application of 500 gallons of 1% formaldehyde per mat. Cost $4.97 (Sections 64, 52, and 61.)
4. March 16. Application of 500 gallons of Bordeaux 5-5-50 per mat. Cost $2.46 (Sections 59, 60, and 63.)
5. April. Supplies planted three feet away from treated diseased stump.

Results

Formaldehyde

Section	Soil	No. Mats	No. Diseased Mats			Remarks
			Oct. 20	Nov. 22	Dec. 28	
64	Light	19	-	2	3	Rest strong
52	Medium	32	8	11	14	One stunted. One has shot fruit. Rest strong.
61	Heavy	4	-	1	2	Rest strong

Bordeaux treatment

Section	Soil	No. Mats	No. Diseased Mats			Remarks
			Oct. 20	Nov. 22	Dec. 23	
59	Light	28	-	-	1	Six plants stunted and three did not germinate
60	Medium	7	-	1	2	Rest streng
63	Heavy	19	-	-	-	Five plants stunted. Rest streng.
Check						
58	Light	13	-	-	1	One plant did not germinate. Three stunted and one damaged.
4	Medium	5	-	-	-	One plant stunted. Rest streng.
62	Heavy	5	-	-	-	Four plants stunted, one streng.
		132	8	15	23	

Flood Fallowing Experiment - In view of the extensive areas of banana land in this division once highly productive but now rendered unavailable on account of Panama Disease, an experiment to reclaim such land by flood fallowing was commenced this year. The Panama Disease fungus (Fusarium cubense) is an organism requiring oxygen to live and is chiefly limited to the upper three inches of surface soil. Tests made in the New York Laboratory showed that when thoroughly infected soil was submerged under two feet of water for 28 days no Fusarium cubense could be found in it.

A block of 90 acres of good banana soil in Naranjo Chino Farm which had previously been put out of production by Panama Disease was selected, an enclosing levee built and the area divided into four separate lakes by cross levees. The flooding of this area was postponed for some time in order to allow for settling of the dirt levees and to prevent undue seepage and washouts

Dragline work on the levees commenced October 2 and was concluded December 11. It is proposed to keep one of the four lakes submerged for 18 months, one for 12 months, one for 6 months, and one for 3 months. The 18 month and 3 month lakes were filled Jan. 2, 1940. It is proposed to fill the 12 month and 6 month lakes later so that the 18, 12, and 6 month tests may be drained and replanted at the same time. Due to raising of water table in adjacent areas, while any one lake is filled, difficulty might otherwise be encountered in securing proper drainage.

Total cost of empoldering the 90 acre block including the clearing and levelling of land, changing drains etc. has amounted to roughly $5185.17 or $57.62 per acre. On the first filling, 92 hours of pump operation were required and pump is now being operated 6 hours daily to maintain proper level. As the levee becomes settled and seepage dimishes this is expected to be less.

III. SOIL INVESTIGATIONS

During the past year soil work has included detailed field surveying and mapping of some 14,630 acres of land in Honduras and 4000 acres in Guatemala. This has consisted largely of company owned areas proposed for planting and privately owned lands being investigated for rehabilitation. A total of 396 mechanical analyses of samples taken from the above areas as well as 451 pH determinations have been made in connection with the surveys. In addition, thorough laboratory studies are being made of chemical soil changes taking place in the flooding experiment, especially as concerns the oxidation-reduction status.

A list of all soil surveys made by members of this department during 1939 is given below. With exception of the Costa Rica reconnaissance survey in which Mr. van Diepen assisted, all surveys were carried out by Mr. Lungwitz.

Detailed Soil Surveys - 1939 - Honduras	Acres
1. Woodland area back of Naranjo Chino and Las Flores farms to the Nana Chumbe canal	1200
2. La Fragua Bolsa woodland	400
3. Yojoa Bolsa woodland	300
4. Woodland between 38 Spur and Tela Jct. along R.R. and to the Martinez canal	430
5. Area between Martinez and Palemas-Tela canal	75
6. Woodland and abandoned areas along Melcher line	275
7. Melcher Bolsa	300
8. Woodland in Indiana Farm	50
9. Monacalito Farm	900
10. Santa Rosa Bolsa woodland	1100
11. Area between Travesia and San Manuel-Terreno Ulua	1000
12. Area between Guaruma III and the National R.R.	600
13. Amapa tract	8000
Total - Honduras	14,630

Detailed Soil Surveys - 1939 - Guatemala	
1. Rio Tinto	1200
2. Ute Bolsa	800
3. Cmagua	2000
Total-Guatemala	4000
TOTAL DETAILED SOIL SURVEYS	18,630

Costa Rica - Reconnaissance Soil Survey	Acres
1. Area north of Rio Colorado and east of Rio Coto	12,266
TOTAL RECONNAISSANCE AND DETAILED SOIL SURVEYS	30,916

IV. FERTILIZERS

Complete Fertilizers - In April 1936 identical sets of fertilizer experiments were started at Tacamiche, Los Indios, and Farm 12 to determine effect of complete fertilizers on bananas in Chamelecon, lower and upper Ulua soils. Fruit weights have been taken continuously on all except in Los Indios where the plots were cut down for Sigatoka infection before spraying in 1937. The experiments have therefore been underway for over three and a half years. It is particularly interesting that for 1937 and 1938 no consistent improvement in fruit weights was found but that in 1939 a marked improvement in the complete fertilizer plots has been obtained.

The average fruit weights for each treatment, Urea, Urea and Potash, Urea and Phosphate, Urea plus potash plus phosphate, and check are given below. Urea was applied at the rate of 2.8 oz. thrice yearly, Phosphate and Potash at 8 oz. five times yearly.

In the Los Indios and Farm 12 experiments each treatment totals two acres. In Tacamiche each treatment totals 1.83 acres.

Comparative Fertilizer Tests - Fruit Weights 1936-1939

Tacamiche Farm
Chamelecon District

	1936	1937	1938	1939	Lbs. increase in 4 year period
Check	45.79	49.17	58.42	55.00	9.21
Urea	45.78	50.32	63.12	63.47	17.69
Potash	46.65	48.58	62.93	61.04	14.39
Phosphate	42.91	48.53	61.72	62.32	19.41
Urea and Potash	42.76	50.63	65.84	66.26	23.50
Urea and Phosphate	40.93	51.03	67.36	67.09	26.16
Urea, Potash, Phosphate	42.57	51.57	69.04	68.75	26.18

Los Indies Farm
Urmuce District

	1936	1937	1938 Aug.-Dec.	1939	Lbs. increase in 4 year period
Check	64.50	Bananas	*81.04	80.26	15.86
Urea	68.70	in Los	*83.87	87.15	18.46
Potash	65.30	Indies	*81.89	81.26	15.96
Phosphate	65.10	cut down	*80.18	78.64	13.54
Urea and Potash	63.90	because	*84.23	87.59	23.69
Urea and Phosphate	60.50	of Sigato-	*82.56	89.90	29.40
Urea, Potash and Phosphate	63.90	ka infec- tion.	*81.39	92.67	28.77

*Plantills type fruit from cut down area

Farm 12
Progreso District

	1937	1938	1939	Lbs. increase in 3 year period
Check	57.64	64.53	72.22	14.58
Urea	53.11	64.32	74.55	21.44
Potash	57.09	65.22	74.06	16.97
Phosphate	55.22	63.11	72.03	16.81
Urea and Potash	53.96	65.24	76.25	20.29
Urea and Phosphate	55.30	64.07	77.54	22.24
Urea, Potash, and Phosphate	58.75	64.15	76.69	17.94*

*Increase smaller in proportion because of high average weight in this plot in 1937.

The heaviest fruit in all cases is found in the Urea plus phosphate and the Urea plus potash plus phosphate plots. Phosphate alone gave lighter fruit than the check plot in Los Indies and Farm 12, while potash alone gave slightly higher weights. Urea plus either phosphate or potash gave higher weights than where Urea had been used alone.

Urea plus phosphate or plus phosphate and potash is producing fruit from 2 to 5.5 lbs. heavier than Urea alone.

The increased weight since 1937 in check plots must be chiefly ascribed to beneficial effect of spraying with Bordeaux and is in line with

increase in average weight of all fruit shipped from this division.

Urea - Bordeaux Mixture Experiment - The possibility of applying Urea along with Bordeaux in the spray systems was suggested by Dr. Morgan. The fertilizer is readily soluble and compatible with Bordeaux, producing no chemical reaction with either. An experiment testing this out on 4 acres in La Lima Farm was started in July using 12.5 lbs. Urea with 250 gallons Bordeaux in twelve monthly applications. Proper checks with no fertilizer and with Urea applied to the soil are provided. Definite results should be obtained by the end of 1940.

V. MISCELLANEOUS RESEARCH

Bordeaux Mixture - A series of experiments to determine the best method of preparing Bordeaux Mixture has been run in the laboratory. Using settling tests for evaluation of the various mixtures it was found the best Bordeaux is made by adding dilute copper sulfate to concentrated lime solution.

Other tests were run to determine the comparative effects of settling and of continued agitation for various periods on Bordeaux. It was found that for all short periods of time when spray pumps are shut down as during showers, lunch hour, break downs, etc., no harm was done by allowing the mixture in the tank to settle.

Bordeaux Toxicity Tests - In view of the extensive and continued applications of Bordeaux Mixture, tests were started in March 1938 to determine any future effect this might have on the soil. One plot on light soil and another on heavy soil were selected and the amount of Bordeaux which ordinarily would be applied to the area in a year was applied to the soil every two weeks. Thus in one year, the soil around the bananas has received as much or more Bordeaux Mixture as it would in 26 years of ordinary spraying. To date no toxic effect has been shown and fruit is normal.

Rubber Fruit Slings and Shoulder Pads - Various tests have been made by Mr. Bowman with sponge and soft gum rubber as substitutes for trash pads in pack saddles. Since locally made trash pads pick up mud and Bordeaux residue, and cannot be cleaned, a substitute of this sort, if effective and economical, would be desirable. Promising results have already been obtained and further materials are being tried out. The ideal material must combine texture that does not bruise or burn the fruit on contact and a high degree of durability.

VI. LANCETILLA EXPERIMENT STATION

The station has continued under the direction of Mr. J. B. Edwards. A good supply of nursery stock of the best grafted varieties of citrus, mangoes, avocados, etc. as well as of ornamental plants is maintained at all times. Shipments of young fruit trees to the Costa Rica and Guatemala Divisions and to various parts of Honduras have been made at frequent intervals. The total number of plants shipped out is as follows:

Citrus plants (grapefruit, oranges, limes, etc.)	602
Miscellaneous fruit trees (Mango, avocado, litchi, etc.)	206
Ornamental trees and shrubs	1,561
Total	2,369

Some 10,000 bamboo poles from the bamboo variety grove have been supplied to the Farms departments for propping banana plants.

Seed of the best varieties of timber bamboos have been supplied the farms as fast as available. These are being planted along river banks and in Panama Disease abandonments and later on should provide abundant and useful material for many purposes.