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ANNUAL REPORT

1968

UNITED FRUIT COMPANY

DIVISION OF TROPICAL RESEARCH

VINING C. DUNLAP LABORATORIES	HONDURAS
CHANGUINOLA RESEARCH STATION	PANAMA

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INTRODUCTORY SUMMARY

Sigatoka

Benlate, a new fungicide produced by DuPont, continues to look most promising for control of Sigatoka at dosages as low as 4 ozs. per acre. The compound actually blocks reproduction of the fungus.

The experiment in Changuinola has shown that oil alone can be used in alternate cycles with the maneb-oil-water emulsion system without detriment to production. This alternate cycling system has now been applied in all Divisions during the rainy season with considerable savings.

The system of measuring disease incidence on a farm scale developed in 1967 is now being tested in the various Divisions. Differences between areas are being found. However, before we can establish standards for level of control, it is necessary to know what disease levels are injurious to yield and quality. To answer this, we have a replicated trial in which disease incidence is being maintained at two levels with ground spray equipment. One level would be considered light to "clean" in commercial practice and the other medium to heavy. Quality and production measurements are being made.

Moko

Moko continues to give trouble especially in Honduras. The cost of control in that Division now exceeds the cost of Sigatoka control.

In December 1968, we received samples of banana rhizome from Farms 63 and 64 in Changuinola showing infection with the B strain of *Pseudomonas solanacearum*. This is the first report of Moko in the Bocas Division since October 1967, emphasizing the insidious persistence of the organism.

The continued high incidence of Moko in Honduras in comparison to other Divisions suggested that perhaps we are dealing with a new strain. Isolates from Farm 3, the most severely-infested farm, showed 2 of the B strain, 33 of the SFR strain, and 69 isolates of a strain whose colonies are morphologically distinct from the two former strains. This new strain has also been found in Higuerito, Santa Rosa, Las Flores, Naranjo Chino, and Copén but not in other farms. It is confined presently to the southern end of the Division and may have originated in Farm 3. It can be insect-transmitted. Field observations show that this new strain can cause internal widespread vascular discoloration of the rhizome without external above-ground symptoms for a considerable period of time, thus making it potentially very dangerous where machete pruning is done. With macana pruning, the vascular tissue is exposed so that cases should be detected early.

Beloran (Fungitex B-100) has been generally adopted for machete disinfection. Where soil-contaminated tools are used, as in macana pruning and seed digging, formaldehyde should still be used since Beloran is not effective against nematodes.

Experiments comparing machete pruning, macana pruning, and kerosene injection pruning are continuing. The average number of suckers produced per mother plant using the three methods is 5.0, 3.6, and 3.2, respectively. Cycles can, therefore, be considerably lengthened using the latter two methods. There have been no differences in fruit yield. Kerosene pruning appears somewhat cheaper than macana pruning and has less danger of Moko transmission. Macana pruning, on the other hand, offers the advantage of earlier detection of Moko cases but with the danger of nematode spread. A combination of the two methods will be tried: firstly, macana pruning for two or three cycles to detect Moko cases and reduce suckers; then, kerosene pruning as a cheap maintenance procedure.

Isolations have been made of virulent Moko bacteria from eleven different species of weeds in banana plantings. Many of these plants were symptomless, indicating a possible threat of spreading the pathogen when the cleaning operation is done by machete.

Fruit Spots

A combination of farm sanitation, weekly Dithane spray and prompt bagging has been successful in fruit spot control. During the year, fungicide coverage has been significantly improved but there has been a tendency to overspray resulting in unsightly residues on some boxed fruit.

The breakdown of the fungicidal activity of Dithane M-45 residues on the fruit 5 weeks after application continues to be the major problem since it permits infection during a few weeks prior to harvest, leading to "latent" spotting that shows up at outturn. This was successfully controlled by Dithane dusting under the bag in the Guatemala Division during an outbreak in July-August. However, dusting creates some problems that require correction and additional improvements must be made before it can be generally recommended. Better control of this late infection is expected now that Thylate is cleared for pre-harvest use on bananas. This fungicide gives equivalent control when fresh as Dithane and does not break down to the same extent during the period from application to harvest. Winter bagging also improves control but is not at present considered competitive in cost if used for fruit spot control only, and does not give adequate protection when inoculum is abundant and weather favorable for spotting.

Cross-inoculation experiments have shown that Pyricularia oryzae, which causes blast on rice, will not infect bananas and Pyricularia grisea, the fruit spot organism, will not affect rice.

Crown and Finger Rots

Further studies with chlorination have shown that whereas Fusarium, Gloeosporium, and most other rotting fungi are killed on short exposure, Botryodiplodia and Deightoniella can survive 2 ppm chlorine for at least 20 minutes. Chlorination will not, therefore, affect rots caused by the latter two organisms.

A most important factor in crown rotting is the method of dehanding. Where blunt knives or improper pressures are applied leading to damaged tissue cells, then crown rot incidence is greatly increased. A quick, clean cut with a thin curved sharp knife is the best method.

In June 1968 Thiabendazole was cleared for post-harvest use on bananas. It is being marketed as a 40% wettable powder formulation under the name "Mertect 340". The simultaneous application of Thiabendazole and alum in a spray just before packing appears to be an effective means of controlling both crown rot and latex stain. Benlate, a new fungicide, gives even better crown rot control than Thiabendazole but it is not yet cleared.

Insect Control

An artificial defoliation experiment to determine the effects of 0, 10, 20, 30, and 40% defoliation on fruit weight and quality was ended in November 1968 after 4 years. A total of 12,528 stems were harvested and examined from 70 plots in San Juan Farm, Honduras. There was a reduction in fruit weight at all defoliation levels with a significant reduction after 20% defoliation. Fruit from plants defoliated 40% required only 3.2 days more to reach grade than fruit from undefoliated plants. There was no premature ripening at any time from any defoliation level. When high winds passed through the defoliation plots, the greatest losses of plants were in plots with the least defoliation. The effect, for example, of removing 20% of the leaf area is to cut plant losses in half.

Bagworms continued to plague the southern Divisions in 1968. This defoliator presents the most vexing control problems because: 1) Each female lays over 5000 eggs; 2) When the caterpillars are more than half grown, they are difficult to kill with insecticides; 3) The caterpillars live within a bag made of silk and leaf pieces; each bag must be opened individually rather than merely counted in order to determine populations and natural or induced mortality; 4) The only effective insecticides are Thuricide (Ca. $12/acre) and ULV Toxaphene (danger of resistance build-up).

Fortunately, natural control agents such as parasitic wasps can reduce bagworm populations to below economic levels. This year's studies were aimed at developing an "integrated control system" where natural control is allowed to build up before resorting to insecticides.

The Almirante red rust thrips control program made a major breakthrough when two sprays of ULV Toxaphene applied at the rate of 29 fl. oz. each cycle completely eliminated this pest from VALERY plantilla in Changuinola. This insect has been the subject of more chemical control experiments than any other banana pest in the past few years. The mealybug, on the other hand, continues to defy attempts to eliminate it from fruit in the field. The chalcid wasp required control in Changuinola this year for the first time.

Crop Production

The time taken by ratoon VALERY plants in Honduras from peeping to shooting at different periods of the year was determined. Plants peeping in May to July take a longer period to shoot perhaps because flower initiation and bud development then takes place during days of cool temperatures and overcast skies (December to February).

The Production Timing experiment in the Guarumas lost 15-20 percent of the extra suckers in the various treatments due to blowdowns; nevertheless, sufficient data were collected to indicate that the optimum number of additional suckers that can be left per acre is about 200. One-hundred and sixty-five extra boxes per acre were obtained some fourteen months after selection of the extra suckers. To obtain maximum production in the Spring, selection should be made in the previous February-March.

The plant population experiment in Ceibita after 26 months continues to show a marked superior production on loam soils compared to the clays with optimal populations of 500 and 600 on the two soil types.

Fruit Protection

Ten different types of winter bag were tested during the 1967-68 winter season and as a result, a double-tissue bag was chosen which eliminated the need for the polyethylene bag with very considerable savings.

Herbicides

Karmex at the rate of $1\frac{1}{2}$ lbs. per acre has been shown to be the most efficient herbicide for control of broadleaf plants presently available. With reasonable care, no phytotoxicity results. It can be combined with the routine dalapon grass control program.

Water Requirements

Fertilizer and spacing experiments have been set up in Palmar and Changuinola and an intricate irrigation experiment in Mopala, Honduras to determine the optimal water regime for the VALERY banana. During the last quarter of 1967 and early

1968, a sharp decline in boxes per stem occurred in most farms in the Bocas Division. An analyses of all factors that might be involved in the decline suggested that sub-optimal drainage was a contributing factor. Root distribution in depth was correlated with water tables and root growth extended down to four feet where the water table did not on occasion rise above this level. In areas where drainage was sufficient to prevent high water tables, 25% or more of the root system was in the 2-4 foot zone. Yields were higher where root distribution down to four feet was greatest. As a result of the root studies, improved drainage was introduced with improvement in production and quality of fruit.

Fruit Scarring

An examination of the scars on fruit at various locations during the harvesting and packing operations showed that 64 percent of post-harvest scarring occurred at the mat at time of harvesting compared with 16 percent during clustering and selecting and 16 percent during packing. Negligible scarring occurred on the cableway.

Oxytrol Storage

VALERY bananas can be held in this system with Polypack with holes for 17 days at 5 percent oxygen level free from rots and molds.

Latex Stain Control

Extension of research on agents for latex control led to the discovery that an alum treatment at relatively low pH was effective in reducing amount and visibility of latex residues. The technique was developed to a practical commercial level within the year and treatment has become regular practice in all Divisions. Data Sheets covering application procedures to be followed at boxing stations were issued.

Half Mil Polyethylene Pack

This pack was introduced into commercial shipments to Europe in 1967 and the Spring of 1968 on both VALERY and Turbo Gros Michel fruit. It has been received with varying response, depending upon destination and prior experiences of customers there with slip-sheet or BANAVAC and the peculiarities of their particular market. It has proven successful in bearing out original claims made for it in that crown conditions stay fresher and scarring is less prominent and moisture loss is lower than slip-sheet packed fruit. In these areas it provides the benefits of BANAVAC. However, it cannot be expected to retard ripening to the extent of BANAVAC. Introductions into the U. S. have been less favorable largely because the trade has objected to the greater care that needs to be taken in temperature control during ripening and post-ripening holding than they are accustomed to with slip-sheet fruit.

Neck Injury

This blemish is of persistent occurrence, being reported at varying leve in QC reports on fruit from all Divisions. Further studies have been made to evaluate incidence, severity, location on clusters and the varied causes that have been suggested. A series of experimental shipments have shown that tran port and handling between Tropics and States are major causes for occurrence neck injury. Severity was observed related primarily to bottom row clusters which have shifted out of the flat down position to a tips up position. Clus ters which were in the latter position were noted to have the most severe inj ries to pedicels (necks).

Breeding - Bananas

During the year, 1563 bunches were pollinated, following a crossing seri designed to combine meiotic restitution, dwarfing, Moko resistance, nematode sistance and pitting disease resistance within each of the four important sub specific categories: banksii, malaccensis, microcarpa and sumatrana.

An additional accession of Musa acuminata siamea, II-317, was found to b resistant to Moko disease.

The Cocos-Lidi hybrid SH-22, producer of institutional market fruit, sho a steadily improving yield performance. In the second ratoon crop SH-22 has reached 89 percent of the yield of VALERY.

Oilseed Trials

During the year numerous trials were made throughout Central America to termine the optimum varieties, locations, and planting dates for annual oilse crops with particular attention to peanuts and soybeans. Some sunflower vari ties were also tested. The Pacific coastal zone of Nicaragua was found to be the most favorable location. The rainfall pattern may permit two planting da -- the "Primera" crop planted in early May utilizing only short-season (80-90 day) varieties which can be harvested during the short dry season in July-August and the more favorable "Postrera" crop planted in September with full season varieties for December harvest. Chemical weed control will be necessa and Eptam-Lorox and Eptam-Enide mixtures look promising. Numerous insect pes and diseases attack these crops and must be controlled.

We have not yet a suitable early soybean variety for the Primera crop. the Postrera crop we have varieties which out-yield Improved Pelican by a lar margin. CES-407 and (Biloxi x Hardee)-109 are the most promising with yields above 36 bushels per acre.

Florigiant was found to be the variety of peanut giving the highest yiel Yields of over 2 tons per acre were obtained. Argentine, Starr, and NC-2 als showed some promise. Valencia gave lower yields but because of its short-growing season is recommended for the Primera crop.

Diseases of Other Crops

During the year, preliminary investigation was made of the following: 1) Bunch rot of oil palm; 2) "Green stem and pod" of soybeans; 3) Soybean mosaic; 4) Bacterial pustule of soybeans; 5) Leaf spot of peanuts.

The list of diseases can be expected to increase with the expansion of our New Crop program.

Resistance to rice blast has been tested with numerous rice accessions. The variety "Dawn" has been shown to be resistant to blast and the variety "Nilo 3A" moderately resistant to the race of Pyricularia present in Honduras. This race has been characterized as Race 13 (U.S. definition) which is the equivalent of international blast race IB-3. Varieties "Washabo", "Apura", and "Holland" from Surinam and IR-8, IR-160, and IR-578 from Colombia were also resistant but only IR-160 was of the desired long-grain type of good milling quality like Dawn and Nilo 3A.

Rice cannot be grown on our banana soils having high levels of copper from Bordeaux spray.

Tropical Cut Flowers

A cut flower project for shipping fresh flowers to North America and Europe was started in 1968. Emphasis at present is on red gingers, heliconias, and anthuriums. An area of 25 acres in La Mesa Farm (Honduras) was selected convenient to water (river), railroad, highway, and airport. To date, 5 acres of red gingers and 6 acres of heliconias are planted. The heliconias are made up of H. latispatha (both yellow and yellow-red varieties), an Amazonian pendulent type, H. humilis, H. caribaea and others. Shade for one acre of anthuriums is being prepared.

Several trial shipments have been made and acceptance seems to be good. The best temperature for holding of red gingers and heliconias was found to be around 56° F. The use of 0.5 mil polyethylene bags improved storage. Some varieties of heliconias held much better than others. Red ginger could be kept in good condition for 18 days. Wax ginger does not store satisfactorily.

Oil Palm Agronomy

The NPK fertilizer experiment in San Alejo has responded to excellent weed control and yielded during the twelve-month period from October 1967 through September 1968 an average of 14,900 lbs. of fresh fruit bunches per acre, the highest production recorded up to now for palms 6-7 years old in Company plantings. However, even there, some 1.6 percent of the palms in the experimental plots have not produced any fruit bunches since recording started in July 1967. Non-productive palms and bunch rots of productive palms are factors of considerable importance to yield and causes are being studied.

Yields in the experimental areas in Quepos are much lower. The Barbural experiment (5-6 year-old palms) yielded 8,000 lbs. of fresh fruit bunches and the Llorona experiment (4-5 year-old palms) only 4,630 lbs. fresh fruit bunches per acre per year. Four percent of the palms were completely non-productive. Similar experiments have been started in Coto.

Foliar analyses have confirmed the overall deficiencies of Nitrogen and Potassium in Company plantings. Younger palms are quicker to respond to fertilization.

Oil Palm Breeding

During the year, 5,689 lbs. of selected Deli dura x Congo tenera improved oil palm seed was supplied to the San Alejo, Quepos and Coto production areas. Approximately one-fifth of the seed received pre-germination heat treatment. A larger heat treatment facility was finished during the year capable of treating all future seed.

Bunch quality evaluations of both Deli dura and Congo tenera palms previously selected for high production began during the year. In addition, progeny tests were planted in San Alejo, to further help in identifying elite parental palms.

The most pressing need in breeding material is that of superior pisifera palms. For this reason, tenera x tenera progenies are being grown out in Coto.

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SIGATOKA

Fungicide Screening - Benlate (DuPont 1991)

Studies were continued with DuPont fungicide 1991 which proved comparable or superior to Dithane M-45 in 1967 tests. During 1968 the chemical structure of 1991 was released: 1-(butylcarbamoyl)-2-benzimidazole carbamic acid, methyl ester. The wettable powder was given the trade name Benlate containing 50% of the active ingredient. Studies in the U.S.A. showed Benlate had therapeutic and systemic activity and blocked reproduction in the apple scab fungus when applied to young spots on leaves. Benlate was applied to yellow and advanced brown streaks of Sigatoka in the field at rates of 4 and 8 ozs. per acre with 3.5 ml. of surfactant F per 3 gals. of water. Production of sporodochia, spermagonia, and perithecia was reduced an average of 75% even when applied at the early stages of spot development. TBZ (60% Thiabendazole) also reduced fructifications when applied at the same rates but was not as effective as Benlate. Subsequent field studies have confirmed that Benlate is effective in blocking reproduction of _M. musicola_ when applied during the early stages of spot development. This is the first compound that is non-phytotoxic and capable of reducing ascospore and conidia production by _M. musicola_ by directly interfering with morphogenesis. The implications of this important discovery in the control program are now being studied.

The systemic activity of Benlate was studied by discharging ascospores onto the lower leaf surface and applying Benlate fungicide with surfactant F four, 8, and 12 days later to the upper leaf surface. There was no consistent reduction in spotting incidence or fructifications. This indicates that Benlate is not readily translocated into the banana leaf from the intact leaf surface and it does not hinder spot development once infection has taken place. Thus, Benlate cannot replace oil which is effective in inhibiting or slowing the rate of spot development when applied long after infection has taken place.

Benlate stored for 6 months in a closed polyethylene bag at shed temperatures from April onward showed a slight reduction in activity when compared with fresh material. Therefore, storage beyond 6 months under tropical conditions is likely to be deleterious. (STOVER)

Role of Oil in Controlling Sigatoka

Studies on the role of oil in controlling Sigatoka were completed in 1968. The results can be summarized as follows.

Oil spray reduced germination, germ tube growth and appressoria formation by spores of Mycosphaerella musicola under field conditions for periods varying from 2 days to 2 weeks. Inhibition occurred only when spores were on the same leaf surface to which oil was applied. Appressoria formation and germ tube growth were reduced up to 33 and 25%, respectively. Conidia and ascospore production and dissemination were not adversely affected by oil spray. However, there were fewer sporodochia and perithecia in spots that were slow to develop as a result of oil spray. Oil application up to 2 weeks before or after infection increased the incubation period and the generation time (time from infection to production of spores), and reduced the number of spots. Oil was effective in retarding spot development when applied either before streaks appeared or at the yellow streak stage of disease development. Oil, when applied during the incubation period or to yellow streaks, caused a variable amount of reduction in spotting and in only a minority of cases was disease development stopped completely. Therefore, leaf spot can build up on oil-sprayed plants when inoculum is abundant and weather favorable. The behaviour of the pathogen on oil-sprayed susceptible banana plants is similar to that on partially resistant varieties.

With respect to the control program, these studies indicate that reliance on streak counts for determining spray cycles offers no particular advantage over cycling at a predetermined number of days based on weather and spotting prevalence. Actually, oil is effective in suppressing disease when applied at any time following infection and this allows a great deal of flexibility in cycling. This important chemotherapeutic action of oil is the indispensable ingredient of a successful control program. However, since oil is not translocated from one position to another, good coverage is the other essential component of successful control. (STOVER, DICKSON)

Alternate Cycling of Maneb-Oil-Water Emulsion and Oil Alone

Of the 15 spray cycles applied in Guaruma 2 in 1968, 7 were oil. Only 2 cycles of spray were applied at intervals of less than 21 days. Spotting increased in August and 4 cycles of maneb plus oil were applied during August, September and October, followed by oil alone alternating with maneb-oil-water emulsion in November and December. No more than 3 cycles of oil alone were applied consecutively. (STOVER)

In May of 1967 the Research experiment in Farm 24, Bocas Division was changed to one cycle of oil alone followed by one cycle of maneb-oil-water emulsion. Results from October 1967 through September 1968 are shown in Table 1. There are no statistically significant differences between treatments. During this period there was a general falling off in yield in all plots due mostly to above normal rainfall along with poor drainage. Since drainage became more deficient and soil texture heavier in the direction of south to north across the experiment, fruit weights were compared by paired plots. The data in Figure 1 show the decline and partial recovery in yield.

Table 1

Effect of Applying Oil Every Second Cycle Versus Continuous Maneb-Oil-Water Emulsion Cycles on Fruit Weight and Number of Leaves

	Weight of Stems		No. Leaves at Shooting		No. Leaves at Harvest	
	Oil	Maneb Emulsion	Oil	Maneb Emulsion	Oil	Maneb Emulsion
October 1967	97.99	99.38	15.21	15.22	10.31	10.28
November	95.63	97.01	14.92	14.66	9.72	9.47
December	93.70	94.41	14.37	14.63	8.97	9.28
January 1968	85.22	83.62	14.24	14.57	8.07	8.43
February	79.34	75.41	13.93	14.27	7.98	8.51
March	77.72	78.21	13.23	13.34	7.93	8.09
April	81.42	80.49	13.26	13.47	8.13	8.45
May	83.26	89.10	13.22	13.53	8.11	8.47
June	88.47	90.02	13.49	13.33	8.44	8.23
July	79.43	83.64	13.69	13.75	8.72	8.91
August	88.64	88.18	14.30	14.44	9.22	9.41
September	89.85	88.78	14.31	14.22	9.18	9.06
October	85.02	83.72	14.69	14.64	9.60	9.54
Period Average	86.59	87.07	14.07	14.16	8.80	8.93
No. stems for period October 1967 to October 1968	3,261	3,000				

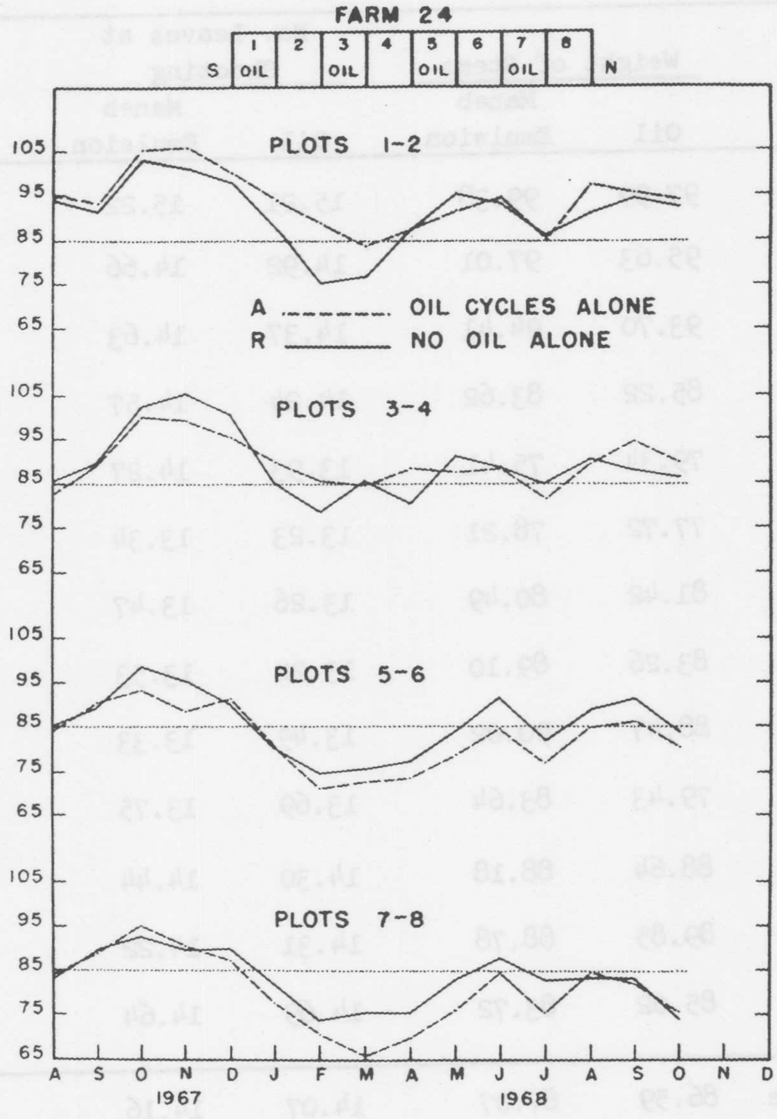


Figure 1

Decline and partial recovery in yield in Farm 24, Bocas, oil alone versus maneb-oil-water emulsion. Oil alone was applied every other cycle from May 1967. Note position effect from Plots 1-2 to 7-8, south to north. Plots 5-8 were more poorly-drained than Plots 1-4.

There was no significant difference in yield between plots sprayed with oil alone every other cycle and no oil alone. During the latter part of 1968, yellow mat and nematode losses increased in the northern half of the experiment. Data collecting was concluded in preparation for fallowing and rehabilitation. There is no evidence to indicate that alternate cycles of oil alone cannot be used under Bocas conditions at least during the most rainy months of the year.

The application of oil alone every third cycle continued throughout the year in most of the Bocas Division and during the rainy season in Golfito, Armuelles, Guatemala and Honduras. Some 260,000 cycle acres were sprayed with oil alone in 1968, resulting in a saving of more than 500,000 lbs. of UF-63, the most expensive ingredient of Sigatoka spray. Also, this system of cycling was introduced to Turbo late in the year. (STOVER, DONALDSON, STEPHENS)

Measuring Sigatoka Incidence

In 1967 control standards were tentatively established for further testing based on the new system of measuring spotting prevalence and intensity described in the 1967 Annual Report. These standards were: no more than 50% of leaves younger than 8 with spots and an average age of youngest leaf with spots between leaf numbers 8 and 9. Data were recorded on medium-sized unshot plants. There was no difficulty in maintaining these standards in Guaruma 2 with 15 cycles of spray per year in 1967 and 1968 with the exception of brief increases in spotting in excess of the standards between August and December each year (Figures 2-3).

A comparison of commercial standards between Farm 63, Bocas and San Juan, Honduras shows that percent of plants with spotting does not exceed 50 (Figure 4); average age of youngest leaf with spots fluctuates between 10 and 13 (Figures 5-6) and percentage of leaves younger than 8 rarely exceeds 6 (Figure 7). Spotting prevalence and intensity was greater in San Juan in 1967 than in 1968 as indicated by a greater percentage of leaves with spots (Figure 4), higher percentage of leaves younger than 8 with spots (Figure 7), and an average age of leaf with spots mostly between 11 and 10 in 1967 and between 12 and 11 in 1968 (Figures 5-6). Spotting was usually more prevalent in San Juan in both years than in Farm 63, Changuinola. These curves serve to compare standards of control among farms and divisions. The low level of disease in Farm 63, Bocas suggests that a further decline in number of cycles may be warranted. Cycles applied in Bocas have declined each year from 25.5 in 1962 to 19.5 in 1967, a remarkable 24% reduction.

Standards for Sigatoka Control

A practical method of measuring Sigatoka incidence has made the establishment of control standards feasible. This would prevent the application of

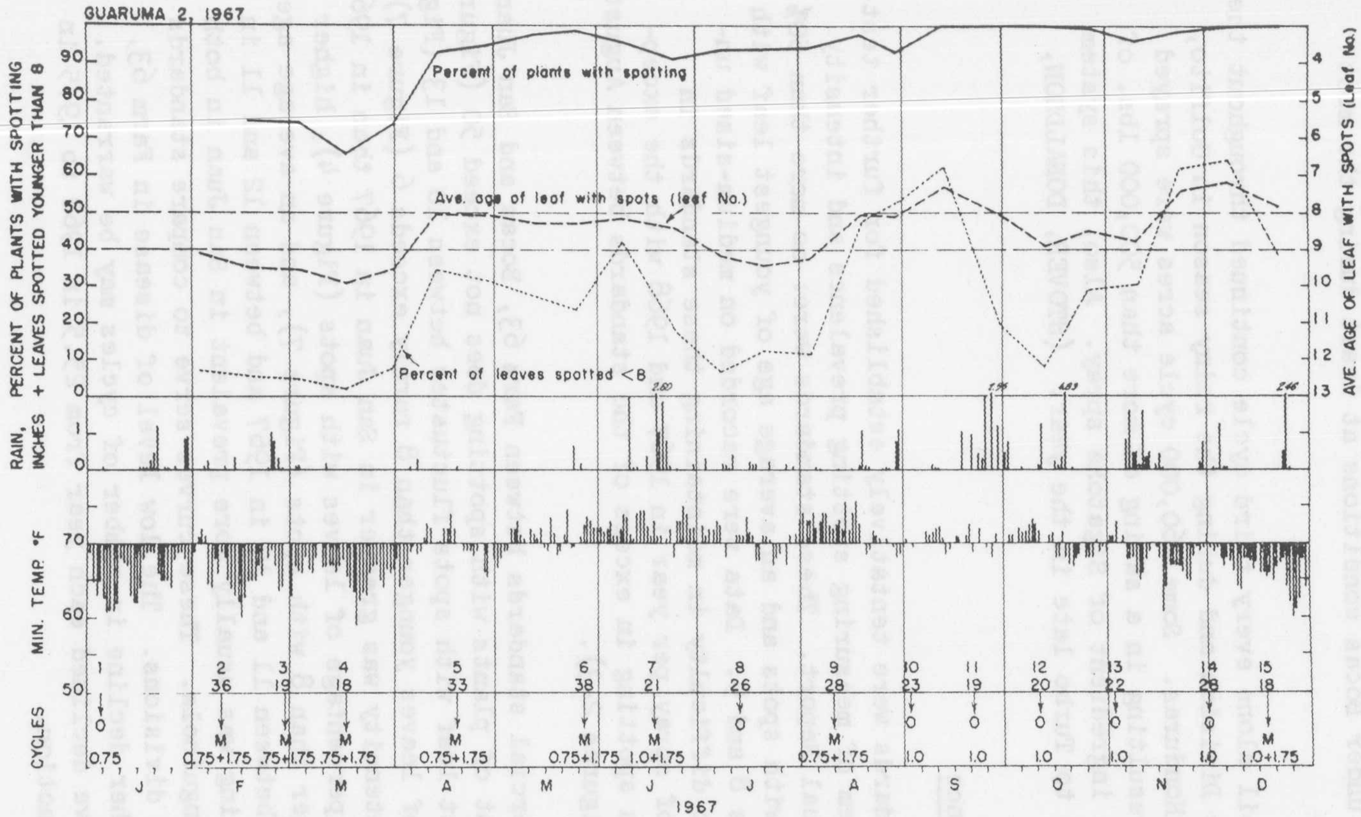


Figure 2

Sigatoka control standards in 1967 in Guaruma 2 in relation to weather and formulations applied. The dotted parallel lines mark the area in which it was desired to maintain average age of leaf with spots and percentage of leaves with spots younger than 8.

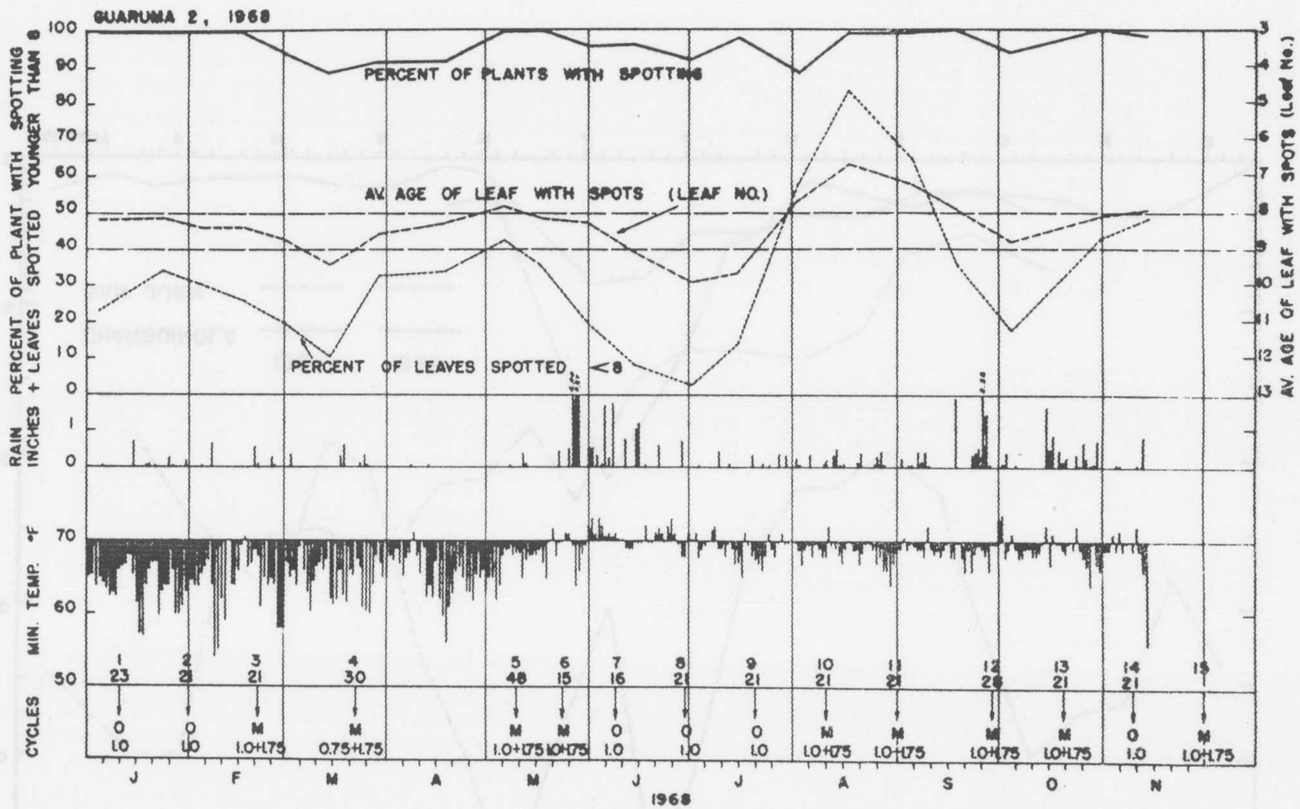


Figure 3

Sigatoka control standards in 1968 in Guaruma 2 in relation to weather and formulations applied. The dotted parallel lines mark the area in which it was desired to maintain average age of leaf with spots and percentage of leaves with spots younger than 8.

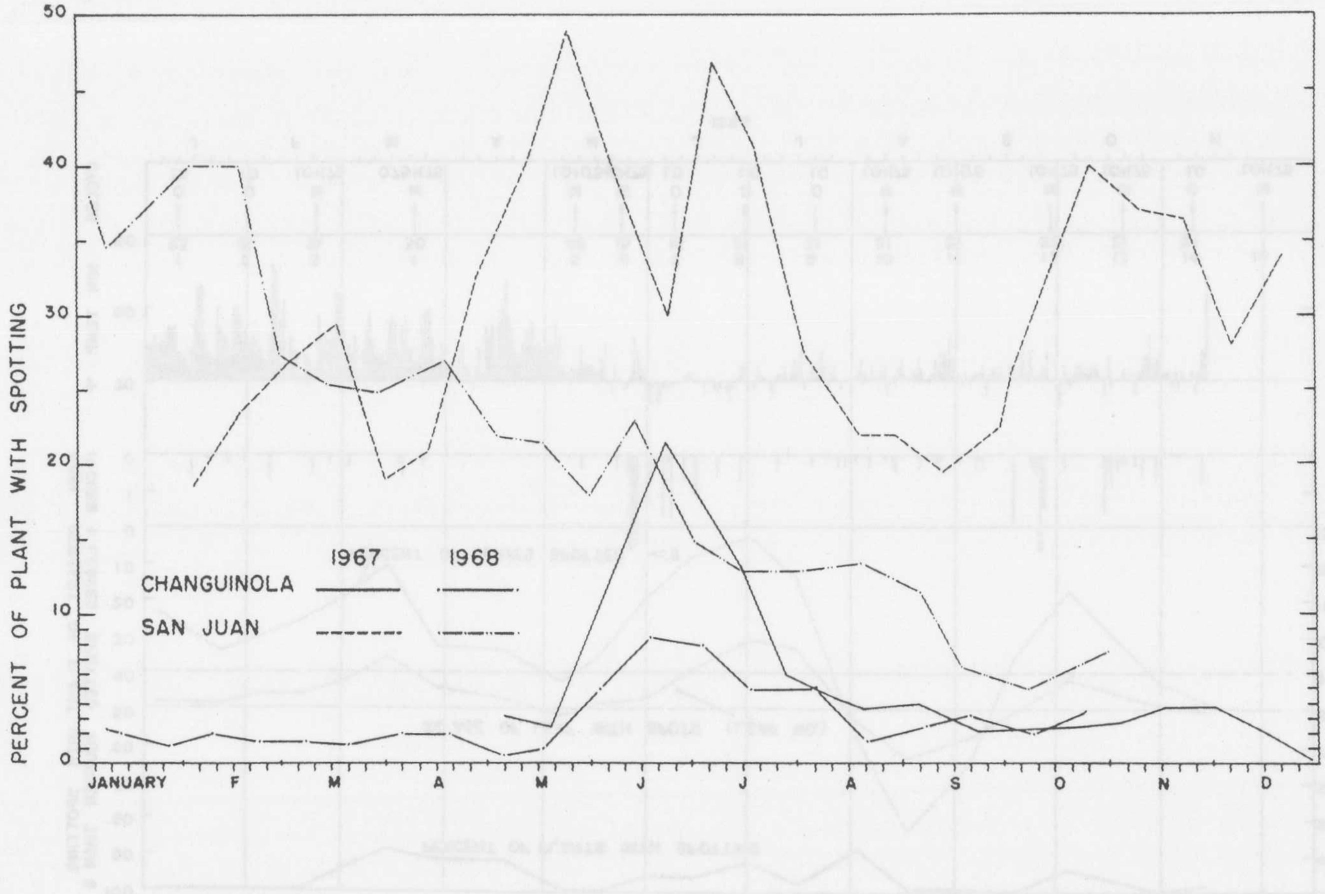
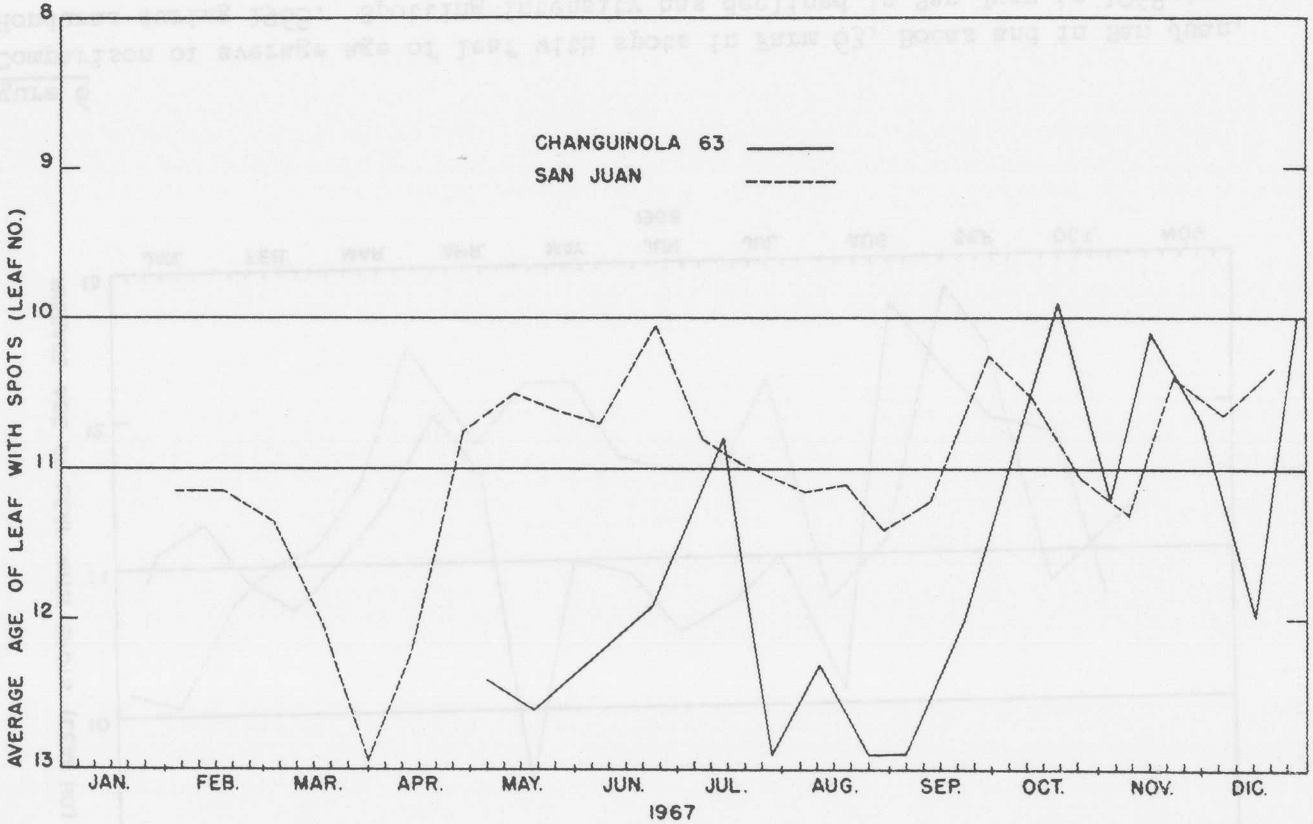


Figure 4
Comparison of percent of plants with spotting in Farm 63, Bocas and San Juan, Honduras in 1967 and 1968. Note greater prevalence of spotting in San Juan.



<u>Figure 5</u>

Comparison of average age of leaf with spots in Farm 63, Bocas and in San Juan, Honduras during 1967. The parallel lines mark the area in which the average age of leaf lies under commercial practice.

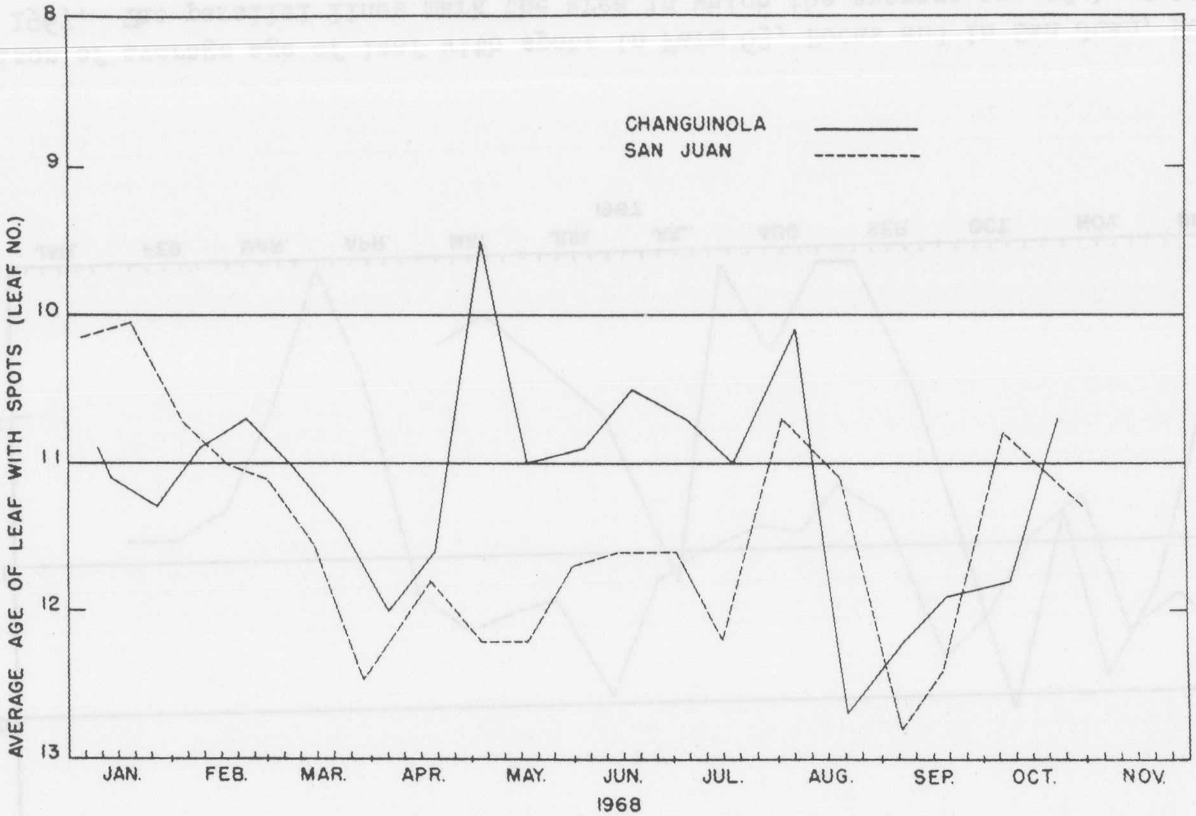


Figure 6

Comparison of average age of leaf with spots in Farm 63, Bocas and in San Juan, Honduras during 1968. Spotting intensity has declined in San Juan in 1968 in comparison with 1967.

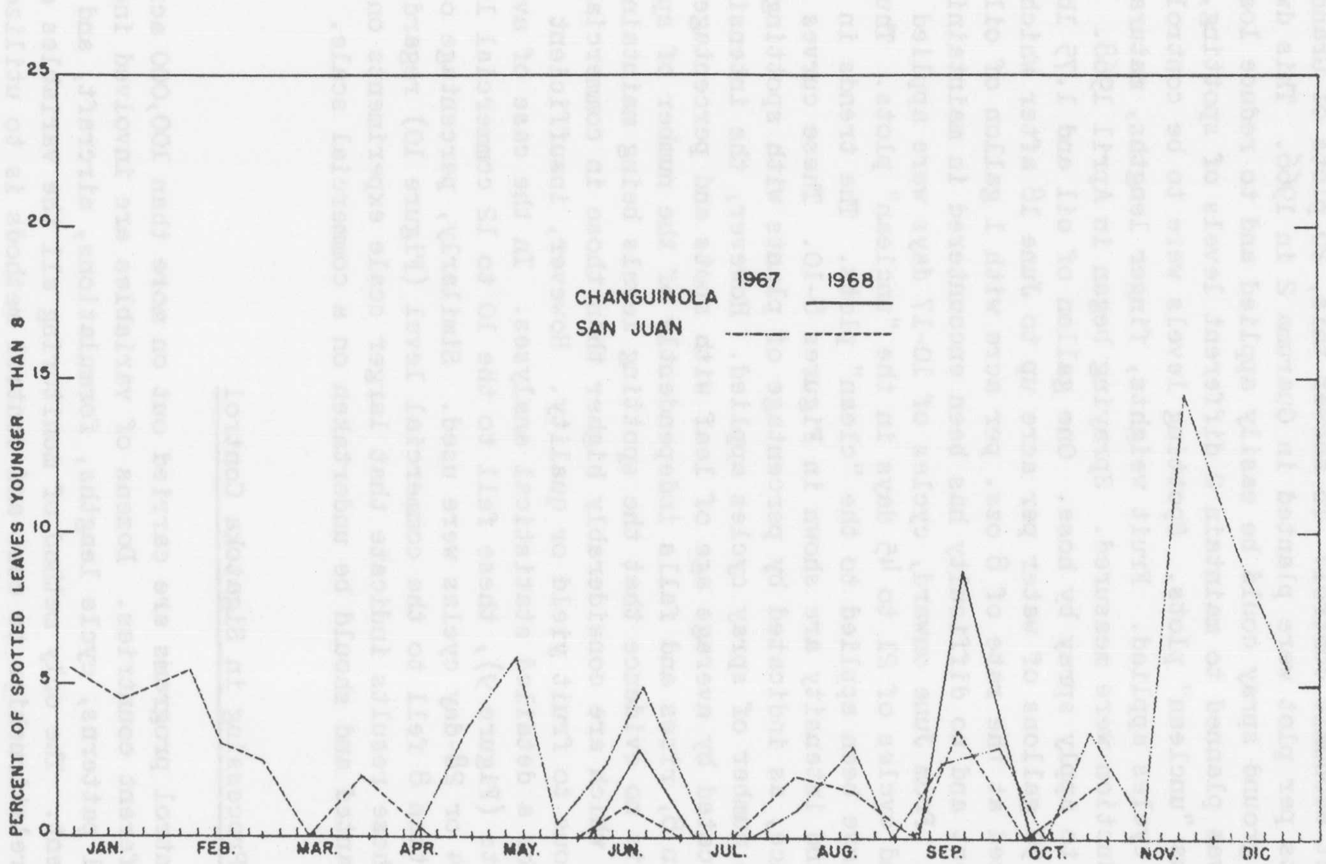


Figure 7
Comparison of percentage of leaves spotted younger than 8 in San Juan, Honduras and Farm 63, Bocas in 1967 and 1968. Sigatoka is more prevalent on younger leaves in San Juan.

unnecessary spray cycles when disease incidence is well within the limits established and would also indicate when cycles should be shortened. However, in order to establish control standards, it is necessary to know what disease levels are injurious to yield and quality. It is impossible to eliminate all spotting. Therefore, what is the level of spotting that is non-injurious and results in the most economic control? To answer this, 20 plots of Grand Nain containing 64 plants per plot were planted in Guaruma 2 in 1966. This dwarf variety was used so ground spray could be easily applied and to reduce losses from blowdowns. It was planned to maintain 2 different levels of spotting, or a set of "clean" versus "unclean" plots. Spotting levels were to be controlled by length of spray cycles applied. Fruit weights, finger lengths, maturation time, and foliage production were measured. Spraying began in April 1968. A Hardy sprayer is used to apply spray by hose. One gallon of oil and 1.75 lb. of UF-63 were applied in 50 gallons of water per acre up to June 18 after which Benlate fungicide was used at the rate of 8 ozs. per acre with 1 gallon of oil. Coverage has been excellent and no difficulty has been encountered in maintaining differen spotting levels. From June onward, cycles of 10-17 days were applied in the "clean" plots and cycles of 21 to 45 days in the "unclean" plots. Thus, twice as many cycles have been applied to the "clean" plots. The trends in leaf spotting incidence and intensity are shown in Figures 8-10. These curves show that Sigatoka incidence, as indicated by percentage of plants with spotting, is directly related to number of spray cycles applied. However, the intensity of the disease, as indicated by average age of leaf with spots and percentage of leaves spotted less than 8, rises and falls independently of the number of spray cycles applied. There is no evidence that the spotting levels being maintained in the "unclean" plots, which are considerably higher than those in commercial use, have been injurious to fruit yield or quality. However, insufficient stems have been harvested for a detailed statistical analyses. In the case of average age of leaf with spots (Figure 9), these fell to the 10 to 12 commercial level whether or not 14 or 28-day cycles were used. Similarly, percentage of leaves spotted younger than 8 fell to the commercial level (Figure 10) regardless of spray cycles. These results indicate that larger scale experiments on spray cycling are warranted and should be undertaken on a commercial scale. (STOVER, DICKSON)

<u>Electronic Data Processing in Sigatoka Control</u>

Sigatoka control programs are carried out on more than 100,000 acres of bananas in 5 different countries. Dozens of variables are involved including climate, rainfall patterns, cycle lengths, formulations, aircraft, and amount of spotting present. The only method of monitoring all the variables and to determine their relationships to cost and control methods is to utilize electronic data processing. Before this is possible, however, it is essential to be able to accurately measure spotting incidence since all variables must in the end be related to the amount of spotting present which in turn would reflect the efficiency of control. The development in 1967 of a system of

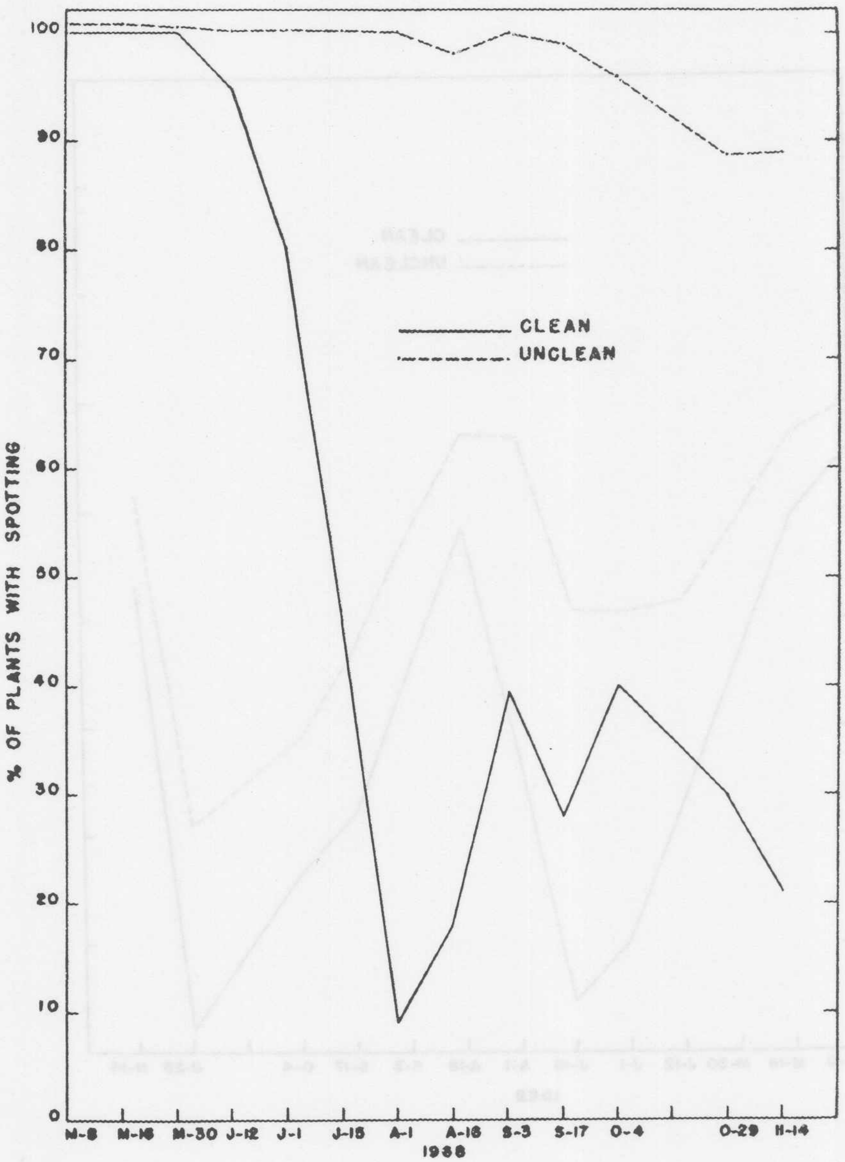


Figure 8

Percentage of plants with spotting under 2 different spray regimes in Grand Nain, Guaruma 1.

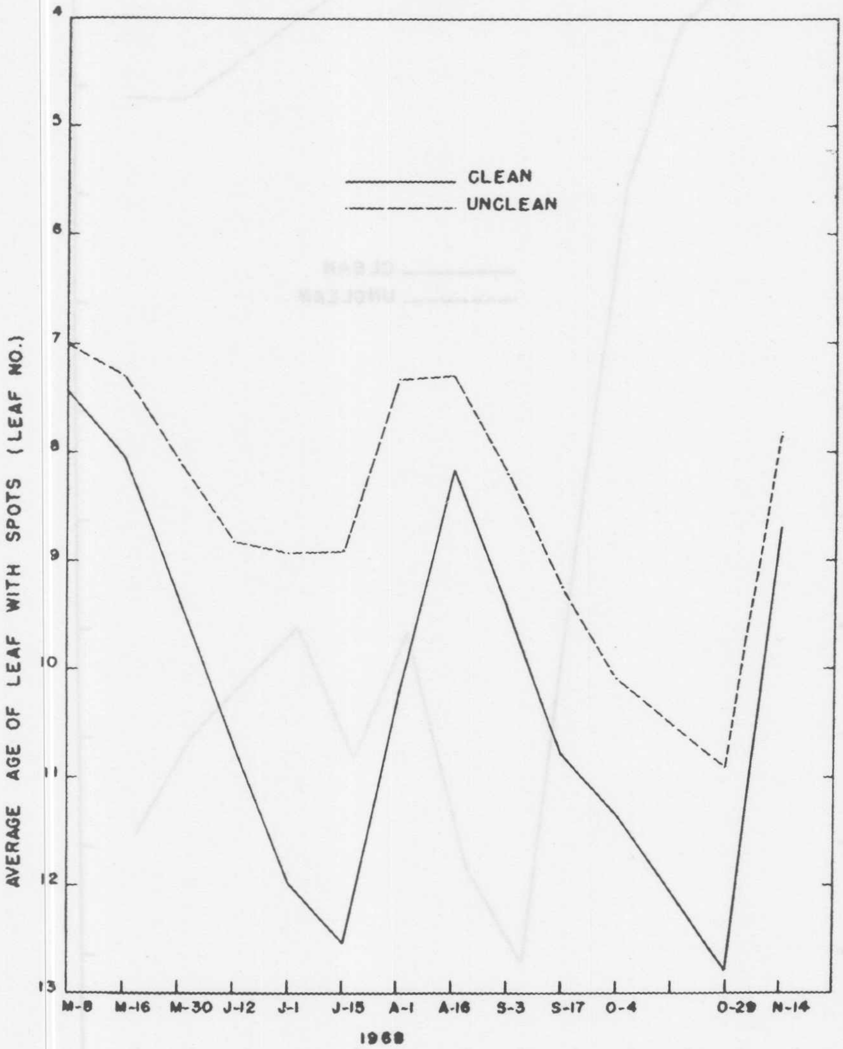


Figure 9

Average age of leaf with spots under 2 different spray regimes in Grand Nain, Guaruma 1.

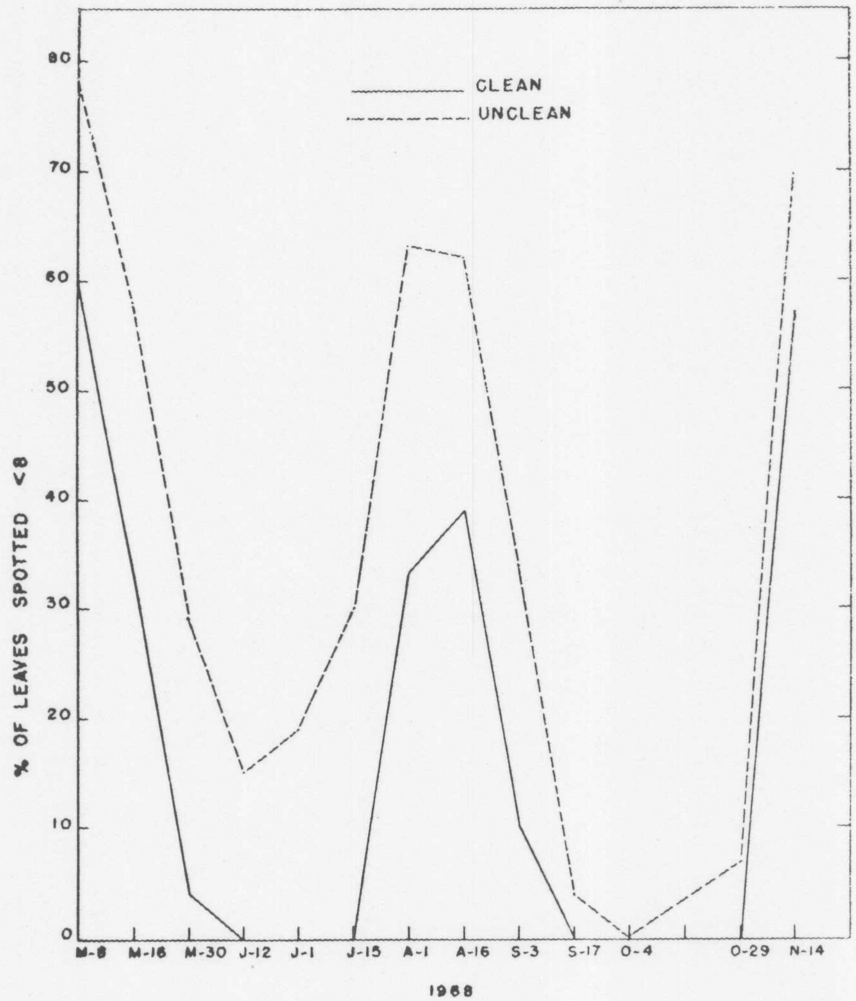
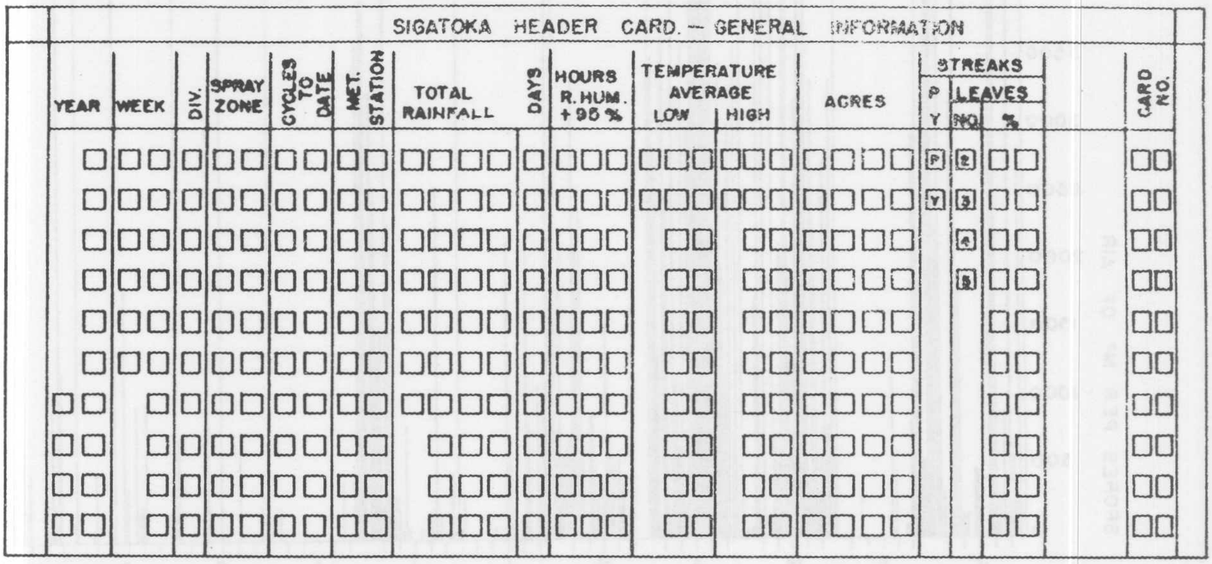


Figure 10

Percentage of leaves spotted younger than 8 under 2 different spray regimes in Grand Nain, Guaruma 1. Regardless of number of cycles of spray applied, the direction of the curves is similar.



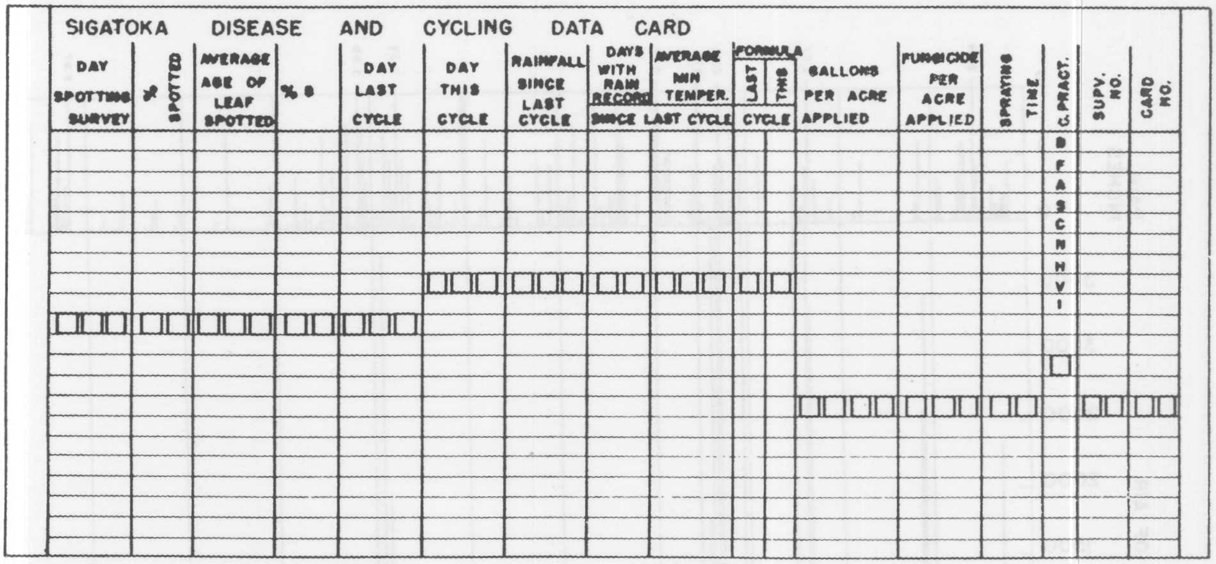


Figure 11

Experimental Porta-punch cards designed for recording essential data on Sigatoka control for electronic data processing.

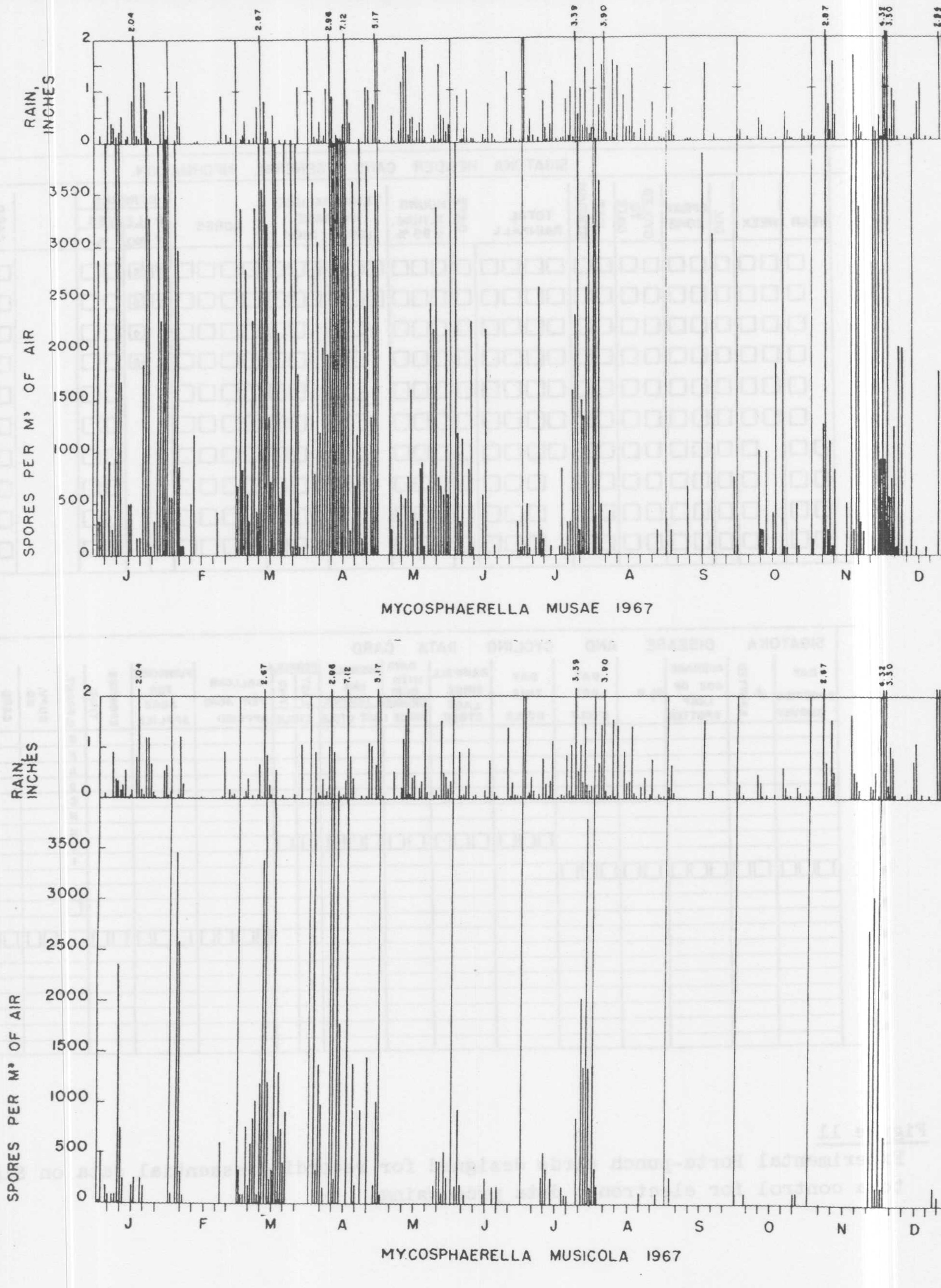


Figure 12

Prevalence of ascospores of M. musae (leaf speckling) and M. musicola (Sigatoka) counted on Hirst spore trap slides from Changuinola in 1967.

shorter; and *M. minima*, a saprophytic co-inhabitant of Sigatoka spots but without an imperfect stage. The black leaf streak *Mycosphaerella* was not found in Central American banana leaf spots.

An examination of black leaf streak material from Fiji, Malaysia, and Taiwan showed the presence of the same perithecia and spermagonia present in Sigatoka spots. Sporodochia were less common and sometimes absent. In culture, however, the black leaf streak *Mycosphaerella* had distinctly different colonies. Also, the ascospores germinated with strongly curved germ tubes which soon branched frequently. The fructifications of the black leaf streak *Mycosphaerella* are not sufficiently different morphologically from those of *M. musicola* to warrant a new species. However, cultural characteristics are distinct and indicate that black leaf streak is caused by a different strain of *M. musicola* than that which causes Sigatoka spotting. Thus far, this strain is not present in Central America. (STOVER)

MOKO

Status of Moko in the Company Divisions

Figure 13 shows Moko incidence in Armuelles, Golfito, Bananera, and Honduras Divisions since 1966. Moko control in 1968 has improved in comparison to 1967.

Armuelles. This Division has had a history of low Moko incidence until late 1966 and early 1967 when Moko increased. The control program was then revised resulting in a decrease in cases. However, during the first half of 1968 there was again an increase. Additional modifications of control practices in June resulted in a decline in cases.

Golfito. Moko incidence in this Division continues at a low level as a result of an efficiently executed and well-organized program.

Bocas. In December 1968 Research received samples of banana rhizome from this Division. The samples were from Lake 13 in Farm 64 and from outside Lake 9 in Farm 63. Isolations revealed that all samples were infected with the F strain of *Pseudomonas solanacearum*. This is the first report of Moko in the Bocas Division since October 1967.

Bananera. Moko incidence in Bananera declined to a low level in 1968 after a sharp increase in 1967. Prior to this outbreak, pruning had been changed to the "parcela" system. With this system of pruning it was difficult to supervise disinfection of machetes. The pattern of Moko cases indicated poor or no tool disinfection on the part of individual "parceleros". The parcela system of pruning was abandoned and Moko incidence decreased. This points out again the importance of tool disinfection in Moko control. Bananera results show that even the SFR strain can be controlled and disease incidence maintained at a low level.

Honduras. Since June 1967, when Moko incidence reached 84 cases/1000 acres, there has been a steady downward trend in disease (Figure 13). The number of cases is still substantially higher than in other divisions. Increased efforts are necessary to bring Moko incidence down to the level of other divisions.

Moko incidence for the four Honduras Districts are presented in Figure 14. Urraco District accounts for a major portion of the reduction in disease incidence in 1968. In other districts Moko incidence has remained relatively steady throughout 1968. The higher incidence in Urraco District (Figure 14) is attributed to the extremely high Moko incidence in Farm 3 in

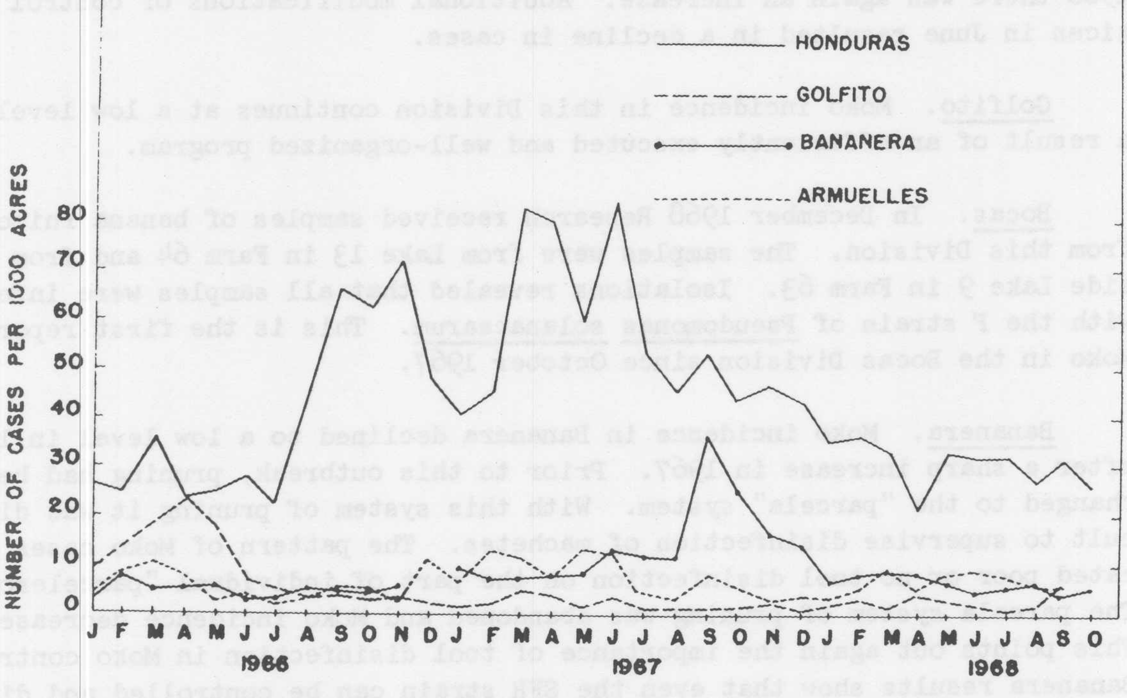


FIGURE 13. MOKO INCIDENCE : ARMUELLES, GOLFITO, BANANERA & HONDURAS DIVISIONS

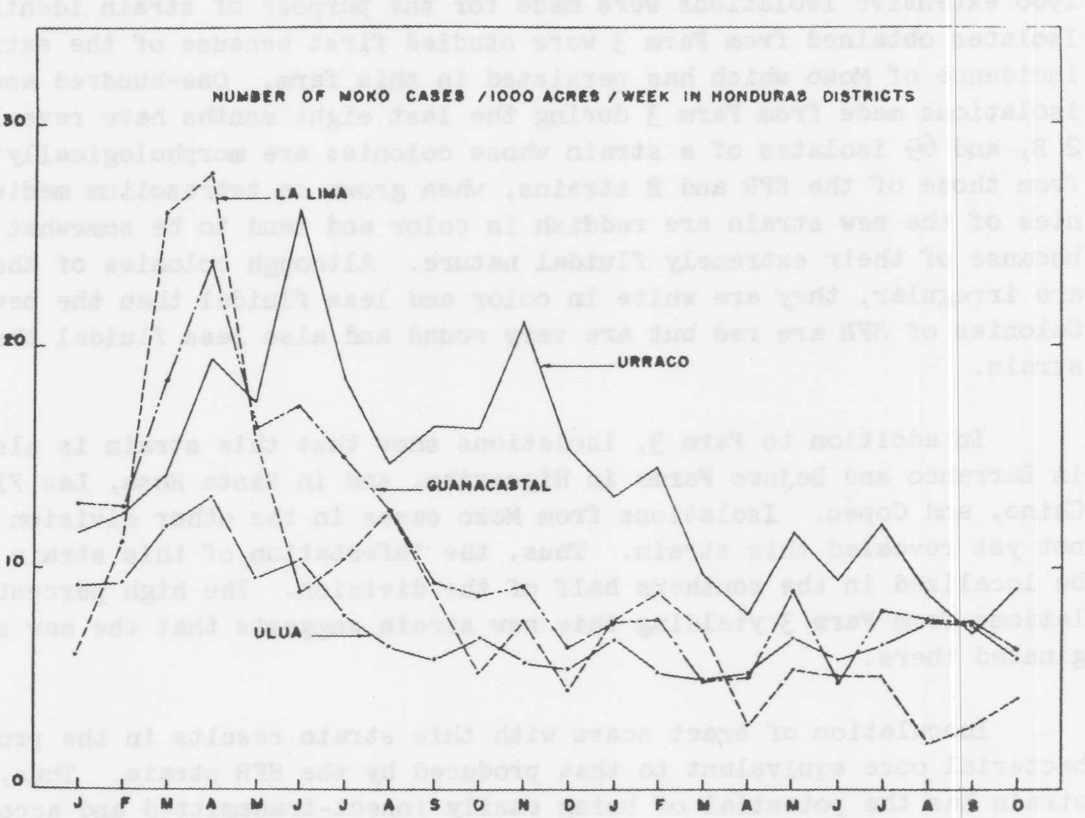

NUMBER OF MOKO CASES /1000 ACRES / WEEK IN HONDURAS DISTRICTS
30
20
10
0
LA LIMA
URRACO
GUANACASTAL
ULUA
J F M A M J J A S O N D J F M A M J J A S O
1967
1968

Figure 14

comparison to the division average (Figure 15). Farm 3 has accounted for 16.8 percent of the Moko cases found in Honduras during the 1967-1968 period. The sharp rise in disease incidence noted in October of 1968, after almost one year of relatively steady decline, can be cited as an example of what can happen when recommended procedures are not followed. Fifty of the 141 cases for the month had been previously reported. However, only the infected suckers were removed instead of destroying the entire plant. Subsequently, Moko re-appeared in the remaining portion of the mat. (BERG, DONALDSON)

<u>A New Moko Strain</u>

The continued high incidence of Moko in Honduras in comparison to other divisions during the last two years suggested that perhaps we are dealing with a new strain which present control procedures cannot keep in check. During 1968 extensive isolations were made for the purpose of strain identification. Isolates obtained from Farm 3 were studied first because of the extremely high incidence of Moko which has persisted in this farm. One-hundred and three isolations made from Farm 3 during the last eight months have revealed 33 SFR, 2 B, and 69 isolates of a strain whose colonies are morphologically distinct from those of the SFR and B strains, when grown on tetrazolium medium. Colonies of the new strain are reddish in color and tend to be somewhat irregular because of their extremely fluidal nature. Although colonies of the B strain are irregular, they are white in color and less fluidal than the new strain. Colonies of SFR are red but are very round and also less fluidal than the new strain.

In addition to Farm 3, isolations show that this strain is also present in Barranco and Bejuco Farms in Higuerito, and in Santa Rosa, Las Flores, Naranjo Chino, and Copén. Isolations from Moko cases in the other division farms have not yet revealed this strain. Thus, the infestation of this strain appears to be localized in the southern half of the division. The high percentage of isolations from Farm 3 yielding this new strain suggests that the new strain originated there.

Inoculation of bract scars with this strain results in the production of bacterial ooze equivalent to that produced by the SFR strain. Thus, the new strain has the potential of being easily insect-transmitted and accounts for its relatively widespread occurrence.

When young, potted banana plants (about 2 ft. tall) were inoculated by injecting 2 ml of a heavy bacterial suspension into the pseudostem, the inoculated plants died within two weeks. Symptoms in the field indicate that this strain is less invasive in older plants. Field observations show that plants infected with this strain will sometimes display no above-ground symptoms. However, when the vascular tissue of the rhizome is exposed, widespread discoloration is evident. The extensiveness of the discoloration indicates that

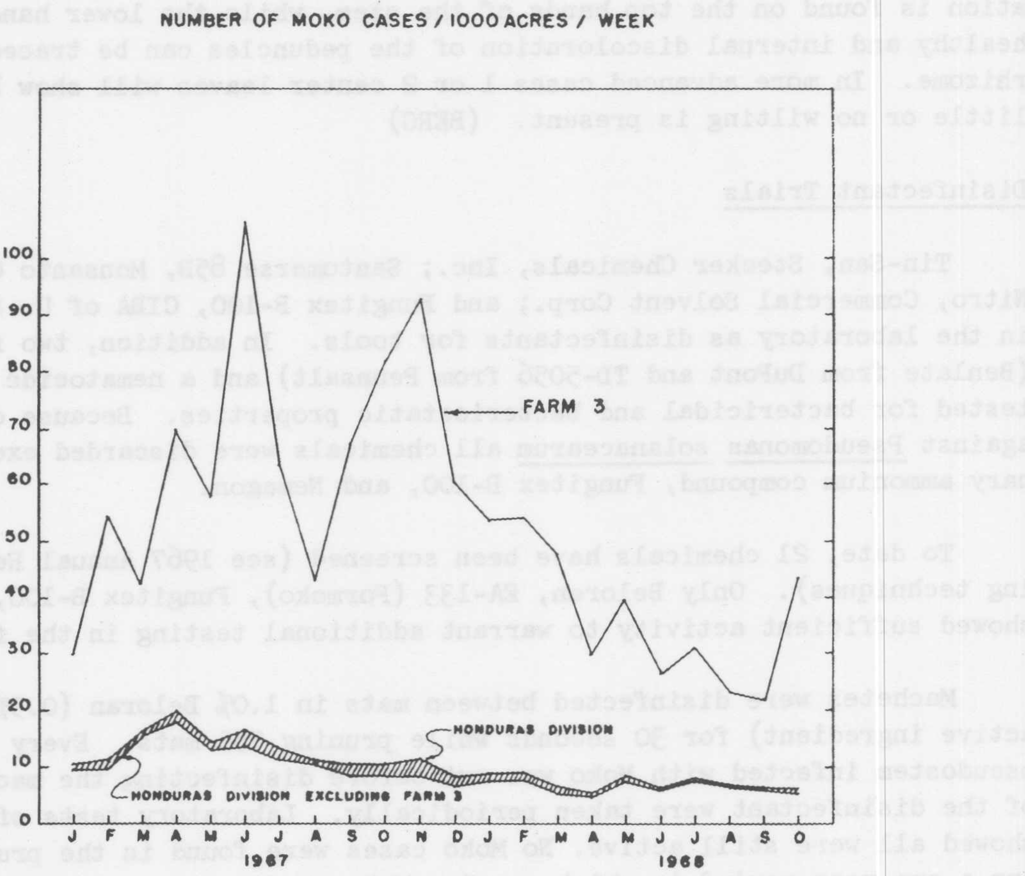

NUMBER OF MOKO CASES / 1000 ACRES / WEEK
FARM 3
HONDURAS DIVISION
HONDURAS DIVISION EXCLUDING FARM 3
100
90
80
70
60
50
40
30
20
10
0
J F M A M J J A S O N D J F M A M J J A S O
1967
1968

Figure 15

the mats have probably been infected for several weeks. Without foliar symptoms this strain can exist in an undetectable, yet infectious condition, making it potentially very dangerous where machete pruning is done. Fortunately, with the present trend towards macana pruning, plants infected with this strain should be detected before above-ground symptoms are apparent. With macana pruning, the vascular tissue of the rhizome is exposed so that internal discoloration can be seen.

When present, external above-ground sucker symptoms are similar to SFR symptoms. Symptoms displayed by plants bearing fruit are sometimes unusual. Cases have been seen where symptoms appear only in the fruit. Upon first glance this appears to be a "fruit case". However, closer observations show that this is not the case because the premature ripening and internal discoloration is found on the top hands of the stem, while the lower hands are still healthy and internal discoloration of the peduncles can be traced back to the rhizome. In more advanced cases 1 or 2 center leaves will show burning, but little or no wilting is present. (BERG)

Disinfectant Trials

Tin-San, Stecker Chemicals, Inc.; Santomerse 85B, Monsanto Company; Tris Nitro, Commercial Solvent Corp.; and Fungitex B-100, CIBA of U. S. were tested in the laboratory as disinfectants for tools. In addition, two fungicides (Benlate from DuPont and TD-5056 from Pennsalt) and a nematocide (Nemagon) were tested for bactericidal and bacteriostatic properties. Because of low activity against Pseudomonas solanacearum all chemicals were discarded except the quaternary ammonium compound, Fungitex B-100, and Nemagon.

To date, 21 chemicals have been screened (see 1967 Annual Report for screening techniques). Only Beloran, EA-133 (Formoko), Fungitex B-100, and Nemagon showed sufficient activity to warrant additional testing in the field.

Machetes were disinfected between mats in 1.0% Beloran (0.5% when based on active ingredient) for 30 seconds while pruning 755 mats. Every 15 mats, a pseudostem infected with Moko was cut before disinfecting the machete. Samples of the disinfectant were taken periodically. Laboratory tests of these samples showed all were still active. No Moko cases were found in the pruned area during a one-year period in which regular Moko surveys were made. This proved the effectiveness of 1.0% Beloran solutions as a machete disinfectant. In late January 1968, a farm scale trial of 1.0% Beloran was initiated in Copen. By periodically taking samples from individual cacharros of machete pruners and testing them in the laboratory, it has been repeatedly shown that 1.0% Beloran remains active throughout a complete working day. Even when additional latex was added to the samples in the laboratory, they were still active against P. solanacearum with a 30-second exposure time.

These results indicated that there would be no problem with loss of activity even with an excessive amount of latex in the cacharro. With an initial concentration of 1.0% Beloran there appears to be a substantial safety margin. This brought up the question of how much safety factor is necessary. Can the initial concentration be lowered and still maintain an ample safety margin? Repeated tests were carried out in the laboratory to determine the lowest effective concentration of Beloran with and without latex when P. solanacearum is exposed for 10, 20, and 30 seconds. The results show that Beloran is effective at low concentrations even when 10% latex is added and with only 10 seconds exposure (Table 2). Thus, it appeared that an initial concentration lower than 1.0% would remain effective throughout a complete day's use.

A field experiment was carried out using Beloran concentrations of 1.09%, 0.79%, and 0.504%. In addition, compound EA-133, tentatively named Formoko, was also tested at the same concentrations. The results of the Beloran test are presented in Table 3. The results show 1.09% and 0.79% Beloran solutions were effective throughout one working day. The 0.504% solution became ineffective after pruning 394 mats. When Formoko was used, the 1.09% solution remained effective throughout the entire working day, whereas the 0.79% and 0.504% solutions deteriorated after pruning 509 and 82 mats, respectively. Thus, a starting concentration of 0.79% Beloran could be safely recommended, while a minimum concentration of 1.09% would be necessary for Formoko.

Using the minimum "safe" concentrations to determine cost, Beloran will be 11.9¢ per gallon of working solution, whereas the estimated cost of Formoko will be between 15 and 20¢ per gallon of working solution. A Technical Data Sheet was issued recommending the use of Beloran instead of formaldehyde which is extremely irritating to the skin and mucous membranes. Beloran was recommended for use at a rate of 1500 ml of 50% concentrate per 50 gallons of water (0.79% based on total chemical, not on active ingredient).

Reactivation of used Beloran solutions was studied. In the absence of an accurate chemical test for determining concentrations of Beloran, the following procedure was used to ascertain the amount of concentrate necessary to rehabilitate used solutions. Starting with the recommended concentration of Beloran, dilutions were made of an unused solution and tested against P. solanacearum at 10, 20, and 30 seconds exposure. Similar dilutions were made of used solutions and tested before and after adding various amounts of Beloran concentrate against P. solanacearum at 10, 20, and 30 seconds exposure to the chemical. Using the results obtained from the unused Beloran dilutions as a standard, it was possible to determine how much concentrate had to be added to the used solutions to obtain equal activity.

If the following amounts are added to used Beloran solutions, they can be considered "safe" for re-use:

Table 2

The Bactericidal Effectiveness of Various Beloran Concentrations With and Without Latex Against Pseudomonas solanacearum When Exposed for 10, 20, and 30 Seconds

Beloran	Without Latex			With Latex		
Concentration	10"	20"	30"	10"	20"	30"
0.0	+	+	+	+	+	+
0.1	±	±	±	+	+	+
0.2	±	±	-	+	+	+
0.3	±	-	-	+	+	±
0.4	-	-	-	±	±	-
0.5	-	-	-	±	-	-
0.6	-	-	-	-	-	-
0.7	-	-	-	-	-	-
0.8	-	-	-	-	-	-
0.9	-	-	-	-	-	-
1.0	-	-	-	-	-	-

\+ Growth

\- No growth

± Growth sometimes present.

Table 3

Growth of <u>Pseudomonas</u> <u>solanacearum</u> in Nutrient Broth
After Varying Periods of Exposure to Samples of 0.504, 0.79, and 1.09% Beloran
Collected at Various Intervals Throughout a Working Day from a Pruner's Cacharro

Sample #	Mats Pruned	1.09% 10 Sec.	1.09% 20 Sec.	1.09% 30 Sec.	Mats Pruned	0.79% 10 Sec.	0.79% 20 Sec.	0.79% 30 Sec.	Mats Pruned	0.504% 10 Sec.	0.504% 20 Sec.	0.504% 30 Sec.
1*		-	-	-		-	-	-				
2**	33	-	-	-	46	-	-	-	27	-	-	-
3		-	-	-		-	-	-		-	-	-
4	64	-	-	-	39	-	-	-	43	-	-	-
5		-	-	-		-	-	-		-	-	-
6	74	-	-	-	35	-	-	-	56	-	-	-
7		-	-	-		-	-	-		-	-	-
8	49	-	-	-	28	-	-	-	98	-	-	-
9		-	-	-		-	-	-		-	-	-
10	57	-	-	-	48	-	-	-	100	-	-	-
11		-	-	-		-	-	-		-	-	-
12	54	-	-	-	54	-	-	-	70	+	-	-
13		-	-	-		-	-	-		+	+	+
14	66	-	-	-	63	-	-	-	75	+	+	+
15		-	-	-		-	-	-		+	+	+
16	68	-	-	-	89	-	-	-	94	+	+	+
17		-	-	-		-	-	-		+	+	+
18	48	-	-	-	72	-	-	-	96	+	+	+
19		-	-	-		-	-	-		+	+	+
20	35	-	-	-	84	-	-	-	105	+	+	+
21												

Continued on next page....

Table 3 (Cont.)

Sample #	Mats Pruned	1.09% 10 Sec.	1.09% 20 Sec.	1.09% 30 Sec.	Mats Pruned	0.79% 10 Sec.	0.79% 20 Sec.	0.79% 30 Sec.	Mats Pruned	0.504% 10 Sec.	0.504% 20 Sec.	0.504% 30 Sec.
22	67	-	-	-	93	-	-	-				
23												
24												
Total	615				651				765			

* Odd numbers are samples taken before refilling cacharro.

** Even numbers are samples taken after refilling cacharro.

\- No growth

\+ Growth

	Amount of Beloran in ml. needed/50 gallons
Original preparation	1500
1st reactivation	200
2nd reactivation	300
3rd reactivation	400

The reactivation of used Beloran solutions plays a very important part in the economy of tool disinfection. Although Beloran solutions (11.9¢ per gallon of working solution) are considerably less expensive than solutions of formaldehyde (21-22¢ per gallon of working solution), additional savings can be obtained by reactivation because only small amounts of the concentrate are required.

If one starts with 100 gallons of the recommended concentration of Beloran and assumes that each time the solution is rehabilitated there is a 25-gallon loss due to spillage, etc. in the field, the actual cost per gallon of disinfectant can be calculated as follows:

	Number of gallons remaining	Cost
Original preparation	100	$11.90
1st reactivation	75	1.19
2nd reactivation	50	1.19
3rd reactivation	25	.79
Total	250	$15.07

Final Cost Per Gallon = 6.028¢

Repeated tests have revealed that the disinfectant used by machete pruners and de-leafers remains effective throughout the working day. However, with macana pruning where large amounts of soil are introduced into the cacharro, the initial concentration of Beloran for this operation had to be increased to 2.0% to insure proper disinfection.

Fungitex B-100 is a substitute for Beloran manufactured by CIBA in the U.S.A. and more quickly obtained than the Swiss product. Laboratory tests indicated that when latex is not present in the disinfectant solutions, Beloran and Fungitex are comparable. When 10% latex was added to Beloran and Fungitex solutions, only a slight reduction in activity was noted in the former but a marked reduction occurred in the latter. This indicated that Beloran and Fungitex were not the same. Additional tests were necessary to determine if they were equally effective under field conditions.

Concentrations of 1.09%, 0.79%, and 0.504% were tested as machete disinfectants in the field. The results (Table 4) showed that latex does not accumulate in sufficient amounts throughout a day's use to cause inactivation of Fungitex, if initial concentrations of at least 0.79 or 1.09% are used.

Fungitex has also been tested as a disinfectant for de-leafing and macana pruning and to date all recommendations previously made for Beloran have held for Fungitex.

The cost differential between Beloran and Fungitex is in favor of Fungitex. Fungitex will cost 4.8¢ per gallon (based on price of \$0.73/lb. f.o.b. shipping point, quoted by CIBA) to 8.5¢ (based on price paid by Research for a gallon lot in Honduras). The actual price should fall somewhere between these two figures when it is bought in large quantities.

<u>Disinfectants for Macana Pruning</u>

Because of the soil and debris which cling to the macana blade even after it is immersed in the disinfectant, the possibility of spreading nematodes from mat to mat is very great. Since Beloran and Fungitex B-100 are not effective nematocides, other chemicals or combination of chemicals had to be considered that would effectively stop the spread of both Moko and nematodes.

It was determined that a 1.0% solution of Nemagon (75% active) and a 3:1 dilution of formaldehyde are sufficient to stop the spread of nematodes. When Nemagon was tested in the laboratory, the above concentration showed excellent bactericidal properties and did not appear to be greatly affected by either latex or soil. However, in the field a 1.0% solution was inactivated almost immediately. A combination of Nemagon and Beloran (or Fungitex B-100) has not been seriously considered because of the potential problems in mixing and rehabilitation, as well as the cost. For these reasons, formaldehyde (3:1) has been recommended for tool disinfection in macana pruning and seed digging to prevent transmission of Moko and the spread of nematodes.

<u>Dyes in Disinfectant</u>

One of the most important factors contributing to the continued presence and spread of Moko is lack of tool disinfection between mats. At present, there is no way of insuring that between-mat disinfection is actually done, except by direct supervision. However, if a dye is added to the disinfectant in sufficiently high amounts so that it will cling to the machete and wipe off on the first one or two suckers which are cut, it would be possible to check machete disinfection for a limited period of time after the work was completed. If the pruners know their work can be checked, they would probably tend to be more conscientious about disinfecting mat to mat.

Table 4

Growth of Pseudomonas solanacearum in Nutrient Broth After Varying Periods of Exposure to Samples of 0.504, 0.79 and 1.09% Fungitex B-100 Collected at Various Intervals Throughout a Working Day from Pruner's Cacharro

Sample		0.504%					0.79%					1.09%			
		Exposure Time					Exposure Time					Exposure Time			
#	Mats Pruned	10 Sec.	20 Sec.	30 Sec.	1 Min.	Mats Pruned	10 Sec.	20 Sec.	30 Sec.	1 Min.	Mats Pruned	10 Sec.	20 Sec.	30 Sec.	1 Min.
1*		-	-	-	-		-	-	-	-		-	-	-	-
2**	86	-	-	-	-	109	-	-	-	-	86	-	-	-	-
3		-	-	-	-		-	-	-	-		-	-	-	-
4	77	-	-	-	-	108	-	-	-	-	79	-	-	-	-
5		-	-	-	-		-	-	-	-		-	-	-	-
6	80	±	+	+	-	70	-	-	-	-	80	-	-	-	-
7		-	-	-	-		-	-	-	-		-	-	-	-
8	48	-	-	-	-	99	-	-	-	-	75	-	-	-	-
9		-	-	-	-		-	-	-	-		-	-	-	-
10	84	+	+	+	-	80	-	-	-	-	108	-	-	-	-
11		-	-	-	-		-	-	-	-		-	-	-	-
12	85	+	+	+	-	79	-	-	-	-	96	-	-	-	-
13		-	-	-	-		-	-	-	-		-	-	-	-
14	99	+	+	-	-	125	-	-	-	-	87	-	-	-	-
15		-	-	-	-		-	-	-	-		-	-	-	-
16	56	-	-	-	-	84	-	-	-	-	94	-	-	-	-
17		+	+	+	-		-	-	-	-		-	-	-	-
18	61	+	+	+	-	102	-	-	-	-	87	-	-	-	-
19		-	-	-	-		-	-	-	-		-	-	-	-
20	63	-	-	-	-	93	-	-	-	-	92	-	-	-	-
21		-	-	-	-		-	-	-	-		-	-	-	-

Continued on next page....

Table 4 (Cont.)

Sample	Mats	0.504%				Mats	0.79%				Mats	1.09%			
		Exposure Time					Exposure Time					Exposure Time			
#	Pruned	10 Sec.	20 Sec.	30 Sec.	1 Min.	Pruned	10 Sec.	20 Sec.	30 Sec.	1 Min.	Pruned	10 Sec.	20 Sec.	30 Sec.	1 Min.
22	92	+	-	-	-	46	-	-	-	-	92	-	-	-	-
23		-	-	-	-		-	-	-	-					
24	86	+	+	-	-	90	-	-	-	-					
25		+	+	-	-										
26															

* Odd numbers are samples taken after refilling cacharro.

** Even numbers are samples taken before refilling cacharro.

\- No growth

\+ Growth

± Growth sometimes present.

Crystal violet, basic fuschin methyl violet, neutral red, and Phloxine B have shown promise for this purpose. However, the price of the dyes in most cases is prohibitive. Phloxine is the most economical of the dyes tested but the cost will still be about 3.2¢ per gallon of disinfectant. Additional studies in the economies and usefulness of dyes is required.

Pruning Practices and Moko Spread

An experiment initiated June 1, 1967 was designed to compare five methods of pruning with standard machete pruning. The six treatments are replicated six times in a 6 x 6 latin square with about 110 mats per plot. Each plot is pruned when the average height of the suckers within the plot is 4 to 4½ feet. In the center of each plot one infected mat is maintained and pruned along with the healthy plants to simulate an undetected Moko case and to determine the efficiency of each technique in controlling the spread of the pathogen from this infected mat. To date, all plots have been pruned 7 times with the exception of plots pruned by kerosene injection which have been pruned only 6 times. The pruning techniques which are being tested are listed below. (See 1967 Annual Report for details on pruning techniques.)

1) Regular machete pruning.

2) Machete pruning plus kerosene spray.

3) Machete pruning plus Karmex spray.

4) Kerosene injection.

5) Macana pruning.

6) Jerk pruning.

Moko Spread. The analysis of the efficiency of these methods in controlling the spread of Moko is difficult as it cannot be stated definitely that all Moko cases which appear within a given block are actually due to spread by pruning tools. It is possible that Moko cases which appear immediately next to the inoculated plants are due to spread of the Moko organism through the roots and/or soil. Also, it is difficult to attribute cases which appear several mats away from inoculated plants with healthy plants in between to spread by pruning tools. To date, 31 Moko cases have been found in the 36 plots and the pattern of spread is shown in Figure 16. An analysis of variance shows no significant difference in the number of Moko cases per treatment that can be attributed to pruning practices. The pattern of spread indicates that other factors such as root spread must be taken into consideration. Out of 32 Moko cases, 21 of them were found no more than 4 meters from the inoculated plants. All but two of these 21 cases appeared 10-13 months after the original plants between harvests. Through October 31, 5,376 stems have been weighed from the 36 plots. An analysis of variance shows that 17 months after the initiation of the experiment no significant differences could be detected in gross weight of stems harvested as a result of using any one of the six pruning techniques.

Cost of Labor and Materials. Records have been kept of pruning times and materials for cost comparisons (Table 7). It is easy to keep accurate records of the time required to prune individual plots. However, labor costs will appear higher than those actually obtained in farm practice because of the extra care taken to insure the work is properly executed. It is more difficult to estimate material costs for small areas in comparison to large, but it is felt the figures given are reasonably accurate.

Regular pruning is the least costly of the pruning techniques on a cycle basis. Spraying the cut surfaces substantially increases both labor and material costs. Macana and jerk pruning are more costly primarily because this type of pruning is slower, increasing labor costs. With practice, efficiency and speed increase and labor costs decrease.

Next to regular pruning, kerosene injection is the least costly when one compares the average cost of the first five cycles. In the beginning this system will cost substantially more than machete pruning, but as the workers become more efficient and because of the reduced number of suckers that develop, costs decrease. Multiplying cycle costs (Table 7) by number of cycle (Table 5) it costs Lps. 57.11, Lps. 59.05, and Lps. 79.38 each year to prune approximately 660 plants when machete pruning, kerosene injection, and macana pruning are used, respectively. Because of high costs with no obvious advantage, further evaluation of regular pruning plus spraying the cut surfaces with kerosene and Karmex, as well as jerk pruning will be discontinued.

There remain two alternatives to machete pruning, macana pruning and kerosene injection, both of which have advantages and disadvantages. The danger of tool transmission of Moko bacteria with macana pruning is probably equal to machete pruning. However, with this technique the surface of the rhizome is exposed and one is able to detect internal Moko symptoms in the rhizome before external symptoms develop. These cases would not be detected by machete pruning and would remain infection foci until external symptoms develop and are detected by surveyors. Thus, macana pruning offers the advantage of earlier detection of Moko cases which greatly aids Moko control. At the same time, the cut surfaces are a disadvantage since it is possible for insects contaminated with Moko bacteria to come in direct contact with the vascular tissue.

The results of this experiment show no increase in the number of days between pruning cycles with macana pruning when compared to machete pruning if both areas are pruned at the same sucker height. However, because of the reduced number of suckers per mother plant with macana pruning the area will be in less need of pruning.

Table 7

Cost Comparison of Six Pruning Techniques

Pruning Cycle	Regular Pruning		Regular Pruning & Kerosene Spray		Regular Pruning & Karmex Spray		Kerosene Injection		Macana Pruning		Jerk Pruning	
	Labor*	Material**	Labor	Material	Labor	Material	Labor	Material	Labor	Material	Labor	Material
2nd	19.85	.33	25.92	2.94	24.30	14.28	24.30	1.47	32.40	0.33	34.83	
3rd	12.15	.22	18.23	1.96	15.66	6.03	12.42	0.69	13.23	0.22	24.64	
4th	10.64	.22	10.87	1.54	12.08	66.00	9.50	0.99	15.36	0.22	17.34	
5th	9.25	.005	11.52	1.545	12.56	5.815	12.93	0.87	10.03	0.07	7.09	
Average Labor/ Cycle	L.12.97		L.16.64		L.16.15		L.14.78		L.17.76		L.20.98	
Average Materials/ Cycle		L.0.19		L.1.97		L.8.03		L.1.01		L.0.21		
Average Labor & Materials/ Cycle	L.13.16		L.18.61		L.24.18		L.15.79		L.18.00		L.20.98	

* Labor = time required to prune 6 plots each of which contains approximately 110 mats.

** Materials = include disinfectant, kerosene and Karmex where used.

A distinct disadvantage of macana pruning is the potential threat of spreading nematodes, making macana disinfection doubly important. The use of formaldehyde is imperative since it possesses both bactericidal and nematocidal properties.

Although detection prior to the development of external symptoms is not possible with kerosene injection, it does offer several advantages over macana pruning. Based on this experiment, kerosene injection should be cheaper than macana pruning. Also, there is a greater reduction in the number of suckers produced per mother plant, as well as an actual increase in the number of days between pruning cycles. This increase appears even greater during the winter months. There will be no danger of spreading nematodes with kerosene injection and little disinfectant will be required to sterilize the needle. There will be less exposed tissue for insect transmission and little disturbance of the area immediately surrounding the mat which may tend to make it more susceptible to blowdowns. One possible disadvantage of this system might be the possible confusion of Moko symptoms with suckers dying as a result of kerosene injection. This method of pruning on a large scale awaits the development of a strong, serviceable injector.

It appears that both pruning systems have advantages to offer and a possible combination of the two should be considered. The first two pruning cycles in areas where machete pruning is being discontinued could be done with a macana to locate as much of the "hidden" Moko as possible and obtain the initial reduction in the number of suckers per mat. These two cycles can then be followed by kerosene injection to avoid the threat of nematode spread, to further reduce the number of suckers per mat, and to take advantage of the increased number of days between pruning cycles. The data to date suggest that the greatest number of days between pruning cycles is obtained during the cool winter months. In succeeding years at least one cycle of pruning could be done with macanas carried out to the best advantage following the extended cycle obtained with kerosene injection during cool months.

Weed Hosts of *Pseudomonas solanacearum*

Studies were undertaken to determine if weeds within the banana plantations maintain a population of bacteria which could be transmitted to bananas in the cleaning operation. Isolations were made from weeds which were growing within the banana plantations. Isolations were carried out by aseptically placing small pieces of surface-sterilized plant material in sterile distilled water and shaking. With a bacterial loop a droplet of this water was streaked on Tetrazolium media. Permanent stock culture tubes were made of the *Pseudomonas* isolates obtained from these weeds and were later used for inoculation of potted VALERY plants to determine pathogenicity. Isolations were also made from the inoculated VALERY plants to compare the isolates with those originally obtained from the weeds. Many of the weeds from which isolations were made appeared healthy or only had one or two necrotic leaves but often showed internal discoloration in the stem.

The following are weeds from which SFR or colony types similar to SFR have been isolated and which were pathogenic when injected into young potted VALERY plants:

	Number of isolations made	Times SFR was isolated
Asclepias curassavica	31	10
Cecropia peltata	30	2
Piper auritum	55	14
Piper peltatum	40	15
Ricinus communis	57	9
Rivina humilis	13	1
Solanum hirtum	2	2
Solanum nigrum	46	10
Solanum umbellatum	35	11
Solanum verbascifolium	31	8
Xanthosoma roseum	59	14

In addition to the weeds listed above, unsuccessful attempts have been made to isolate Pseudomonas from the following weeds:

Acalypha pseudoalopecuroides
Acalypha setosa
Amaranthus sp.
Asclepias curassavica
Baltimora recta
Bidens pilosa
Bidens squarrosa
Blechum pyramidatum
Boerhaavia erecta
Borreria laevis
Canna indica
Cassia bacilloris
Cayaponia microdonta
Cirsium sp.
Cissus sicyoides
Cleome serrata
Commelina diffusa
Commelina erecta
Cordia dentata
Desmodium affine
Fleurya astuans
Hybanthus attenuctes
Jussicea suffruticosa
Lagascea mallis
Lippia reptans
Physalis lagascae
Pilea microphylla
Piper tuberculatum
Portulaca oleracea
Priva lappulacea
Ruellia nudiflora
Stigmaphyllon lindenianum
Syngonium podophyllum
Urera elata
Wedelia trilobata

The relatively large number of weeds which have been found to be potential hosts of Pseudomonas solanacearum points out the possible threat of spreading the pathogen in the cleaning operation. The actual role of weeds in the maintenance of Moko and its spread remains to be determined.

Rehabilitation and Buffering

Much of the work which was done in the past concerning buffering of new Moko cases and the rehabilitation of old Moko sites involves only the B strain of *Pseudomonas solanacearum* and Gros Michel. The following observations were made in VALERY plantings infected with the SFR strain:

1) Four large "Moko holes" which involved 103 Moko cases were replanted February 1, 1967. The Moko cases had been treated 2-6 months prior to the planting date. The new planting was off-set. These areas were surveyed weekly for one year during which time no Moko cases appeared, indicating a fallow period of less than six months is possible.

2) In the greenhouse 10" pots of soil were inoculated with 100 cc of a heavy water suspension of the SFR strain. One, 2, 3, and 4 weeks after inoculation, seed pieces of VALERY bananas were planted in these pots. The results show that all plants planted four weeks after inoculation survived and were healthy, indicating a very short survival time of the SFR strain in the soil.

With the above information in mind and new techniques for treating Moko cases, the following experiment was initiated in the Guarumas to determine minimum buffer and fallow time in VALERY infected with SFR and B strains. Two hundred mats were inoculated with a mixture of B and SFR strains of the Moko bacterium on May 8, 1968. Two weeks after inoculation Moko symptoms began to appear. Approximately 95 percent of the plants had visible Moko symptoms four weeks after inoculation. In order to allow the maximum time that a Moko case might go undetected in the farms, as well as to give the bacterium sufficient time to spread into the root system, the inoculated plants were not treated until July 4, 1968, or approximately two months from the time they were inoculated.

Infected plants were destroyed either with Dow Formula 40, as previously recommended, or with a Banvel-D (dicamba) - Herbicide 273 (endothal) mixture as recommended in the April 1968 Data Sheet. Buffer plants were not destroyed. Replanting is done 2, 3, 4, 5, and 6 months after treatment. There are 10 randomized treatments (one plant per treatment) replicated 20 times.

Results to date show that 30 Moko cases have developed in plants immediately surrounding the 200 inoculated plants. However, 27 of these cases were around inoculated plants treated with Dow Formula 40 and only 3 were around inoculated plants treated with the Banvel-D - Herbicide 273 mixture. It is very likely that the three cases which did appear would have been avoided if the inoculated plant had been treated as soon as the first visible symptoms were apparent. Unless additional Moko cases are found around Moko-infected plants treated with bananacide at a later date, the small amount of spread from cases treated with this technique would hardly justify the destruction of a buffer zone.

When compared to Dow Formula 40, the necessity of retreatment is much less when the bananacide is used. However, when infected plants are treated with the concentration of bananacide given in the original technical data sheet (two parts dicamba and three parts endothal), more than 50% of the time one or more of the neighboring plants had herbicide symptoms as a result of translocation of Banvel-D through the root systems. This problem has now been alleviated by changing the concentration of the two chemicals to 6% Banvel-D, 60% Herbicide 273 and 34% water.

Replanting has now been made 2, 3, and 4 months after treatment. The seeds are off-set from the original mat. At the present time, the young plants are developing well and to date no Moko has been found in any of the plantings, indicating that replanting of Moko abandonment could be safely carried out earlier than the present recommendation of six months from the time of treatment. (BERG)

FUSARIAL WILT RESISTANCE

Banana breeders in Jamaica reported in July 1968 at the International Phytopathology Congress in London that there was difficulty in obtaining high levels of wilt resistance to F. oxysporum f. cubense Race 2 in tetraploid hybrids of Highgate x M. acuminata. Accordingly, inoculation of 5 tetraploid hybrids including SH-22 was made in August using Race 2 isolates from diseased Chatos ABB and Race 1 isolates from diseased VALERY plants in Palmar. To date, none of the hybrids have become wilted. Presumably, diploid "Lidi" used in Honduras crosses carries resistance to Race 2 as well as Race 1. We should be certain Race 2 resistance is present in the major breeding lines.

In Palmar about 50 cases of wilt appeared in VALERY during 1968. Isolations were made and a virulent strain of Race 1 was obtained. This strain wilted M. balbisiana seedlings more rapidly than an isolate from Cocos in Honduras. Inoculations of VALERY plants were made in Honduras but no wilting was obtained with the Palmar isolates. There has been no spread or reoccurrence of the disease in the mats involved. Thus, at present there is no threat of a new race capable of attacking Cavendish group varieties. (STOVER)

NEMATODES

No division-wide surveys were made in 1968. Areas for plantains were surveyed in Birichiche - Honduras, Caimito - Costa Rica, and Eskimo Farm - Guatemala. Results of VALERY surveys carried out in Honduras are shown in Table 8. Radopholus similis continues to spread throughout all farms. A detailed survey of Farm 24, Bocas was made to delimit highly infested areas for fallow.

In Honduras seed for replanting areas fallowed for Moko disease was being taken from various locations in 25 farms and planted without heat treatment. A large number of the locations were infested with R. similis. This source of infection should be eliminated by planting only heat-treated seed.

Soil and plant debri on macanas (chisels) used for underground pruning contained live nematodes even when disinfected in 2% Fungitex B-100. To avoid spreading R. similis from plant to plant by this method of pruning, a nematocidal disinfectant was required. Both 9% formaldehyde (1 part 37% formalin to 3 parts water) and 1% Nemagon (75% active) were effective in killing nematodes adhering to macanas when the tool was immersed for 30 seconds in the disinfectant solution. However, Nemagon was not effective in killing P. solanacearum. Therefore, all tools used underground such as shovels in seed-digging operations and macanas in pruning should be disinfected with 1:3 solution of formaldehyde between mats to prevent spreading R. similis and P. solanacearum.

An examination of primary and secondary roots of VALERY in the old Limones seedbed (Section 27) was made to determine if Rotylenchulus sp. was contributing to banana root injury as reported from the Windward Islands. No Rotylenchulus sp. was found. The most abundant pathogens were Radopholus, Helicotylenchus, and Meloidogyne species. (STOVER)

Table 8

Incidence of Radopholus similis Infection in Honduras

Farm	Date Surveyed 1965-66	% Infection 1965-66	Date Surveyed 1968	% Infection 1968
Corozal	10/65	1.10	9/18/67	2.98
Mopala	10/25/65	1.41	2/16/68	4.33
Sta. Rosa	2/25/66	0.88	2/23/68	2.88
Ceibita	11/20/65	0.45	2/26/68	1.43
Indiana	11/27/65	0.97	2/27/68	4.27
Caimito	12/9/65	0.35	2/28/68	0.78
Limones	12/15/65	4.09	2/29/68	11.03
Laurel	12/20/66	1.25	2/29/68	4.33
Mercedes	1/66	0.73	3/1/68	3.17
Tibombo*	1/66	0.60	3/4/68	2.77
San Juan	10/11/66	1.07	3/5/68	3.84
La Curva	10/18/66	0.60	3/6/68	1.40
Tacamiche	10/26/66	1.01	3/11/68	2.67
Copén	12/21/66	0.03	3/11/68	0.06
Finca 3	2/15/66	0.18	3/12/68	0.37

* Does not include Coco Bolsa where no infection was found in the last survey of January 1966.

FRUIT SPOTS

A combination of farm sanitation, weekly Dithane spray and prompt bagging has been used in all the Company Divisions, except Bocas, for fruit spot control. Various modifications of equipment and techniques were tested during the year and as a result fungicide coverage has been significantly improved. However, there has been a tendency to overspray resulting in unsightly residues on some boxed fruit. Some new techniques developed during the year proved to be very helpful during fruit spot epidemics, e.g. Dithane dusting under the bag was effectively used in Bananera to control an epidemic during July-August.

The breakdown of the fungicidal properties of Dithane M-45 residues on fruit 5 weeks after application continues to be a major problem. For this reason, a great deal of infection that takes place a few weeks before harvest passes undetected at the boxing station and shows up at points of disembarkation (Figure 17). However, better control of this "late" infection is expected now that Thylate (thiram) is cleared for preharvest use on bananas. Studies have continued on Thylate to determine the optimum rate of application and the best formulation for fruit spot control in the Northern as well as in the Southern Divisions. Because of the less conspicuous color of Thylate, the problem of excessive spray residue on fruit will be also minimized.

Fungicidal Activity of Thylate and Dithane Residues on Fruit at Harvest Time

Preliminary studies had shown inhibition of spore germination of *Pyricularia grisea* and *Fusarium roseum* 10 weeks after the second fungicide application on fruit sprayed with Thylate at the rate of 1.23 lbs. per 5 gallons of water and protected with double tissue chill protection bag (Annual Report 1967). This work was repeated with fruit sprayed with Thylate at the rate of 1.0 lb. per 5 gallons of water plus 7 ml of Triton X-45 and protected with polyethylene bag. Fruit was from Research experiments in Farm 47, Coto, and Ceibita, Honduras. Fruit sprayed with Dithane at 1.0 lb. per 5 gallons of water plus 7 ml of Triton X-45 and unsprayed fruit were used for comparison. Four sets of fruit samples were collected at the boxing station between September and November. One droplet of an aqueous spore suspension of *P. grisea* was deposited on each of two areas per finger selecting those areas with visible residues of Dithane and Thylate.

After an incubation of 8 hours at 24° C, aqueous Phloxine B was added to the spore suspension droplets and spore germination and appressorium formation were recorded.

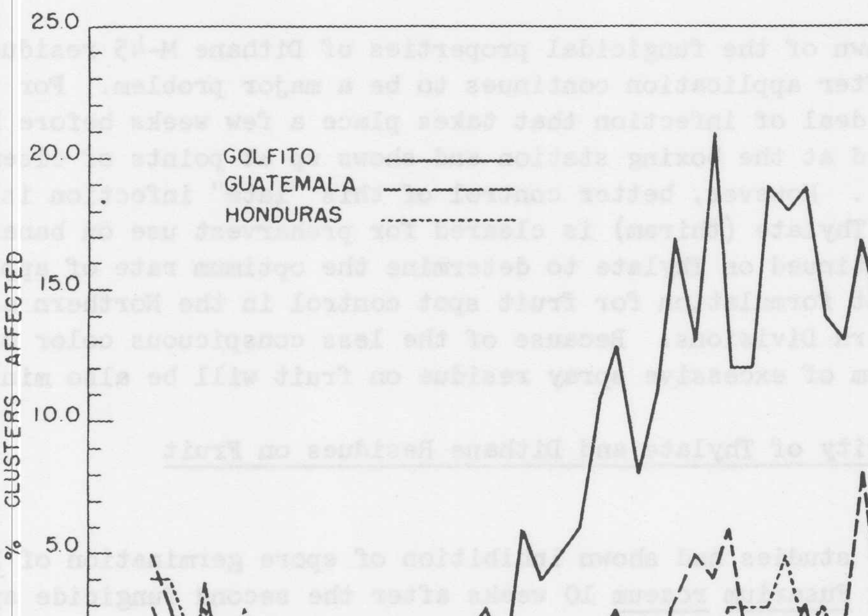


FIGURE 17. PITTING DISEASE - AFTER RIPENING IN U.S.
(Q C WEEKLY REPORTS)

Spore germination varied between 2 and 25% on fruit sprayed with Thylate and between 20 and 95% on fruit sprayed with Dithane (Table 9). The higher germination on the Dithane residue indicates breakdown of its fungicidal properties.

On fruit sprayed with Thylate, only about 50% of the germ tubes formed appressoria during the 8-hour incubation period. On fruit sprayed with Dithane, 80-90% of the germ tubes formed appressoria. Poor fungicide protection at or a few weeks before harvest time could result in a high incidence of spotting that may or may not develop before the fruit is boxed. (MUÑOZ)

Dusting for Fruit Spot Control

The large amount of infection that can occur a few weeks before harvest, possibly due to the breakdown of the fungicidal properties of Dithane M-45, prompted an investigation into other possibilities for additional protection of the fruit, with the bag in place.

Samples of fungicide-dust formulations obtained from Rohm & Haas and DuPont were tested in Ceibita Farm, Honduras on fruit bagged with both polyethylene and 1-ply tissue bags. Unsprayed fruit was dusted from 5-7 weeks before harvest with the bag in place using a Hudson Roto Power 6801 duster. Four days after dusting, fingers were picked up at random from the 3 uppermost hands of each of ten stems per treatment. This sampling was continued at weekly intervals up to 47 days after dusting when the test fruit was already 1 or 2 weeks beyond harvest grade. In the laboratory, spores of Pyricularia grisea were applied following the same experimental procedures described in the preceding section, except that in this case the spore suspension droplets were deposited at random.

The effect of the fungicide dusts on spore germination varied with the concentration of active ingredient and the type of bag used (Table 10). On fruit protected with a polyethylene bag and dusted with Dithane M-45 at 10% active ingredient, over 50% spore germination was recorded after 11 days, while on fruit protected with a 1-ply tissue bag 40% spore germination was not reached until 26 days after dusting. At 20% concentration not much bag effect was observed for either Dithane M-45 or Thylate. At this higher concentration spore germination varied between 0 and 10-15% during the first 3 weeks and it stayed below 50% up to 6 weeks after dusting. On Manzate T dusted fruit over 50% spore germination was recorded a few days after dusting. There was no inhibition of spore germination on untreated fruit. Appressorium formation followed a trend similar to germination (Table 11).

The wide range in spore germination observed in Table 10 may be due in part to the random selection of samples, spore deposition, and uneven coverage. Handling of the samples, too, may have added to this variation by removing fungicide dust deposit from the fruit because of the characteristic low tenacity of dusts.

Table 9

Spore Germination and Appressorium Formation of *Pyricularia grisea* on Mature Fruit Sprayed Before Bagging with Thylate and Dithane M-45

Treatment[1/]	Date	Sample Origin[2/]	No. Fingers Tested	Percent Spore Germination	Percent Appressorium Formation
Thylate	9/10	Coto, Costa Rica	22	2.27	0.95
Dithane			24	20.19	17.63
Thylate	9/17	Ceibita, Honduras	20	16.45	7.70
Dithane			20	87.75	72.90
Unsprayed			10	100.00	96.40
Thylate	10/28	Coto, Costa Rica	30	25.37	3.60
Dithane			30	72.65	47.07
Unsprayed			19	100.00	97.47
Thylate	11/11	Coto, Costa Rica	50	2.72	1.86
Dithane			50	95.80	86.08
Unsprayed			20	100.00	97.85

1/ Fruit sprayed with Thylate and Dithane at 1.0 lb./5 gallons of water and protected with polyethylene bag.

2/ Samples taken from boxing station.

Table 10

Spore Germination of *Pyricularia grisea* on
Fruit Dusted with Various Dust Formulations[1]

Fungicide Dust	Concentration (% Act. Ing.)	Bag	Percent Spore Germination — Days After Treatment: 4	11	18	26	33	40	47
Dithane M-45	20	Polyethylene	0	0	0	42.2	43.1	34.6	68.0
		Tissue, 1-ply	9.6	0	0	67.9	10.0	10.0	42.1
	10	Polyethylene	12.6	20.0	60.4	98.7	83.0	70.5	45.9
		Tissue, 1-ply	0	0	2.6	41.0	40.0	11.8	68.2
Thylate	20	Polyethylene	1.7	0	10.0	25.5	1.2	24.3	29.2
		Tissue, 1-ply	9.3	16.0	5.3	42.6	26.4	21.8	62.4
Manzate T	20	Polyethylene	33.7	68.3	14.5	100.0	70.2	100.0	95.0
		Tissue, 1-ply	89.6	81.8	55.5	90.7	98.5	100.0	66.6
Untreated		Polyethylene	100	100	100	100	100	100	100
		Tissue, 1-ply	100	100	100	100	100	100	100

1/ Fruit dusted 6 $\pm$ 1 weeks before harvest.

Table 11

Appressorium Formation of *Pyricularia grisea* on Fruit Dusted with Various Dust Formulations[1/]

Fungicide	Concentration (% Act. Ing.)	Bag	Percent Appressorium Formation: Days After Treatment 4	11	18	26	33	40	47
Dithane	20	Polyethylene	0	0	0	39.3	40.6	28.8	64.5
		Tissue, 1-ply	7.6	0	0	60.3	9.3	9.6	38.3
	10	Polyethylene	2.8	10.3	43.4	91.4	77.4	62.5	35.1
		Tissue, 1-ply	0	0	.8	37.7	34.9	11.8	64.0
Thylate	20	Polyethylene	0	0	6.0	16.9	.5	7.5	11.5
		Tissue, 1-ply	4.2	8.3	.5	36.8	19.3	.8	30.7
Manzate T	20	Polyethylene	27.0	53.6	.6	97.5	61.6	96.0	79.8
		Tissue, 1-ply	74.1	73.8	45.4	87.1	75.2	95.2	62.0
Untreated		Polyethylene	96.9	97.6	98.0	96.8	96.0	96.1	97.3
		Tissue, 1-ply	97.8	97.3	97.6	97.3	96.2	96.5	93.8

1/ Fruit dusted 6 ± 1 weeks before harvest.

Dusting fruit 5-7 weeks before harvest, when the Dithane spray residue may not be effective, would offer the additional protection needed in the field against late infection by fruit spotting fungi. During the fruit spot epidemic in Bananera in July-August, this control practice was found valuable. In Golfito, however, dusting was not successful. In this Division the bag and fruit are very wet in the morning and stick together and do not permit the insertion of a nozzle between bag and stem. Under these wet conditions, too, large lumps of fungicide dust are deposited on the fruit.

The problems of fruit scarring and excess fungicide residue which were observed to a large extent in Golfito and to a lesser extent in Bananera may be due to particle size and shape of the fungicide carrier, inadequate equipment, faulty technique and cart transportation of the fruit. Work is in progress to overcome these deficiencies should dusting still be needed in the future as an adjunct to spray in fruit spot control. (MUÑOZ)

Effect of Spray Intercycles and Trash Leaf Removal on Pitting Disease Incidence in Coto, Costa Rica

The effect of spray intercycles and trash leaf removal on pitting disease incidence was tested in Farm 47, Coto on fruit sprayed with Thylate and Dithane at the rates of 0.5 and 1.0 lb. per 5 gallons of water plus 7 ml of Triton X-45, respectively. Both fungicides were sprayed in weekly cycles and weekly cycles plus intercycles. All 4 fungicide-cycle treatments consisted of 3 replications, each approximately 4 acres in size. Trash leaf removal was practiced on all 12 plots since the beginning of the experiment on July 9. The first experimental fruit was harvested November 10. On this date and thereafter, fruit from adjacent areas representing standard farm practice of fruit spot control, namely, weekly spray cycles and no trash leaf removal, was also harvested and examined.

Data to date show that trash leaf removal alone would greatly reduce pitting disease incidence in Coto, most likely by cutting down on the amount of inoculum (Table 12). The combination of trash leaf removal and spray intercycle resulted in an even lower incidence of pitting disease. This was most evident with Dithane M-45. This added effect of the spray intercycle on pitting disease control could be related to the length of time in between spray cycles during which large areas of host tissue, without fungicide protection, are exposed to infection. A rapid inflorescence exposure is also apparent in Golfito. There is an average of 12-13 days from peeping of the inflorescence to complete inflorescence exposure for Golfito and 13.5-15 days for Honduras.

A shorter spray cycle with Dithane M-45 in Golfito at least during the worst of the fruit spot season increases protection of the rapidly emerging fingers and will help to reduce spotting. (MUÑOZ)

Table 12

Effect of Spray-Intercycle and Trash Leaf Removal on Pitting Disease Incidence in Coto, Costa Rica

Treatment	Rate (Lbs./5 Gals.)	No. of Stems Examined	Ave. No. of Spots/Stem	% Reduction Over Farm Practice
Thylate Weekly cycle	0.5	195	1.73	41.19
Thylate Weekly cycle + intercycle	0.5	211	1.56	46.94
Dithane M-45 Weekly cycle	1.0	186	1.78	39.28
Dithane M-45 Weekly cycle + intercycle	1.0	201	1.37	53.37
Standard Farm Practice Weekly cycle of Dithane M-45 and no trash leaf removal	1.0	584	2.94	

Effect of Dithane Concentration on Pitting Disease Incidence in Coto

Because of the high precipitation in Golfito, the fruit is wet for several hours in the morning until evaporation occurs. When this fruit is sprayed, a large amount of the fungicide mixture is washed off with run-off water leaving a poor fungicide deposit on the fruit. To compensate for this, the concentration of Dithane in the spray mixture was increased during the rainy season from 1 to 1.5 and 2.0 lbs. per 5 gallons of water. The amount of Triton X-45 was maintained as recommended, at 7 ml per 5 gallons of spray mixture.

Fruit sprayed at the rate of 1 and 2 lbs. of Dithane per 5 gallons of water was examined at the boxing station in Farm 48 and pitting disease incidence was recorded. In Farm 48 fruit spot incidence was generally higher than in other farms of Coto District in 1967 and 1968. Half of the farm had been on the 2-lb. rate since the beginning of the year.

Table 13 shows data taken in July and September on fruit picked up at random at the boxing station. Only on July 16 was pitting disease incidence similar for the 2 fungicide rates. On the other 2 sampling dates disease incidence in the 1-lb. rate was about 40% more than the 2-lb. rate. (MUÑOZ)

Field Testing of Experimental Bags in Coto

A series of tissue bags were tested in Farm 47 of Coto District for:- 1) fruit spot protection, 2) incidence of fruit scarring, and 3) weathering. A description of bag treatments and suppliers is given in Table 14.

A total of 25 stems per week were protected with each bag type during 6 weeks in August and September. The bags were periodically observed in the field and at harvest time readings were taken on fruit scarring, weathering, and pitting disease incidence. The degree of fruit scarring was classified as clean, light, medium, and severe, depending on the number and size of areas scarred. Table 15 shows that for all bag treatments 50-60% of the stems had some degree of scarring. Tearing was used as a measure of weathering and was classified as slight, moderate, and excessive, depending on the number and size of the ruptures. The ability of the bags to withstand weathering was dependent on the presence or absence of an external polyethylene bag and/or in the presence or absence of wet strength additives (Table 15). Without a polyethylene bag, the double tissue bag performed very well but the single tissue bag performed poorly. Protection against pitting disease was very similar for all bag types. Average number of spots per stem varied between 1.82 and 2.10 between August and December. (MUÑOZ)

Field Testing of Thylate for Fruit Spot Control in Costa Rica

An experiment was initiated in Farm 47 on April 29 to test Thylate under conditions of heavy rainfall and high inoculum level. In this experiment

Table 13

Incidence of Pitting Disease on Fruit Sprayed with Dithane at 1.0 and 2.0 Lb. Per 5 Gallons of Water[1/]

Treatment		Dates 7/16	7/29	9/4	Total
Dithane 1.0 lb.	No. of stems	55	50	50	155
	No. of spots	409	412	219	1040
	Ave. No. of Spots/Stem	7.44	8.24	4.38	6.70
Dithane 2.0 lbs.	No. of stems	41	50	146	237
	No. of spots	342	225	400	967
	Ave. No. of Spots/Stem	8.34	4.50	2.74	4.08

1/ Fruit sampled at random at boxing station in Farm 48 of Coto, Costa Rica.

Table 14

Description of Bag Treatment

Treatment No.1/	Bag Treatment
1	Single-ply 15-lb. tissue Kraft soft finish inside polyethylene bag.
2	Single-ply 20-lb. tissue Kraft non-wet strength inside polyethylene bag.
3	Single-ply 20-lb. tissue Kraft wet strength, no polyethylene bag.
4	Single-ply 20-lb. tissue Kraft non-wet strength, no polyethylene bag.
5	Outer ply 20-lb. tissue Kraft wet strength. Inner ply 10-lb. tissue Kraft soft finish, no polyethylene bag.
6	Single-ply Chase tissue inside polyethylene bag.

1/ Treatment 1-5 - Plyboard Industries.

Treatment 6 - Chase Bag Company.

Table 15

Effect of Bag Treatment on Fruit Scarring and Field Performance in Coto[1/]

Bag Treatment	No. of Stems or Bags Examined	Scarring				Degree of Tearing			
		Clean	Light	Medium	Severe	Intact	Slight	Moderate	Severe
		Percentage				Percentage			
1	89	44	16	33	7	7	58	29	6
2	95	46	17	25	12	17	49	28	6
3	88	45	18	21	16	10	6	42	42
4	91	43	27	18	12	0	11	41	48
5	97	40	29	29	2	25	39	34	2
6	103	40	25	21	14	2	28	44	26

1/ August-December 1968.

Dithane M-45 and Thylate were applied at the rates of 1/2 and 1 lb. in 5 gallons of water and the fruit was bagged with polyethylene and single-ply tissue bags. Triton X-45 was used at the recommended concentration of 7 ml per 5 gallons of spray mixture. The 12 fungicide-bag treatments were replicated 4 times in a split-split plot experimental design using bag type as the main plots, fungicides as the sub-plots and rates as the sub-subplots for a more critical statistical evaluation of rates. Each replication was about 1 1/3 acres in size.

From May 1 to July 9 spraying was carried out on weekly cycles plus intercycles. On July 9 the intercycles were discontinued. Trash leaf removal was practiced between May and August. The fruit was bagged immediately after the last spray application and all other farm practices were similar to those of the Division. Data on fruit spot incidence were taken at harvest time at the boxing station. Approximately 10 stems per treatment per week were examined and the number of pits, diamond and brown spots on the 3 oldest hands of each stem were counted.

Thus far, pitting disease is the most important fruit spot in Coto (Table 16). There are about 20 times more pitting disease spots than diamond spots and about twice as much pitting disease as brown spots. When the incidence of pitting disease alone was analyzed (Table 17), the difference between bag means was found significant at the 5% level for the fruit sprayed with Dithane or Thylate. At the same level, however, no significant difference was observed between bag means of fruit sprayed with Thylate and bagged with polyethylene bag and fruit sprayed with Dithane and bagged with tissue bag. The difference between rate means was found significant at the 1% level for the 0 and 1/2 and 0 and 1 lb. rates. Between the 1/2 and 1 lb. rates there was no significant difference even at the 5% level. An interaction was observed between bag treatment and fungicide rates. As shown in Figure 18, the effect of this interaction was on magnitude of response. At all fungicide rates bag treatment had an effect on the incidence of pitting disease. An analysis of the incidence of all spots (pitting disease, diamond and brown spots) shows essentially the same trend (Table 18). In the interaction between bag treatments and fungicide rates, however, the effect of Thylate on pitting disease incidence was more affected by bag treatment (Figure 18). The effect of bag and fungicide treatments on the weekly incidence of all spots is also shown in Figures 19 and 20. On fruit protected with polyethylene bag and sprayed with Thylate there was generally less spotting in the 1-lb. rate than in the 1/2-lb. rate. When the tissue bag was used, however, about the same level of spotting was observed for the 2 rates of Thylate. The peaks in disease incidence observed after October 15 in Figures 19 and 20 are apparently the result of the discontinuation of the spray intercycles on July 9. Disease incidence increased in all fungicide treatments even though inoculum level was decreasing as shown by the drop in disease incidence on the unsprayed fruit.

Table 16

Incidence of Pitting Disease, Diamond and Brown Spots on Fruit Sprayed with Dithane and Thylate and Protected with Polyethylene and Single-Ply Tissue Bags

		Polyethylene Bag			1-Ply Tissue Bag		
		Ave. No. of Spots/Stem 1/			Ave. No. of Spots/Stem		
Fungicide	Rate (Lbs./5 Gals.)	Pitting Disease	Diamond Spot	Brown Spot	Pitting Disease	Diamond Spot	Brown Spot
Dithane	0.5	1.43	0.09	0.47	1.23	0.07	0.39
Dithane	1.0	1.17	0.04	0.44	0.89	0.10	0.39
Thylate	0.5	1.11	0.07	0.33	0.74	0.06	0.28
Thylate	1.0	0.88	0.04	0.32	0.78	0.04	0.40
Unsprayed	-	2.81	0.13	1.23	1.88	0.10	0.69

1/ Based on examination of 409 to 453 stems per fungicide treatment and 830 to 837 stems for unsprayed checks. Stem = 3 oldest hands.

Table 17

Incidence of Pitting Disease on Fruit Sprayed with Dithane and Thylate and Protected with Polyethylene and Single-Ply Tissue Bags

		Ave. No. of Spots/Stem1/			
		Rates			Bag
Bag	Fungicide	0	1/2	1	Mean
Polyethylene	Dithane	2.81	1.42	1.17	1.80
	Thylate	2.81	1.11	0.87	1.60
Tissue, 1-Ply	Dithane	1.92	1.21	0.88	1.34
	Thylate	1.83	0.74	0.77	1.11
Rate Mean		2.34	1.12	0.92	

1/ Based on examination of 409 to 453 stems per fungicide-bag treatment. Stem = 3 oldest hands.

Least Significant Difference	.01	.05
1. Between bag means	NS	0.37
2. Between rate means	0.28	0.20
3. Between rates in same bag treatment	0.39	0.29

Coefficient of Variation: 19%

Generally, the single-ply tissue bag appears to offer more protection against fruit spots than the polyethylene bag in Coto (Figure 21) in spite of the high degree of tearing recorded for this bag in Table 15. Thylate at the rate of 1/2 pound controls pitting disease as effectively as Dithane at the rate of 1 lb. and control is increased when Thylate is used at the rate of 1 lb. on fruit protected with polyethylene bag. On fruit protected with the single-ply tissue bag no difference in fruit spot control was observed between the 1/2 and 1 lb. rates of Thylate. (MUÑOZ)

Field Testing of Thylate for Fruit Spot Control in Honduras

The same experimental design and combination of bag-fungicide-rate treatments used in Coto were used for testing Thylate in Ceibita Farm, Honduras. In this experiment all treatments were initiated on April 8 and the spraying was carried out only in weekly cycles.

From July 10 to November 12 approximately 494 to 611 stems per fungicide-bag treatment were examined at the boxing station and the number of pits, diamond and brown spots on the 3 oldest hands were counted. The incidence of each of these fruit spots is shown in Table 19. There were about 3-4 times more brown spots than pitting disease spots and about 6-7 times more brown spots than diamond spots. When the incidence of pitting disease was analyzed (Table 20), only the difference between rate means was found significant at the 5% level. In the analysis of the incidence of all fruit spots (pitting disease, diamond and brown spots) a significant difference was found between rate means at the 5% and 1% levels and between rates in the same fungicide treatment at the 5% level (Table 21). The differences in disease incidence between 0 and 1/2 and 1/2 and 1 lb. rates were generally larger on the Dithane-sprayed fruit than on the Thylate-sprayed fruit protected with either polyethylene or tissue bags. On the Thylate-sprayed fruit protected with tissue bag there was no significant difference at the 5% level between the 1/2 and 1 lb. rates. Also, the difference between the 0 and 1/2 lb. rates was larger than the difference between the same rates on the Dithane-sprayed fruit. In the analysis of the incidence of all fruit spots an interaction was observed between the effect of rates and the effect of fungicide treatments and between rates, fungicide and bag treatments. Figure 22 shows that on fruit protected with either polyethylene or tissue bag the effect of rates on disease incidence was more important for Dithane than for Thylate. A bag treatment effect was also observed on the Thylate sprayed fruit.

The weekly incidence of diamond spot on fruit sprayed with Thylate at the rates of 1/2 and 1 lb. and Dithane at 1 lb. per 5 gallons of water is shown in Figures 23 and 24. Diamond spot incidence on fruit protected with either bag type and sprayed with Thylate at 1 lb. was generally lower than on fruit sprayed with Dithane at the same rate. On fruit protected with polyethylene bag and sprayed with Thylate at 1/2 lb., diamond spot incidence was greater than on

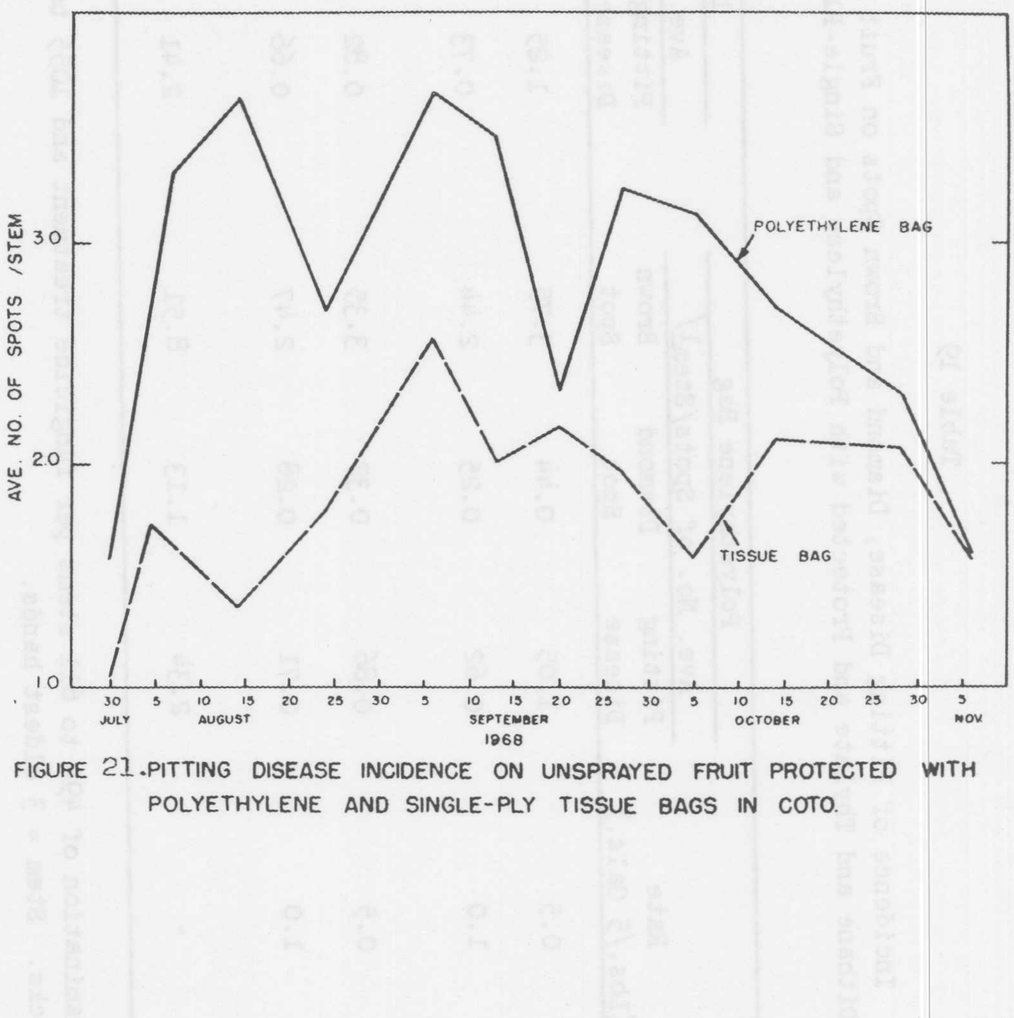


FIGURE 21. PITTING DISEASE INCIDENCE ON UNSPRAYED FRUIT PROTECTED WITH POLYETHYLENE AND SINGLE-PLY TISSUE BAGS IN COTO.

Table 19

Incidence of Pitting Disease, Diamond and Brown Spots on Fruit Sprayed with Dithane and Thylate and Protected with Polyethylene and Single-Ply Tissue Bags

		Polyethylene Bag			1-Ply Tissue Bag		
		Ave. No. of Spots/Stem 1/			Ave. No. of Spots/Stem		
Fungicide	Rate (Lbs./5 Gals.)	Pitting Disease	Diamond Spot	Brown Spot	Pitting Disease	Diamond Spot	Brown Spot
Dithane	0.5	1.05	0.44	3.75	1.25	0.59	3.72
Dithane	1.0	0.62	0.25	2.44	0.73	0.37	2.07
Thylate	0.5	0.86	0.32	3.35	0.82	0.37	2.87
Thylate	1.0	0.71	0.28	2.47	0.66	0.32	2.42
Unsprayed	-	2.34	1.13	8.51	2.41	1.15	7.39

1/ Based on examination of 494 to 611 stems per fungicide treatment and 1055 to 1120 stems for unsprayed checks. Stem = 3 oldest hands.

Table 20

Incidence of Pitting Disease on Fruit Sprayed with Dithane and Thylate and Protected with Polyethylene and Single-Ply Tissue Bags

Bag	Fungicide	Ave. No. of Spots/Stem[1/] Rates 0	1/2	1	Bag Mean
Polyethylene	Dithane	2.64	1.05	0.61	1.43
	Thylate	2.21	0.86	0.75	1.27
Tissue, 1-Ply	Dithane	2.54	1.27	0.73	1.51
	Thylate	2.28	0.85	0.64	1.26
Rate Mean		2.42	1.01	0.68	-

1/ Based on examination of 494 to 611 stems per fungicide-bag treatment. Stem = 3 oldest hands.

Least Significant Difference	.01	.05
1. Between bag means	NS	NS
2. Between rate means	0.28	0.21
3. Between rates in same bag treatment	NS	NS

Coefficient of Variation: 21%

Table 21

Incidence of All Fruit Spots on Fruit Sprayed with Dithane and Thylate and Protected with Polyethylene and Single-Ply Tissue Bags

Bag	Fungicide	Ave. No. of Spots/Stem[1/] Rates 0	1/2	1	Bag Mean
Polyethylene	Dithane	13.45	5.23	3.27	7.32
	Thylate	10.76	4.54	3.55	6.28
Tissue, 1-Ply	Dithane	11.07	5.69	3.18	6.65
	Thylate	10.65	4.05	3.32	6.01
Rate Mean		11.48	4.88	3.33	-

1/ Based on examination of 494 to 611 stems per fungicide-bag treatment. Stem = 3 oldest hands.

Least Significant Difference	.01	.05
1. Between bag means	NS	NS
2. Between rate means	0.88	0.65
3. Between rates in same bag treatment	NS	NS
4. Between rates in same fungicide treatment	NS	0.92

Coefficient of Variation: 14%

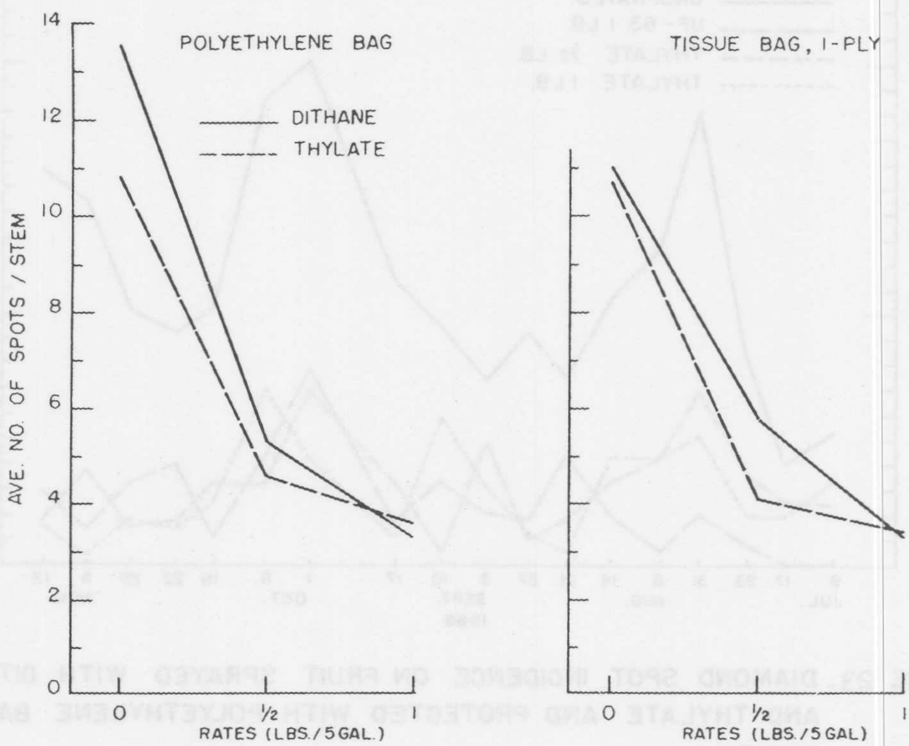


FIGURE 22. EFFECT OF RATE, FUNGICIDE AND BAG TREATMENTS ON THE INCIDENCE OF ALL FRUIT SPOTS IN CEIBITA.

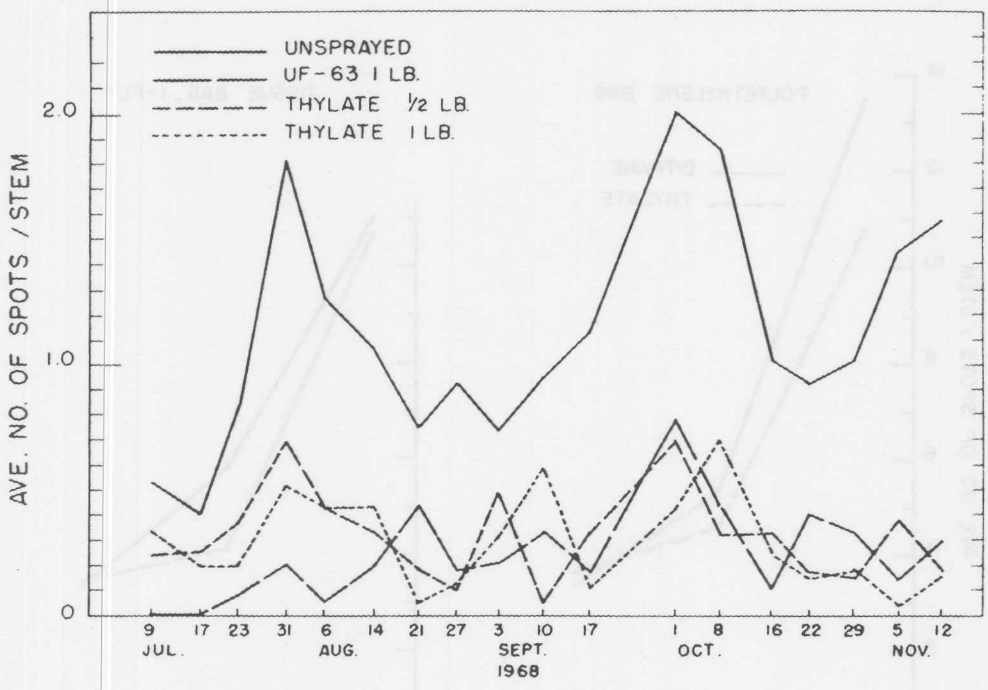


FIGURE 23. DIAMOND SPOT INCIDENCE ON FRUIT SPRAYED WITH DITHANE AND THYLATE AND PROTECTED WITH POLYETHYLENE BAG IN CEIBITA.

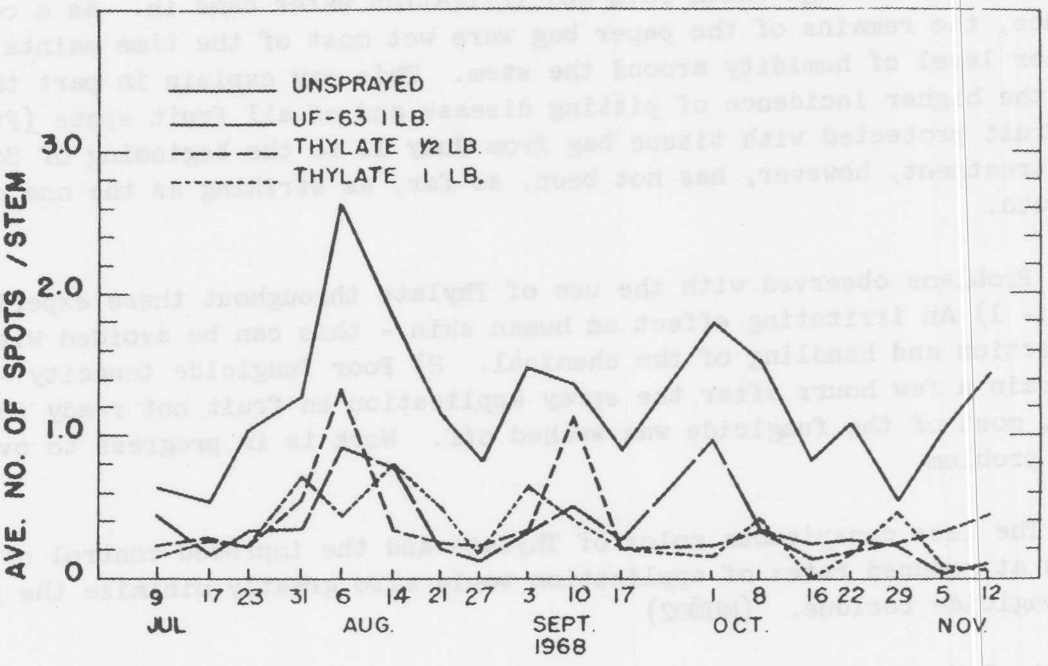


FIGURE 24. DIAMOND SPOT INCIDENCE ON FRUIT SPRAYED WITH DITHANE AND THYLATE AND PROTECTED WITH SINGLE-PLY TISSUE BAG IN CEIBITA.

fruit sprayed with Dithane at 1 lb., especially on late July and October. Brown spot incidence on fruit bagged with polyethylene or tissue bags and sprayed with Thylate at 1/2 lb. was about the same as on fruit sprayed with Dithane at 1 lb. since the beginning of September (Figures 25 and 26).

Although no significant difference at the 1% or 5% level was observed between bag treatments, a comparison of fruit spot incidence on unsprayed fruit bagged with polyethylene and with single-ply tissue bags was made. Figure 27 shows a greater amount of spotting on fruit protected with tissue bag up to the beginning of September. A blowdown on May 24 affected 25-40% of the experimental area and greatly damaged the tissue bag causing ruptures of all sizes through which rain and irrigation water came in. As a consequence, the remains of the paper bag were wet most of the time maintaining a higher level of humidity around the stem. This may explain in part the reason for the higher incidence of pitting disease and of all fruit spots (Figure 27), on fruit protected with tissue bag from July 10 to the beginning of September. Bag treatment, however, has not been, so far, as striking as the one observed in Coto.

Problems observed with the use of Thylate throughout these experiments were:- 1) An irritating effect on human skin - this can be avoided with proper protection and handling of the chemical. 2) Poor fungicide tenacity - if there was rain a few hours after the spray application on fruit not ready for bagging, most of the fungicide was washed off. Work is in progress to overcome this problem.

The less conspicuous color of Thylate and the improved control of fruit spots at reduced rates of application would also greatly minimize the problem of fungicide residue. (MUÑOZ)

Effect of Weather on Inoculum and Pitting Incidence in Honduras

The rain and temperature effect on Pyricularia spores, trapped in Guaruma 1, were similar to previous years. Spore peaks during January and February 1968 were below 3000 because of low night-time minimum temperatures (Figure 28). The average minimum temperature during the first three months was 63.4 F. Low temperatures are known to reduce Pyricularia sporulation. On the third week in March, during a warmer period, minimum night temperature was 66.0 F and 0.12 inch of rain produced two peaks of more than 3000 spores. The following dry period of 57 days with only 0.34 inch of rain reduced the number of P. grisea spores to practically nil. A rainy period started on May 22nd and 11.46 inches of rain fell on 12 consecutive days, but there was only one peak of 3000 spores on May 28. Rainfall in May increased the average daily spore count to over 300 as compared to 56 during the dry period in April. The number of spores in June increased further and peaks well over 3000 spores developed, including a high record count of over 20,000 spores on June 29. During July and August, 18 important spore peaks were produced by a rainfall of

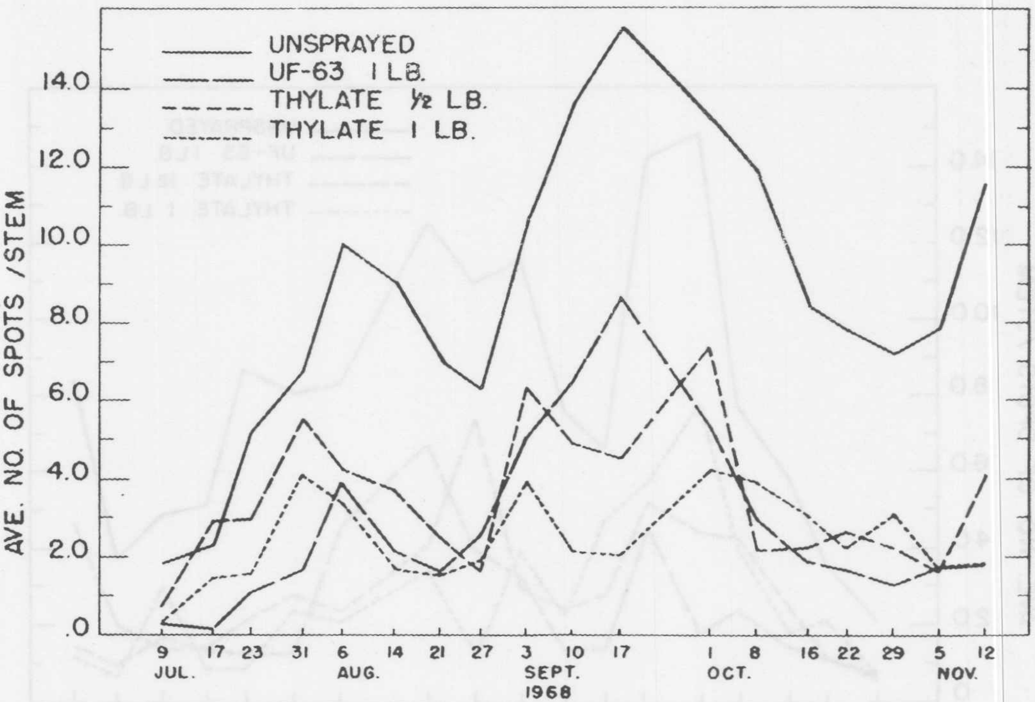


FIGURE 25. BROWN SPOT INCIDENCE ON FRUIT SPRAYED WITH DITHANE AND THYLATE AND PROTECTED WITH POLYETHYLENE BAG IN CEIBITA.

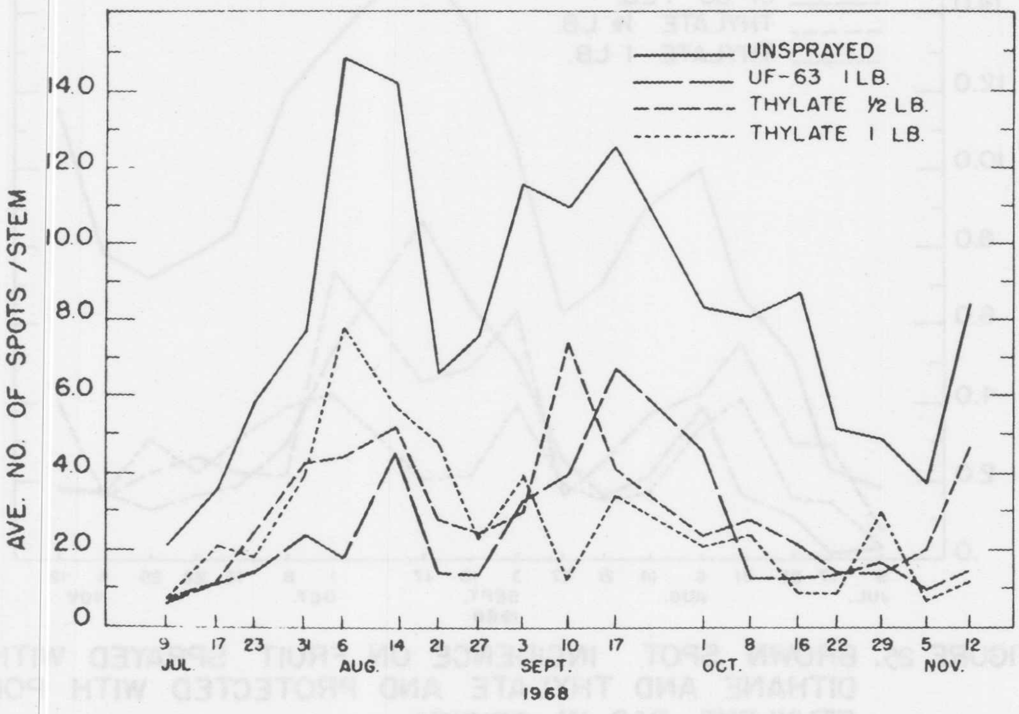


FIGURE 26. BROWN SPOT INCIDENCE ON FRUIT SPRAYED WITH DITHANE AND THYLATE AND PROTECTED WITH SINGLE-PLY TISSUE BAG IN CEIBITA.

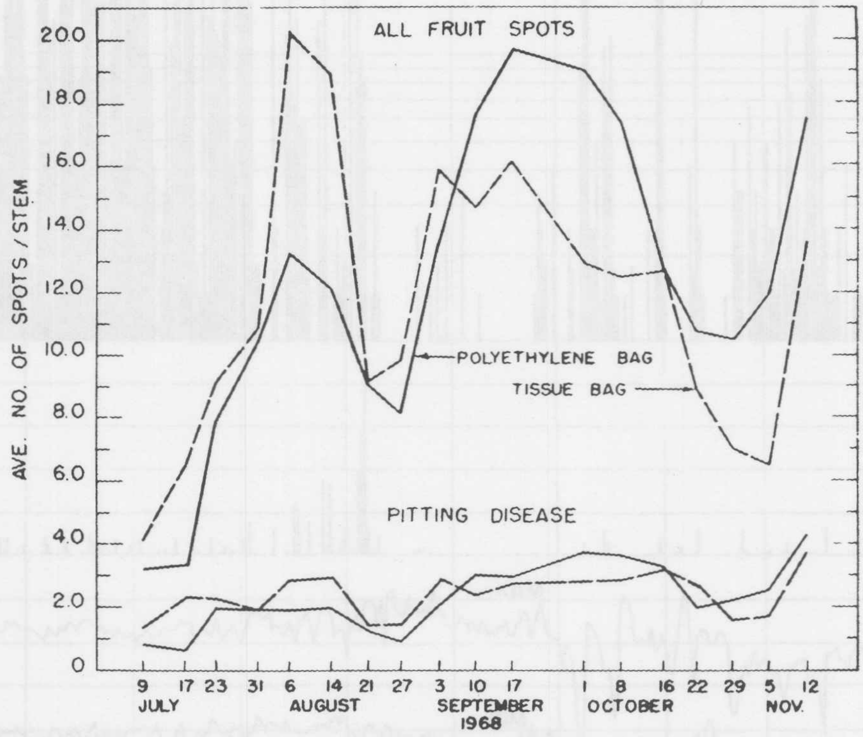


FIGURE 27. INCIDENCE OF PITTING DISEASE AND OF ALL FRUIT SPOTS ON UNSPRAYED FRUIT PROTECTED WITH POLYETHYLENE AND SINGLE-PLY TISSUE BAGS IN CEIBITA.

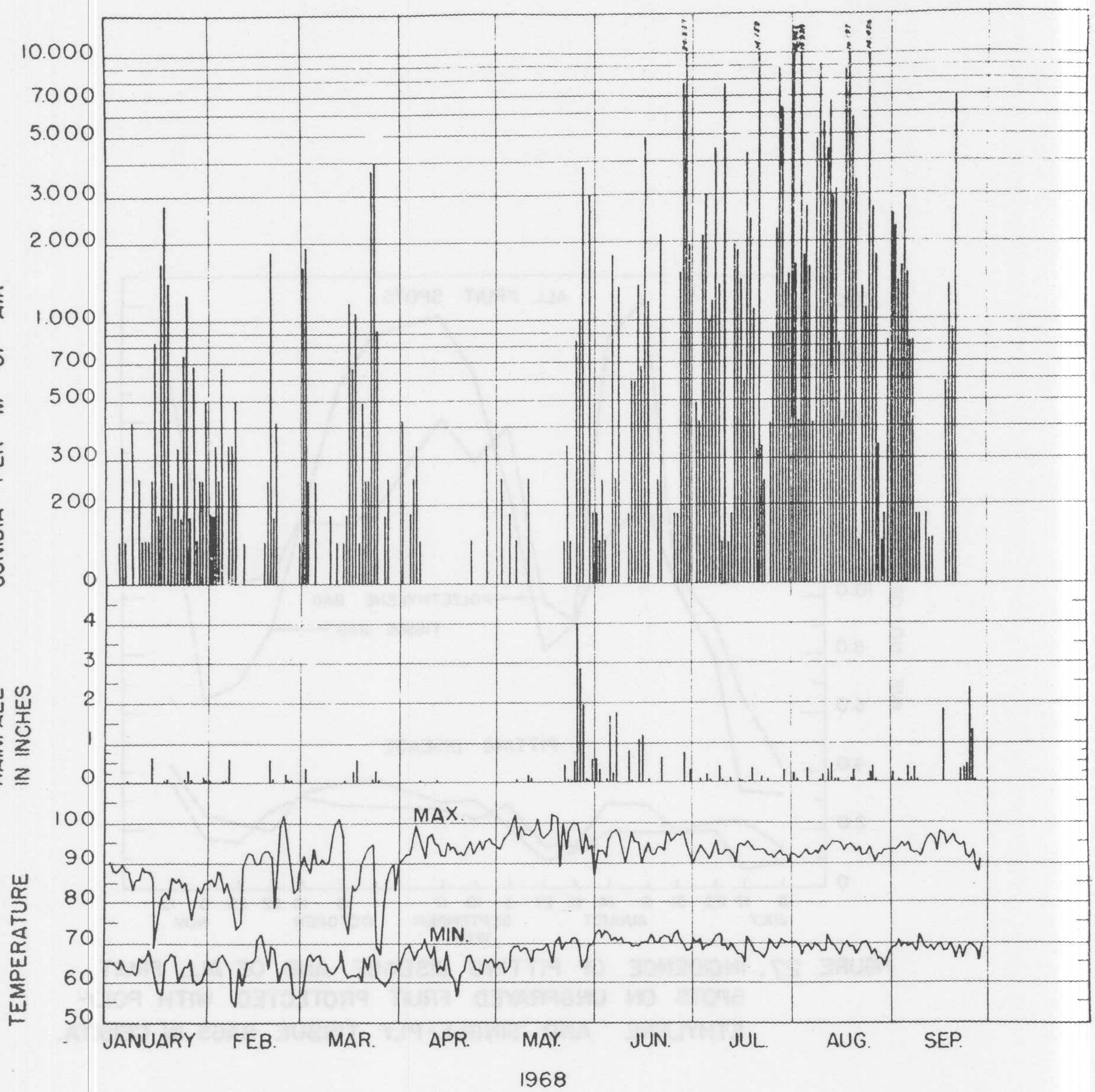


Figure 28

Daily counts of Pyricularia grisea conidia per m^3 of air from Hirst spore trap slides from Guaruma 1 in relation to maximum-minimum temperatures and rainfall.

0.5 inch or less. Minimum night temperatures during these peaks were at least 68.0 F or higher. As in previous years, the amount of spores trapped was not related to the amount of rain.

The number of Pyricularia spores trapped in the Guaruma 1 area was considerably higher than in other farms, because plants with hanging dead leaves were close to the spore trap and provided a favorable substrate for sporulation.

Pitting incidence at Ceibita and San Juan was recorded on 500 inner whorl fingers of the 3 oldest hands prior to fruit selection. Peaks of pitting incidence recorded at both stations were below 2 percent of fingers on fruit protected with paper-lined chill bags (Figure 29). Pitting was almost absent from March through mid-July, followed by an increase to 3.5 and 2.5 percent spotting in Ceibita and San Juan stations, respectively. The lower pitting incidence in San Juan Farm was probably the result of a cleaner plantation. Fruit spotting on clusters after ripening was at or below 5 percent, as indicated by Quality Control reports. Data from these reports was plotted 2 weeks prior to report date to correlate with disease examination date at the packing stations. (HALMOS)

Effect of Weather on Inoculum and Brown Spot Incidence in Honduras

Cercospora hayi, causal organism of brown spot, was counted daily on spore trap slides from Guaruma 1 (Figure 30). Low daytime maximum and night time minimum temperatures at the beginning of the year had a reducing effect on spore numbers. The daily average spore count from January through March was 400, while during May and September it was 900 and 1800, respectively. Peaks in May and September produced over 8000 to 10,000 spores but these peaks were not associated with rainfall. However, large amounts of Cercospora spores were dispersed when dry periods with high daytime maximum temperatures were followed by less than 0.2 inch of rain. Spore peaks in May and September appeared regularly during the past four years. Therefore, collection of spore trap data was discontinued. It is now evident that ample inoculum is available during these periods to cause serious spotting provided other conditions for infection are optimum.

Brown spot infection on the fruit was surveyed at San Juan packing station. The percent of inner whorl fingers spotted was plotted (Figure 30). Peaks of fruit infection were below the commercially significant 25 percent level all year. This spot reduction was the result of the fruit spray program, which was in effect throughout the year. Brown spot infection during previous years caused economically significant fruit losses during August-September and November through January. (HALMOS)

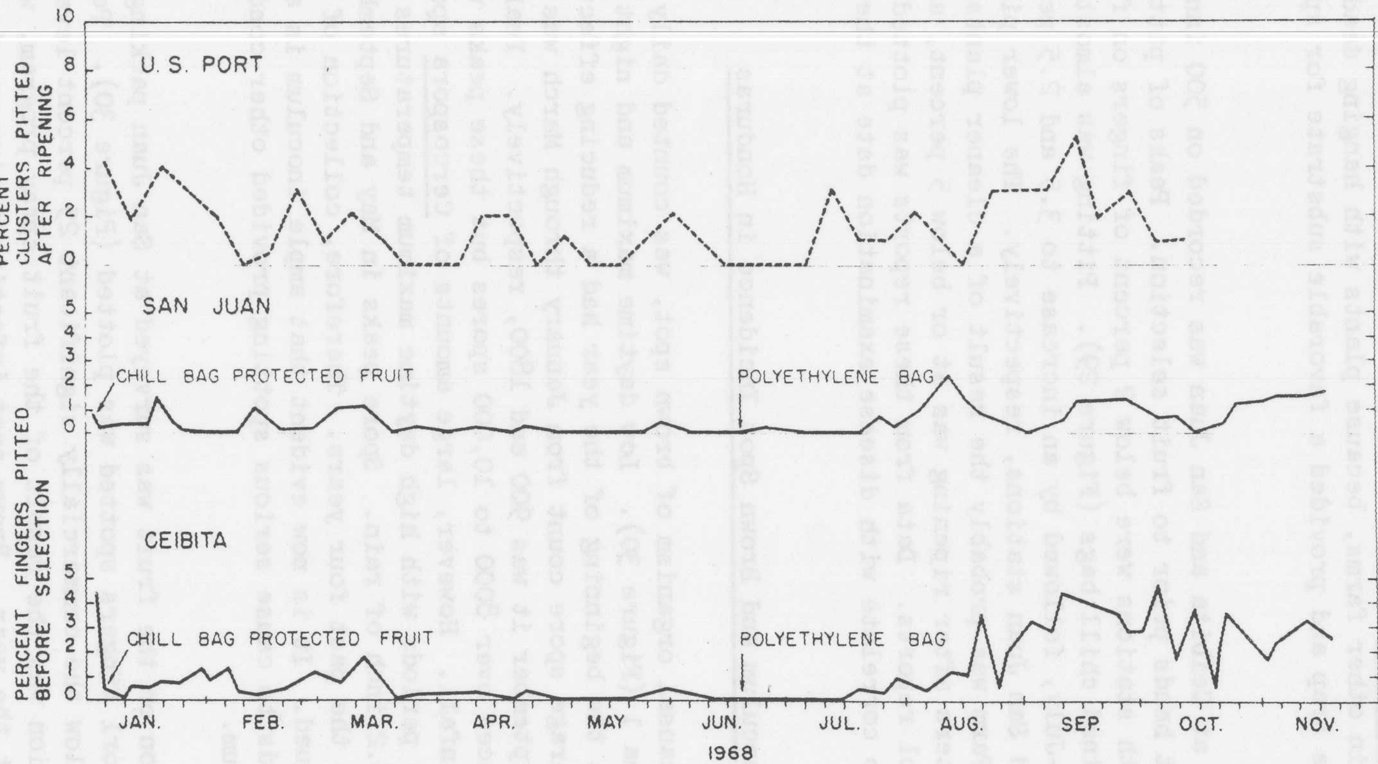


Figure 29
Pitting disease incidence at Ceibita and San Juan packing stations from weekly survey of 500 inner whorl fingers, as compared to percent clusters affected with pitting after ripening in U. S. A.

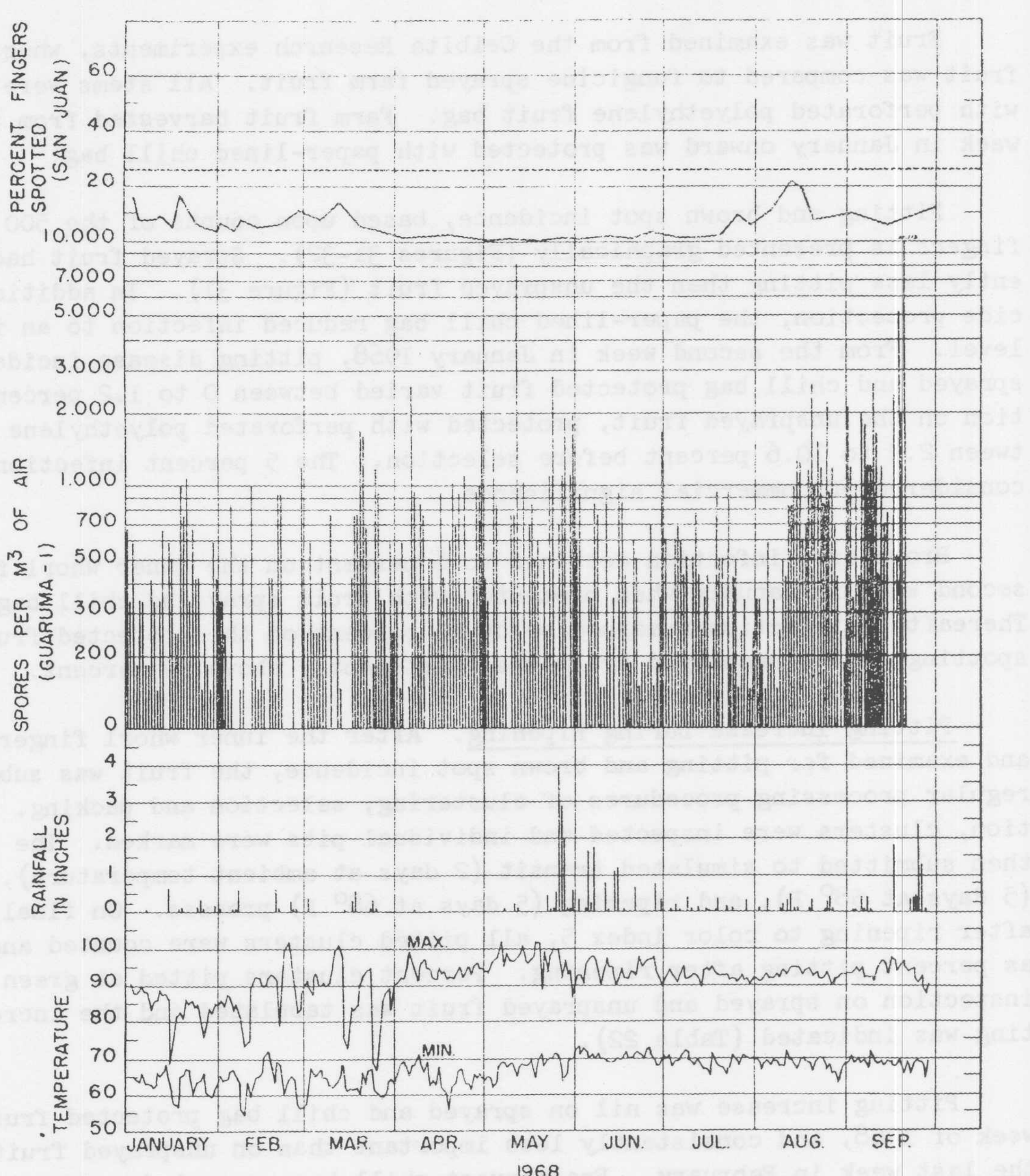


Figure 30

Daily counts of Cercospora hayi spores per m^3 of air from Hirst spore trap slides from Guaruma 1 in relation to weather and percent of inner whorl fingers affected with brown spot at the San Juan packing station during 1968.

Pitting Disease and Brown Spot Incidence on Sprayed and Unsprayed Fruit in Ceibita

Fruit was examined from the Ceibita Research experiments, where unsprayed fruit was compared to fungicide sprayed farm fruit. All stems were protected with perforated polyethylene fruit bag. Farm fruit harvested from the second week in January onward was protected with paper-lined chill bag.

Pitting and brown spot incidence, based upon counts of the 500 inner whorl fingers is presented graphically (Figures 31-32). Sprayed fruit had consistently less pitting than the unsprayed fruit (Figure 31). In addition to fungicide protection, the paper-lined chill bag reduced infection to an insignificant level. From the second week in January 1968, pitting disease incidence on the sprayed and chill bag protected fruit varied between 0 to 1.2 percent. Infection on the unsprayed fruit, protected with perforated polyethylene bag, was between 2.2 to 10.6 percent before selection. The 5 percent infection level was considered of commercial significance.

Brown spot infection declined to 6 percent on the inner whorl fingers the second week in January when protected with fruit spray and chill bag (Figure 32). Thereafter, infection remained below 10 percent on the protected fruit, while spotting on the unsprayed fruit was consistently above 25 percent.

Pitting Increase During Ripening. After the inner whorl fingers were counted and examined for pitting and brown spot incidence, the fruit was submitted to regular processing procedures of clustering, selection and packing. After selection, clusters were inspected and individual pits were marked. The fruit was then submitted to simulated transit (2 days at ambient temperature), shipping (5 days at 58° F), and ripening (5 days at 68° F) process. On final inspection, after ripening to color index 5, all pitted clusters were counted and expressed as percent pitting after ripening. Percent clusters pitted at green and ripe inspection on sprayed and unsprayed fruit was tabulated and the increased pitting was indicated (Table 22).

Pitting increase was nil on sprayed and chill bag protected fruit the second week of 1968, and consistently less important than on unsprayed fruit, except on the last week in February. Pre-harvest chill bag removal from the sprayed fruit may have permitted late infection because spray residues are largely inactivated after 6 weeks. (HALMOS)

Pyricularia Inoculation of Bananas and Rice Plants

Host specificity of Pyricularia was studied because it was thought that cross infection may occur between rice and bananas. Morphological differentiation based upon conidial measurement between pitting disease and rice blast organisms was difficult or often impossible. Cultural characteristics were

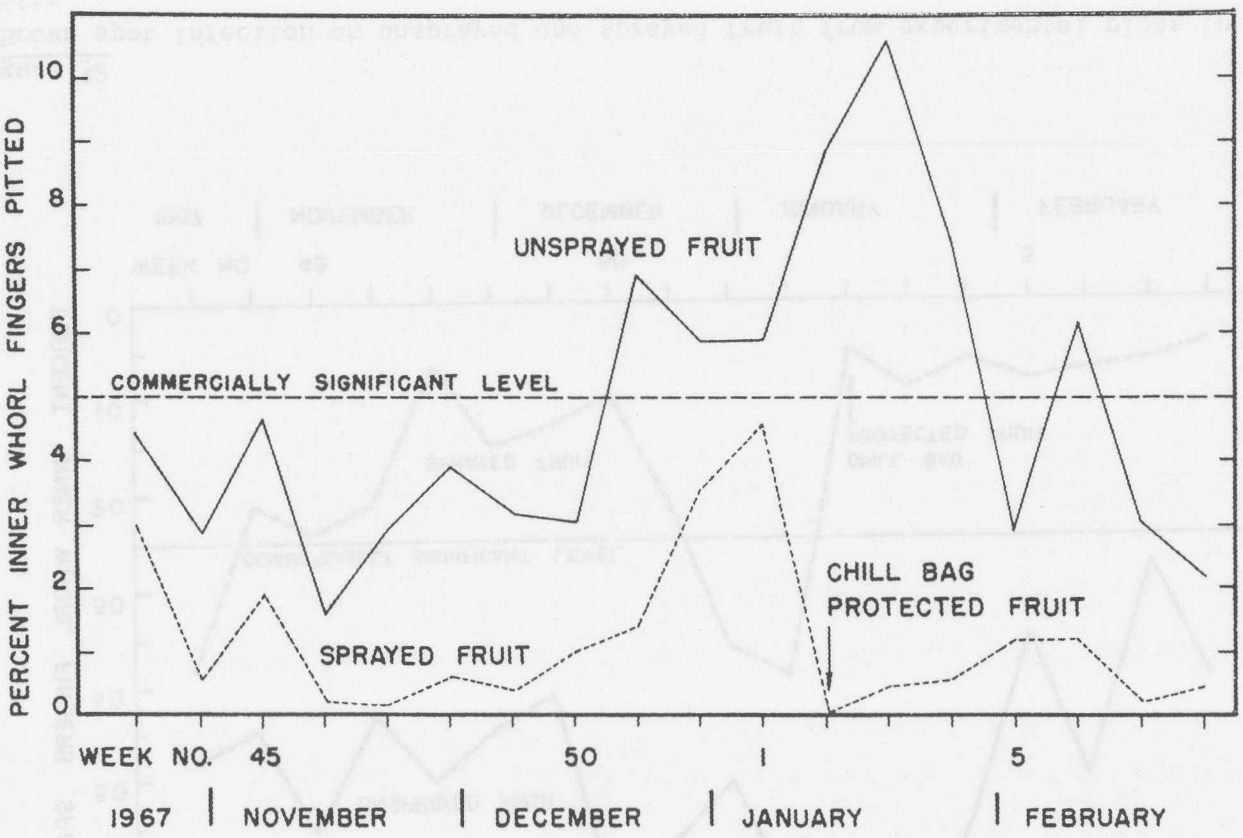


Figure 31
Pitting disease incidence, as counted on 500 inner whorl fingers on the three oldest hands prior to selection on unsprayed and sprayed fruit from experimental plots in Ceibita Farm.

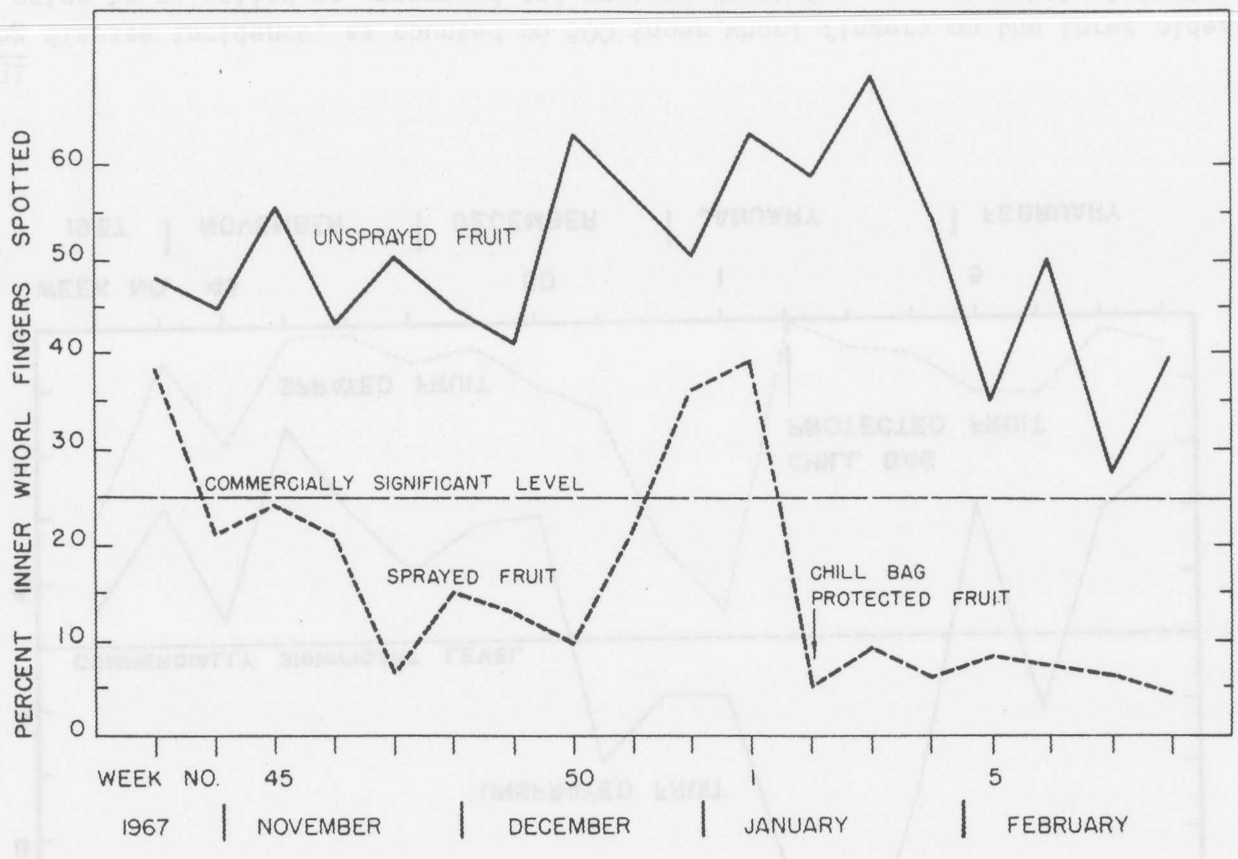


Figure 32
Brown spot infection on unsprayed and sprayed fruit from experimental plots in Ceibita.

Table 22

Percent Pitting Increase During Simulated Transit, Shipping and Ripening Processes on Sprayed and Unsprayed Fruit From Ceibita

Fruit Harvest Date	Dithane M-45 Sprayed Fuit (a)				Unsprayed Fruit (b)			
	Percent Clusters Pitted			Pitting	Percent Clusters Pitted			Pitting
	No. Clusters	Green	Ripe	Increase	No. Clusters	Green	Ripe	Increase
12/27/67	96 (b)	5.2	9.4	4.2	80	10.0	17.5	7.5
1/3/68	93 "	4.3	7.5	3.2	92	20.7	35.9	15.2
1/9	80 (c)	1.3	1.3	0	72	11.1	19.4	8.3
1/16	77 "	1.3	2.6	1.3	83	13.3	19.3	6.0
1/23	78 "	3.8	11.5	7.7	76	3.9	23.7	19.7
1/30	87 "	2.3	8.0	5.7	89	4.5	12.4	7.9
2/6	102 "	1.9	7.8	5.9	90	8.9	23.3	14.4
2/13	96 "	2.1	12.5	10.4	100	6.0	17.0	11.0
2/20	83 "	3.6	16.9	13.3	84	3.6	13.1	9.5

(a) One pound of Dithane M-45 per 5 gallons of water fruit spray.

(b) Standard, perforated polyethylene fruit bag.

(c) Tissue paper-lined perforated polyethylene fruit bag.

identical when growing on autoclaved Commelina leaves, used as standard sporulating media. Eight-day-old sporulating cultures of P. grisea and P. oryzae were used to inoculate bananas at 14/32 inch grade. To provide direct transfer of P. oryzae spores, heavily blasted Bluebonnet rice leaves were used for inoculation. No spotting occurred on bananas which were inoculated with spore suspension of P. oryzae or with blast infected rice leaves. After 8 days of incubation at 28° C characteristic pits developed on bananas which were inoculated with spore suspension of Pyricularia grisea from bananas.

Blast susceptible Bluebonnet rice plants were inoculated at the fourth leaf stage both with Pyricularia oryzae and P. grisea from bananas. After the spore suspension was applied the potted plants were enclosed in humidified plastic bags and incubated for two days in the air-conditioned laboratory (24 ± 1.5° C). Following incubation, the plants were transferred to the open air. Within 3 days, water-soaked lesions appeared on the leaves of all plants which were inoculated with P. oryzae. These lesions developed into characteristic blast symptoms eight days after inoculation. Other plants which were inoculated with P. grisea remained healthy. (HALMOS)

CROWN ROT

Inoculum Potential in Dehanding and Delatexing Tanks

To determine kinds and numbers of organisms present in wash water and how they are affected by the current chlorination practices, four packing stations with widely differing water conditions were surveyed. At hourly intervals throughout the working day, samples of water from both dehanding and delatexing tanks were taken and tested for chlorine concentration and microbial population. Each hour five boxes of fruit were also taken for later determination of crown rot. Residual chlorine was determined by iodometric titration immediately after each sample was taken. For the determination of the microflora in the water, samples were taken to the laboratory, and serial dilutions were prepared and plated with nutrient agar for counting bacteria, and ripe banana agar containing 0.25% lactic acid for counting fungi. The fruit was ripened on a 16-day schedule with simulated rail and ship transit (48 hours at ambient temperature outdoors followed by 10 days at 56^{o} F) and was then examined for crown rot.

None of the stations tested maintained the recommended 1 ppm residual chlorine in both tanks throughout the working day (Figure 33). In general, residual chlorine levels declined as the day progressed, due to the accumulation of debris in the tanks. The residual chlorine in the dehanding tanks almost always remained well below 1 ppm, while the delatexing tanks contained close to, or above the recommended level.

The bacterial and fungal populations of the dehanding tanks were considerably higher than those of the delatexing tanks (Figure 33). The only exception was in Tacamiche where recirculation of insufficiently chlorinated water in the delatexing spray booths allowed the accumulation of viable spores.

A low residual chlorine level in the water usually resulted in a high number of viable fungal spores and bacteria. However, the hourly fluctuations in microbial population appeared more strongly influenced by the random introduction of inoculum into the water from the fruit and trash brought in with the fruit. This was especially evident in the dehanding tanks where the residual chlorine was always low. Only when the chlorine concentration was well above 1 ppm were the fungi and bacteria held to consistently low levels. Even at 1 ppm, significant numbers of fungal spores remained viable, including some known crown rotting organisms such as Botryodiplodia theobromae, Fusarium roseum and Deightoniella torulosum.

Qualitative changes in the fungal population also appeared to be a function of the random introduction of inoculum into the water from the fruit and

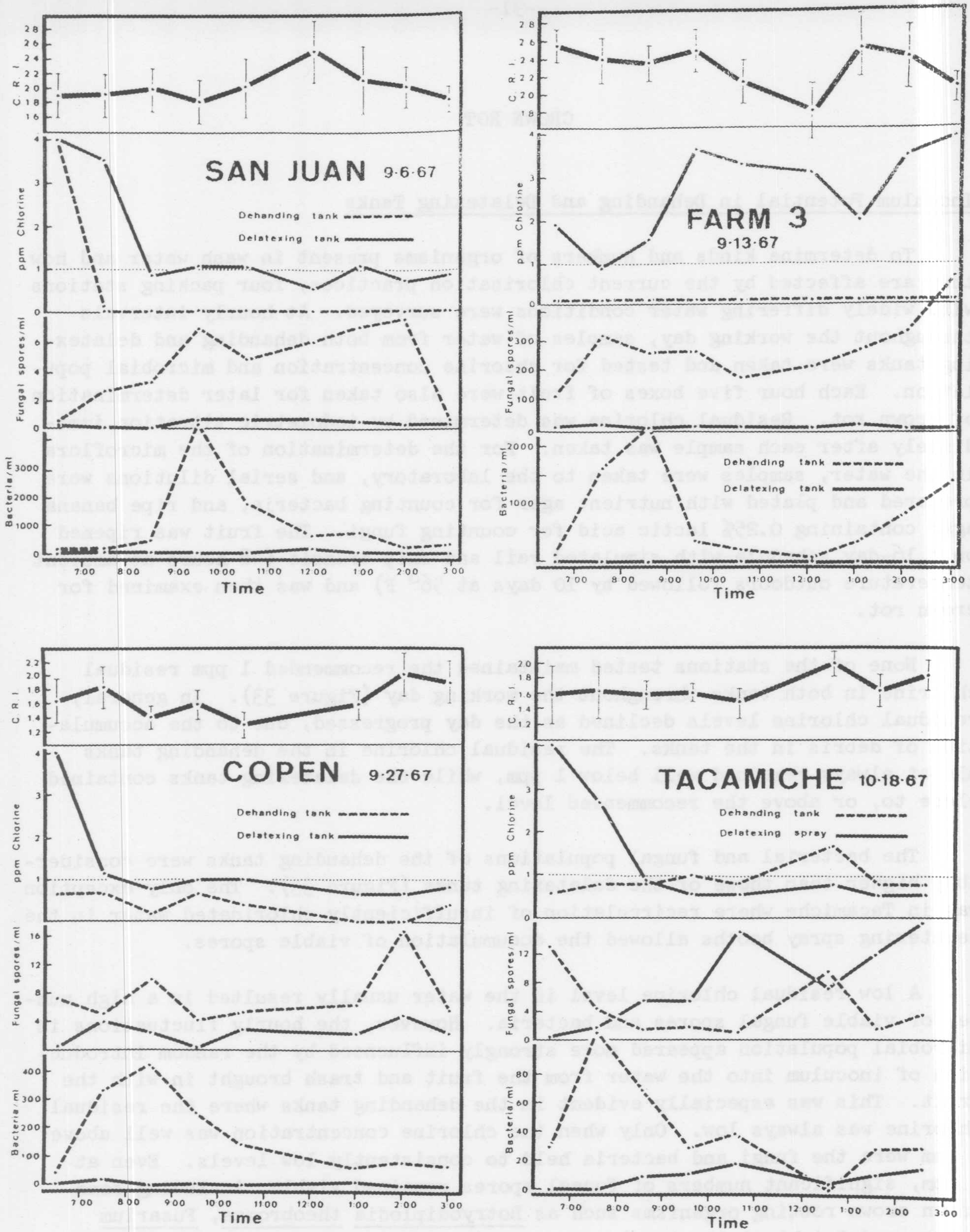


Figure 33

Inoculum potential in dehanding and delatexing tanks. Shown for each packing station are: the crown rot index (with 95% confidence limits) of hourly fruit samples and the residual chlorine, fungal spore population and bacterial population of hourly water samples.

trash carrying widely differing spore loads. Typical of these fluctuations are the results from Farm 3 dehanding tank (Figure 34). A given fungal species may be present in the water all day with wide variation in the numbers of spores from one hour to the next, or a fungus may be present for only one or two hours. The genera of the fungi identified and the average number of colonies obtained per 100 ml. sample from the dehanding tanks of the four stations surveyed are shown in Table 23.

There was no consistent correlation between crown rot index and chlorine concentration in either tank nor between crown rot index and the microflora population in either tank. Nor was there any obvious correlation between crown rot index and the population of any given fungal species. Although the variations in crown rot index from one sample time to the next were statistically significant, the differences were small and unconvincing. Despite the low incidence and severity of crown rot in this survey, it is obvious that potential crown rotting fungi are present in the water, often in considerable numbers. Under different environmental conditions it is likely that fruit could be more susceptible and more crown rot could result. (ARNESON)

<u>Chlorine Sensitivity of Crown Rotting Fungi</u>

Because significant numbers of crown rotting fungi survived 1 ppm residual chlorine in the wash water, tests were made to determine the chlorine sensitivities of the most commonly occurring species capable of rotting crowns. Serial dilutions of "Chlorox" (5% sodium hypochlorite) were prepared with 0.05 M phosphate buffer, pH 7, to yield approximately 0, 0.5, 1, 2, 4, 8, 16 and 32 ppm equivalent Cl_2. To 490 ml. of each of these buffered chlorine solutions, 10 ml. of a heavy spore suspension of the fungus being tested was added with vigorous stirring. After intervals of 1, 5, 10 and 20 minutes, aliquots of about 100 ml. were taken and quickly filtered with suction through a Millipore filter. The filtrate was collected and the residual chlorine determined by iodometric titration. The spores on the filter were quickly rinsed 3 times with about 10 ml. distilled water, the filter being sucked dry after each rinse. The spores were then resuspended in about 1 ml. distilled water, and drops of this suspension were placed on clean microscope slides. The slides were placed in moist chambers to incubate for 24 hours, and then the percent germination was determined by microscopic examination.

The percent germination was plotted versus parts per million residual chlorine (Figures 35 and 36). Virtually complete kill of <u>Fusarium</u>, <u>Gloeosporium</u>, <u>Verticillium</u> and <u>Cephalosporium</u> was achieved with 2 ppm Cl_2 or less, even with only a one-minute exposure. <u>Botryodiplodia</u> and <u>Deightoniella</u>, on the other hand, survived 2 ppm Cl_2 for at least 20 minutes and survived a one-minute exposure to as high as 24 ppm Cl_2. The fungi, therefore, fall into two distinct groups as regards their sensitivity to chlorine. The species which have thin-walled, hyaline conidia are relatively sensitive to chlorine, while the fungi with thick-walled, brown conidia are not.

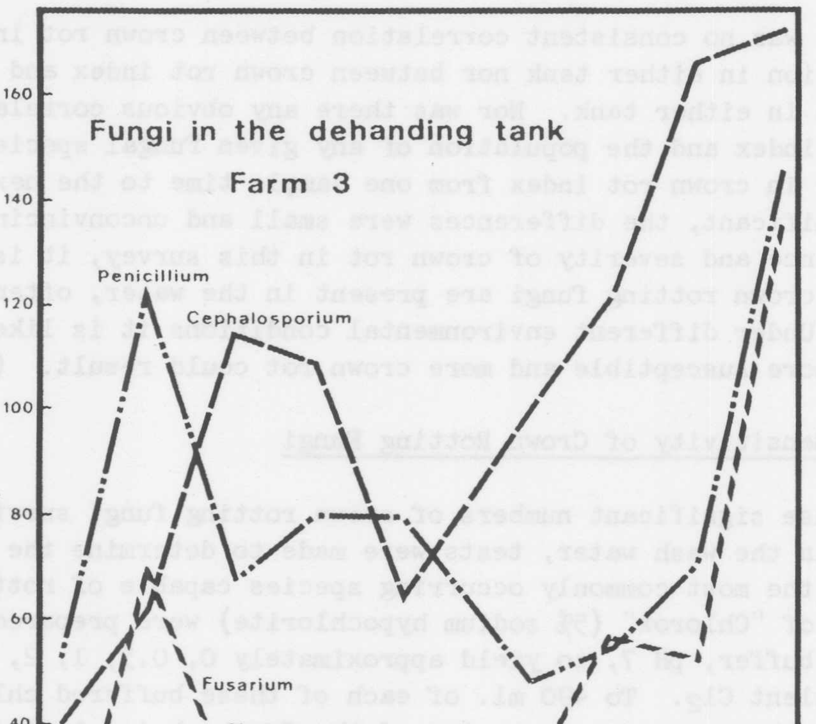


Figure 34
Fungi in the dehanding tank of Farm 3. The populations of the various fungi, identified to genus, were determined in plate counts of hourly samples of the wash water.

Table 23

Fungi in the Dehanding Tank

	Colonies Per 100 ml. of Sample*			
	San Juan 9/6/67	Farm 3 9/17/67	Copen 9/27/67	Tacamiche 10/18/67
Aspergillus	4.5	45.0	5.0	0
Botryodiplodia	18.0	22.0	215	35.0
Cephalosporium	0	10,500	0	8.0
Cladosporium	8.9	1,470	2.5	2.5
Deightoniella	8.9	0	5.0	0
Fusarium	2.2	4,430	37.5	0
Fusidium	0	0	0	27.5
Geotrichum	0	22.0	0	0
Gloeosporium	0	257	0	0
Humicola	0	0	2.5	0
Neurospora	0	66.6	0	0
Nigrospora	78.0	111	142	17.5
Pestalotia	2.2	22.0	7.5	2.5
Penicillium	258	823	242	250
Trichoderma	0	22	0	0
Unknown fungi	26.7	1,180	62.5	77.5

* The figures given are means of eight hourly samples per day, five replicate plates per sample.

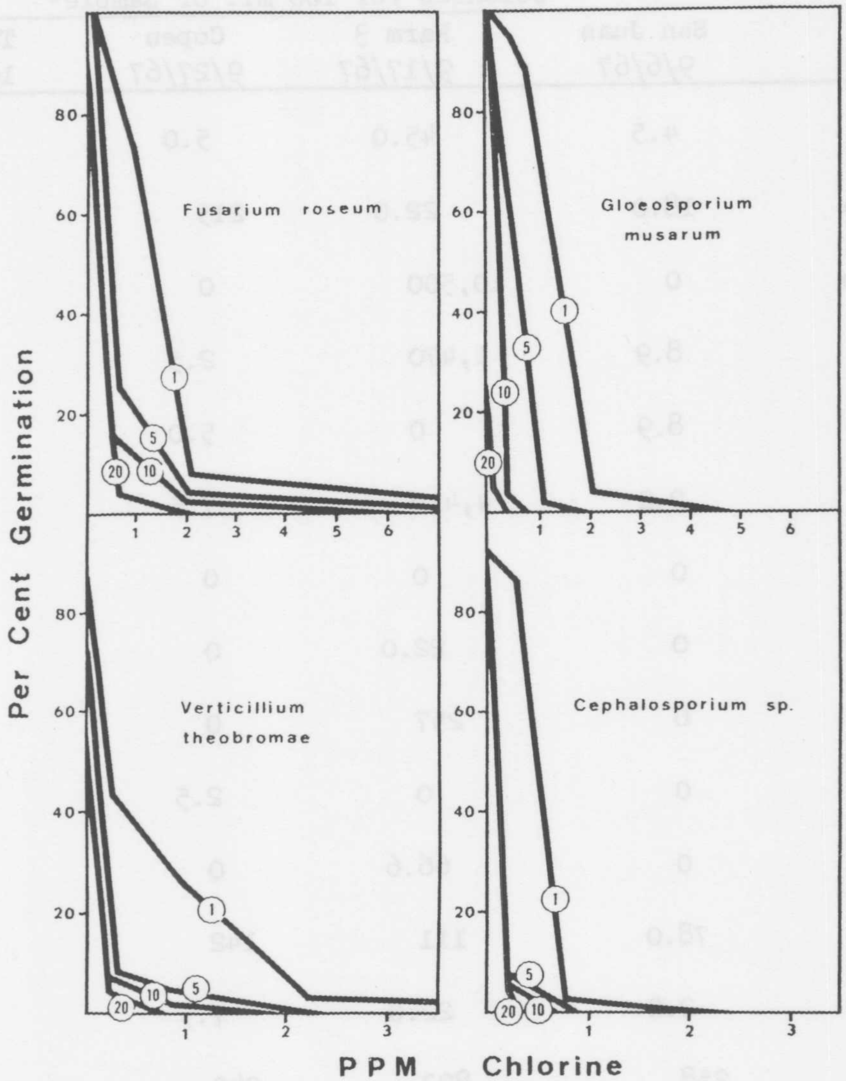


Figure 35
The chlorine sensitivity of crown rotting fungi. The percent germination of the conidia was determined after exposure to the given concentration of chlorine for 1, 5, 10 and 20 minutes.

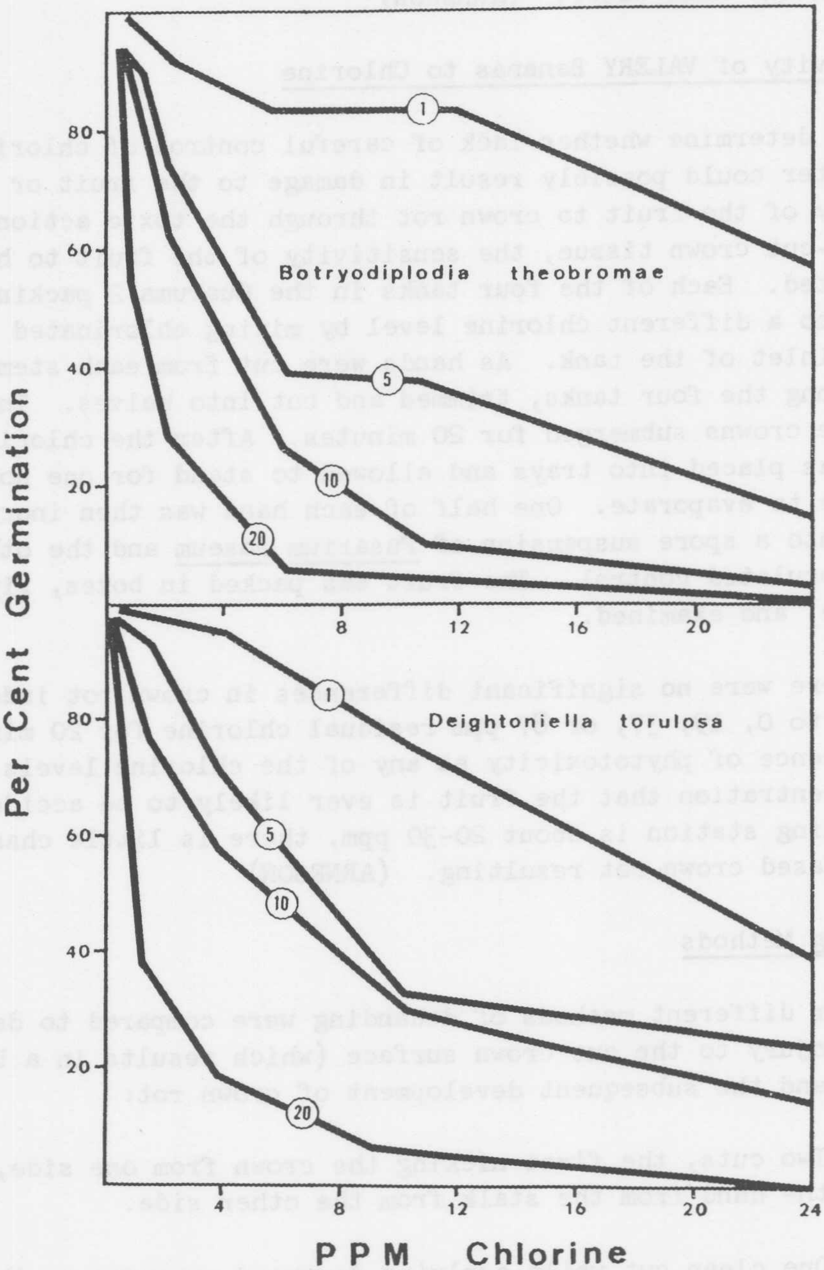


Figure 36

The chlorine sensitivity of crown rotting fungi. The per-cent germination of the conidia was determined after exposure to the given concentration of chlorine for 1, 5, 10 and 20 minutes.

Control of Botryodiplodia and Deightoniella (and perhaps Fusarium, if the heavy-walled chlamydospores are present) with chlorine does not appear practical because of the high levels of residual chlorine required. Chlorination, however, is a practical means of lowering the inoculum potential of the other fungi in the wash water. (ARNESON)

Sensitivity of VALERY Bananas to Chlorine

To determine whether lack of careful control of chlorine levels in the wash water could possibly result in damage to the fruit or increase the suscep tibility of the fruit to crown rot through the toxic action of chlorine on the freshly-cut crown tissue, the sensitivity of the fruit to high chlorine levels was tested. Each of the four tanks in the Guaruma 2 packing station was adjusted to a different chlorine level by mixing chlorinated water and fresh wat at the inlet of the tank. As hands were cut from each stem, they were distrib uted among the four tanks, trimmed and cut into halves. The fruit was then le with the crowns submerged for 20 minutes. After the chlorine treatment, the fruit was placed into trays and allowed to stand for one hour to allow the bou chlorine to evaporate. One half of each hand was then inoculated by dipping t crown into a spore suspension of Fusarium roseum and the other half was left a an uninoculated control. The fruit was packed in boxes, ripened on a 16-day schedule, and examined.

There were no significant differences in crown rot index among the fruit exposed to 0, 19, 37, or 87 ppm residual chlorine for 20 minutes. Nor was the any evidence of phytotoxicity at any of the chlorine levels. Since the highes Cl_2 concentration that the fruit is ever likely to be accidentally exposed to the packing station is about 20-30 ppm, there is little chance of phytotoxicit or increased crown rot resulting. (ARNESON)

Dehanding Methods

Four different methods of dehanding were compared to determine their effe on the injury to the cut crown surface (which results in a blackening of the c tissue) and the subsequent development of crown rot:

1) Two cuts, the first nicking the crown from one side, the second severi the hand from the stalk from the other side.

2) One clean cut while applying downward pressure on the hand.

3) One quick, clean cut with a thin, strongly-curved knife.

4) One cut with the stems inverted, that is, with the fingers pointing up ward at the time of dehanding.

After the fruit had passed through the tanks, it was placed in trays and was allowed to stand for 15 minutes while the blackening reaction (which indicates injured tissue) developed. The crowns were then examined and the number of black crowns was counted. The fruit was then packed, ripened on a 16-day schedule, and examined for crown rot.

The amount of injury to the crown tissue is greatly affected by the method of dehanding as shown by the incidence of black crown (Table 24). The two-cut method results in more black crown than dehanding with one clean cut. Applying downward pressure on the hand while cutting also increases the amount of injury. Apparently, when the stem is hanging with the softer tissues of the crown cushion underneath (that is, with the fingers pointing downward), the weight of the hand can crush these tissues as the hand is cut. Inverting the stem reduces considerably the amount of injury and thus the incidence of black crown.

Black crowns are more susceptible to crown rot than are the normal crowns (Table 25). The crushed cells are probably killed and thus are less able to resist fungal invasion while at the same time providing a good food base for fungi. (ARNESON)

Crown Trimming

To determine the importance of crown trimming for the control of crown rot, four lots of fruit received the following treatments:

1) The crowns of each cluster were carefully trimmed and beveled as shown in Figure 37-1.

2) The crowns were left untrimmed.

3) The sharp edge and corners on the face of untrimmed crowns were crushed as shown in Figure 37-5 by pressing them firmly against a table.

4) The fruit was dehanded leaving a small piece of stalk tissue attached to the crown as shown in Figure 37-3.

The fruit was processed without chlorination, packed in boxes with slip-sheets, and ripened on a 16-day schedule.

The incidence and severity of crown rot is markedly reduced by careful crown trimming and beveling (Table 26). The effectiveness of crown trimming in the control of crown rot is probably due to several factors:

1) It removes small pieces of extraneous tissue which dry up and die and thus serve as good infection sites for crown rotting fungi.

Table 24

The Effect of Dehanding Method on Black Crown Incidence

	% Black Crown	Number of Crowns in Sample
Two cuts	64	99
Push while cutting	41	96
One clean cut	28	100
Stem inverted	17	95

Table 25

Susceptibility of Blackened Crowns to Crown Rot

		Black Crown	Normal Crown
Crown rot severity (% of clusters)	None	0	0
	Trace	9.7	42.3
	Light	56.3	52.8
	Medium	22.2	4.9
	Severe	11.8	0
Crown Rot Index		3.38	2.63
Total number of clusters examined		144	246

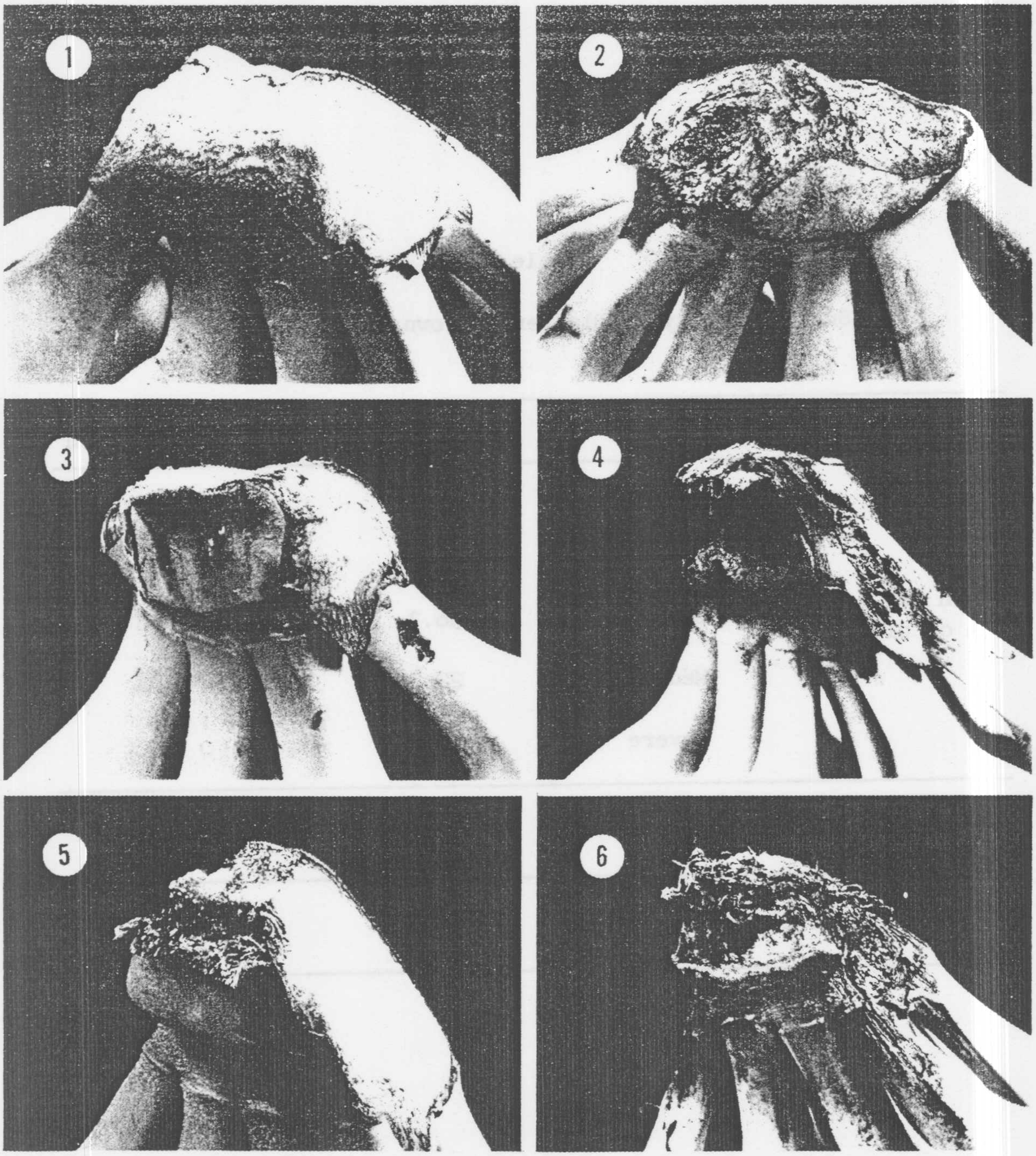


Figure 37

The effect of crown trimming on crown rot. 1) A properly trimmed crown; 2) A properly trimmed crown, after ripening; no crown rot; 3) An untrimmed crown; 4) An untrimmed crown, after ripening; medium crown rot; 5) A crown with soft edge crushed; 6) A crown with edge crushed, after ripening; severe crown rot.

Table 26

The Effect of Crown Trimming on Crown Rot

		Well-Trimmed Crown	Untrimmed Crown	Corners Crushed	Stalk Piece Attached
Crown rot severity (% of clusters)	None	35.7	5.9	0	0
	Trace	50.0	29.6	1.8	12.8
	Light	10.4	30.3	6.0	33.3
	Medium	2.6	13.8	4.2	22.4
	Severe	1.3	20.4	88.1	31.4
Crown Rot Index*		1.85	3.23	5.81	3.90

* The least significant difference is 0.447 at the 95% level and 0.598 at the 99% level.

2) It removes crushed and bruised tissue (often apparent as a blackened area on the softer tissues of the crown) which also serves as an excellent infection site for crown rotting fungi.

3) It removes the sharp edges and corners of the softer tissues of the crown which otherwise would be easily crushed and bruised in packing and transit.

4) And perhaps to a limited extent, it removes some of the fungal spores which have been sucked into the cut vascular elements and become lodg at depths up to about 5 mm.

Finger Removal

When fingers are removed from clusters during selection, wounds are left which often become centers of infection for crown rot. To determine which method of finger removal is least likely to produce crown rot, one finger was removed from each cluster by one of the following methods as the fruit was se ected and transferred to the delatexing tank:

1) A center finger was jerked out, leaving a small, jagged hole as shown in Figure 38-2.

2) A center finger was cut off, leaving a 1/4-inch stub of the pedicle a shown in Figure 38-1.

3) A finger at one end of the cluster was pulled off, stripping off a bi of the side of the crown with it as shown in Figure 38-4.

4) A finger at one end of the cluster was cut off by cutting upward thro the whole crown and removing a piece of the crown with the finger. A clean surface was left on the side of the crown as shown in Figure 38

5) Fingers were removed from one end of the cluster, leaving a projectin piece of the end of the crown as shown in Figure 38-5.

The fruit was packed in boxes and ripened on a 16-day schedule. The rot orig ating at the site of finger removal was rated as follows: none, no rot; trac rotted tissue just around point of finger removal; light, rot advanced to cro area; medium, up to 1/2 crown rotted; and severe, more than 1/2 crown rotted.

The severity of rot is shown in Table 27. Jerking out a finger from the center of a cluster results in less rot than cutting the finger off and leavi a stub of the pedicle. Cutting an end finger off along with a piece of the crown results in less rot than pulling the finger off. A projecting piece le on the crown after finger removal greatly increases crown rot. (ARNESON)

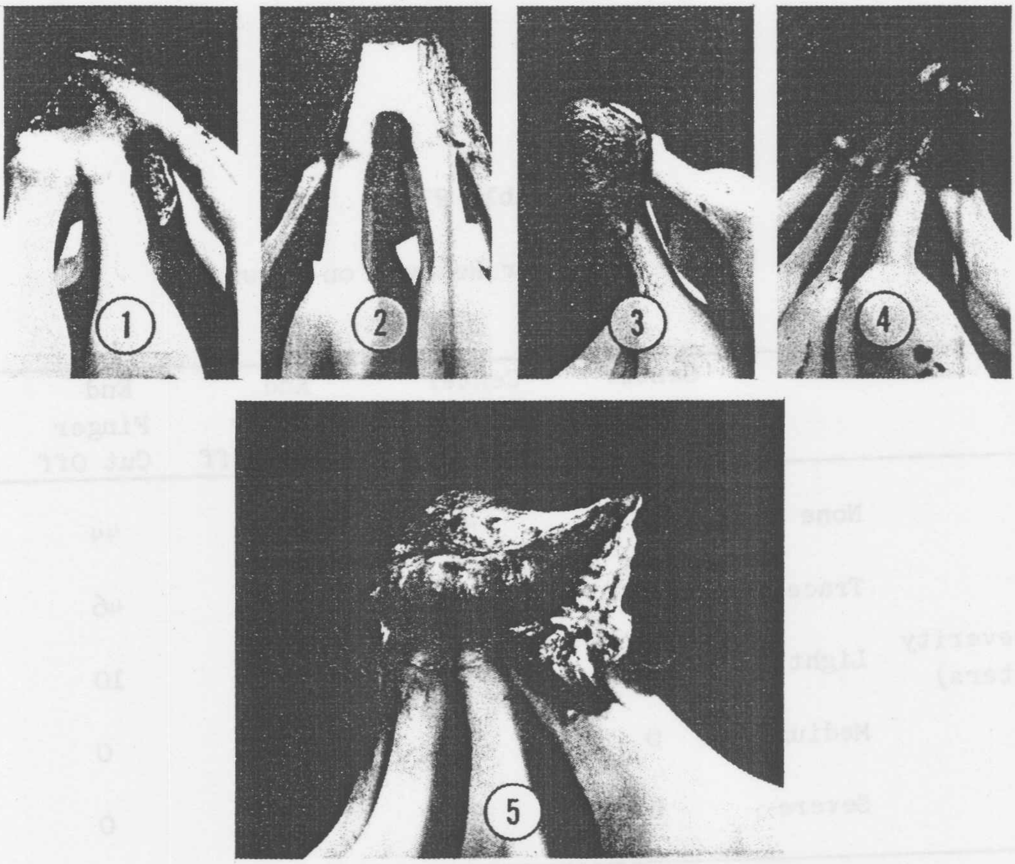


Figure 38

The effect of finger removal on crown rot. Fruit is shown after ripening. 1) Finger cut off, leaving a stub of pedicle. The rot advanced internally from the cut stub into the crown itself; 2) Finger jerked out. A trace of rot developed in the "socket"; 3) End finger removed by cutting upward through the crown. No rot developed on the clean cut surface; 4) End finger pulled off. A trace of rot developed on the torn surface; 5) Fingers cut from end of cluster, leaving projecting piece of crown. Severe crown rot advanced from cut surfaces throughout entire crown.

Table 27

The Effect of Finger Removal on Crown Rot

		Center Finger Jerked Out	Center Finger Cut Off	End Finger Pulled Off	End Finger Cut Off	End Piec Left on Crown
	None	10	4	12	44	2
	Trace	82	22	62	46	22
Crown rot severity (% of clusters)	Light	8	70	26	10	46
	Medium	0	4	0	0	24
	Severe	0	0	0	0	6

Mertect 340 (Thiabendazole) As a Post-Harvest Fungicide

In June 1968 Thiabendazole was cleared for post-harvest use on bananas. It is being marketed as a 40% wettable powder formulation under the name "Mertect 340" by Merck Sharp and Dohme, Inc.

Although its labelled use is for a post-harvest dip, this method of application is very costly in time and labor. Therefore, the application of Thiabendazole with the latex stain control spray was tested. Immediately before packing, fruit was sprayed with the following treatments:

1) 1% alum (ammonium aluminum sulfate)

2) 2 oz. active/100 gal. Thiabendazole

3) 1% alum plus 2 oz./100 gal. Thiabendazole

With a stainless steel knapsack sprayer, the spray was directed evenly over the fruit in the trays to the point of run-off. Unsprayed fruit was taken as the control. Ten boxes of each treatment were then packed in 1/2 mil Polypack with standard 4 x 1/2" perforations. The fruit was ripened on a 22-day schedule, simulating both rail and ship transit.

The presence of 1% alum had no significant effect on the effectiveness of Thiabendazole for the control of crown rot (Table 28). Likewise, the presence of Thiabendazole had no significant effect on the effectiveness of 1% alum for the control of latex stain. The simultaneous application of Thiabendazole and alum in a spray just before packing appears to be an effective means of controlling both crown rot and latex stain.

The effectiveness of Thiabendazole was compared with that of chlorine for the control of crown rot. Fruit was processed in two lots, the first with unchlorinated water and the second with 1 to 2 ppm residual chlorine in the water. Immediately before packing, the fruit was given the following treatments with a knapsack sprayer:

1) 1% alum

2) 1% alum plus 2 oz. active Thiabendazole/100 gal.

3) 1% alum plus 3 oz. active Thiabendazole/100 gal.

The spray was applied evenly over the fruit to the point of run-off. Ten boxes of each treatment were packed with polyethylene slip-sheets and ripened on an 18-day schedule simulating rail and ship transit.

Table 28

Crown Rot and Latex Stain in Polypack Fruit Treated with Alum and Thiabendazole

		No Treatment	Alum	Thiabendazole	Alum Plus Thiabendazole
Crown rot severity (% of clusters)	None	40.3	63.5	69.8	80.2
	Trace	42.8	32.5	29.4	17.4
	Light	9.2	3.3	0.8	2.5
	Medium	3.4	0.8	0	0
	Severe	4.2	0	0	0
Crown Rot Index*		1.92	1.42	1.32	1.23
Latex stain severity (% of clusters)	None	42.9	56.9	39.5	72.7
	Trace	24.4	26.8	26.0	20.7
	Light	17.6	13.1	11.8	4.1
	Medium	5.9	0.8	2.5	1.7
	Severe	9.2	2.4	20.2	0.8
Latex Stain Index**		2.14	1.65	2.39	1.43

* The least significant difference at the 99% level is 0.296.

** The least significant difference at the 99% level is 0.430.

In the treatments which received no Thiabendazole, there was no significant difference between the crown rot index of the fruit processed with chlorination and that of the fruit processed without chlorination (Table 29). All of the Thiabendazole treatments markedly reduced crown rot incidence and severity. The use of chlorination in addition to Thiabendazole gave barely significantly better crown rot control than Thiabendazole alone. (The difference at the 2 oz. rate was significant at the 95% level, but not at the 99% level.) Thiabendazole treatment is clearly superior to chlorination for the control of crown rot.

Because of the high price of Mertect 340 ($10 per pound) it may be necessary to use a rate of application somewhat less than that which gives maximum crown rot control before the treatment becomes economical. To determine the minimum effective concentration of Thiabendazole for the control of crown rot when applied with the alum spray, the following treatments were applied to fruit just before it was packed:

1) 1% alum (ammonium aluminum sulfate)

2) Alum plus 1 oz./100 gal. Thiabendazole (1 oz. active ingredient/100 gal. 1% alum).

3) Alum plus 2 oz./100 gal. Thiabendazole

4) Alum plus 3 oz./100 gal. Thiabendazole

5) Alum plus 4 oz./100 gal. Thiabendazole

The spray was applied with a knapsack sprayer at the rate of 1/10 gallon per box of fruit, approximately the rate applied in the alum spray booths. Ten boxes of each treatment were packed using polyethylene slip-sheets. The fruit was then ripened on an 18-day schedule with simulated rail and ship transit.

The cost figures in Table 30 represent costs of material only and are based on the current price of $10.00 per pound for the 40% wettable powder formulation. For the purposes of comparison, the costs quoted by the Accounting Department in Honduras are $0.0014/box for chlorination and $0.0027/box for the UF-63 dip. Significant control of crown rot was achieved with only 1 oz. Thiabendazole/100 gal. at a cost of $0.0016/box. Better control could be achieved at double the price and optimum control at triple the price. (ARNESON)

Benlate (DuPont Fungicide 1991) As a Post-Harvest Fungicide

DuPont fungicide 1991, a new compound chemically related to Thiabendazole, will be marketed under the name "Benlate". Preliminary screening tests indicated Benlate was as effective as TBZ in crown rot control. Since Benlate

Table 29

Comparison of Thiabendazole with Chlorination for the Control of Crown Rot

		CHLORINATED			UNCHLORINATED		
		Alum	Alum Plus 2 oz./100 gal. TBZ	Alum Plus 3 oz./100 gal. TBZ	Alum	Alum Plus 2 oz./100 gal. TBZ	Alum Plus 3 oz./100 gal. TBZ
Crown rot severity (% of clusters)	None	12.8	46.4	53.6	12.9	30.6	56.0
	Trace	41.3	49.2	41.8	52.6	49.7	34.5
	Light	30.2	4.5	4.5	18.1	17.8	9.5
	Medium	10.1	0	0	5.2	0.9	0
	Severe	5.5	0	0	11.2	1.8	0
Crown Rot Index*		2.63	1.57	1.51	2.57	1.90	1.53

* The least significant difference at the 95% level is 0.250 and at the 99% level is 0.334.

Table 30

Cost of Thiabendazole Applied with Alum Spray

		No Treatment	1 oz./ 100 gal.	2 oz./ 100 gal.	3 oz./ 100 gal.	4 oz./ 100 gal.
Cost Per Box*		-	$0.00156	$0.00313	$0.00469	$0.00625
Crown rot severity (% of clusters)	None	35.6	63.2	74.5	91.2	84.0
	Trace	42.6	33.3	23.8	8.8	16.0
	Light	16.5	2.6	1.7	0	0
	Medium	4.3	0.9	0	0	0
	Severe	0.9	0	0	0	0
Crown Rot Index**		1.90	1.41	1.27	1.09	1.16

* Based on the current price of $10.00/lb. for Mertect 340.

** The least significant difference at the 95% level is 0.19 and at the 99% level is 0.26.

will likely be cheaper than Thiabendazole, experiments were begun to provide DuPont with data for an application for F.D.A. and U.S.D.A. clearance for post-harvest application of Benlate. A label for bananas is not expected until 1971.

The effectiveness of Benlate was compared with that of Thiabendazole for the control of crown rot. As it was removed from the delatexing tank, the fruit was arranged in trays and sprayed with the following treatments:

1) UF-63, 3 lb./100 gal.

2) Thiabendazole (1 oz./100 gal.)

3) Thiabendazole (2 oz./100 gal.)

4) Benlate (1 oz./100 gal.)

5) Benlate (2 oz./100 gal.)

Untreated fruit served as the control. Ten boxes of fruit were packed for each treatment, using polyethylene slip-sheets. The fruit was ripened on the standard 18-day schedule with simulated rail and ship transit, then examined for crown rot.

The fruit treated with 2 oz. Benlate/100 gal. had a significantly lower crown rot index than the fruit treated with Thiabendazole at the same rate (Table 31). At 1 oz./100 gal. the difference between Benlate and Thiabendazole was not significant. The Benlate and Thiabendazole treatments at both rates gave markedly better control of crown rot than UF-63.

To determine whether Benlate could be incorporated into the alum spray, fruit was sprayed with the following treatments immediately before packing:

1) 1% alum

2) 2 oz. Benlate/100 gal. water

3) 2 oz. Benlate/100 gal. 1% alum

Ten boxes of each treatment were packed in 1/2 mil Polypack. The fruit was ripened on a 22-day schedule, simulating both rail and ship transit.

Alum had no significant effect on crown rot control by Benlate, and Benlate did not affect latex stain control by the 1% alum (Table 32). Benlate, like Thiabendazole, can be effectively incorporated into the alum spray to simultaneously control crown rot and latex stain. Whether Benlate should be used to replace Thiabendazole for crown rot control once Benlate has been cleared for post-harvest use on bananas will depend on price.

Table 31

Comparison of Benlate with Thiabendazole for Crown Rot Control

		No Treatment	UF-63	1 oz./100 gal. Thiabendazole	1 oz./100 gal. Benlate	2 oz./100 gal. Thiabendazole	2 oz./100 gal. Benlate
Crown rot severity (% of clusters)	None	0	0	12.8	23.3	15.7	52.2
	Trace	30.1	48.7	79.9	67.3	60.8	46.1
	Light	36.8	33.1	12.0	7.8	20.9	1.7
	Medium	12.8	10.7	1.7	1.7	2.6	0
	Severe	23.1	7.4	0.8	0	0	0
Crown Rot Index*		3.49	2.79	2.05	1.88	2.11	1.50

* The least significant difference at the 99% level is 0.38.

Table 32

Crown Rot and Latex Stain in Polypack Fruit Treated with Alum and Benlate*

		Alum	Benlate	Alum Plus Benlate
Crown rot severity (% of clusters)	None	63.5	72.5	92.4
	Trace	32.5	26.7	7.6
	Light	3.3	0.8	0
	Medium	0.8	0	0
	Severe	0	0	0
Crown Rot Index**		1.42	1.28	1.08
Latex stain severity (% of clusters)	None	56.9	45.0	61.9
	Trace	26.8	22.5	20.3
	Light	13.1	11.7	10.2
	Medium	0.8	5.0	4.2
	Severe	2.4	15.8	3.4
Latex Stain Index***		1.65	2.26	1.68

* See Table 6 for data on Thiabendazole from this same experiment.

** The least significant difference at the 99% level is 0.296.

*** The least significant difference at the 99% level is 0.430.

<u>Other Chemicals for Control of Post-Harvest Rots</u>

Three other compounds were tested for the control of post-harvest rots but were found to be ineffective or no better than chlorination. These were Halophen, Thylate, and Resyn 25-1251. (ARNESON)

2) 24 hours after wounding

3) 48 hours after wounding

4) 72 hours after wounding

5) 96 hours after wounding.

The fruit was incubated in moist chambers at 72° F for the specified time before inoculation and for 7 days after inoculation.

The following are the results expressed in terms of Finger Rot Index and the number of fingers which showed any degree of rot:

	F.R.I.	No. Fingers with Rot
Immediately after wounding	2.9	10 (100%)
24 hours after wounding	2.1	7
48 hours after wounding	1.1	1
72 hours after wounding	1.0	0
96 hours after wounding	1.0	0

The wounds apparently "healed" and became resistant to infection within 48 hours.

Effect of Maturity of Fruit on Susceptibility to *Botryodiplodia*

Fifteen fingers were selected from each of the following classes of fruit (1) fruit ripened to color 3 to 4; (2) green fruit of harvest grade; (3) immature fruit about 50 days after shooting. Each finger was wounded by cutting a V-notch in the peel just deep enough to reach the pulp. A drop of a spore suspension of *Botryodiplodia theobromae* was applied to the fresh-cut surface. The fingers were then incubated in moist chambers for 8 days at 72° F. All of the fruit was infected after 8 days. The mean Finger Rot Index of the ripe fruit was 6.6, the green fruit 4.9, and the immature fruit 4.8. Although finger rot progresses more rapidly in ripe fruit, green and immature fruit are also susceptible.

Effect of Flower Removal on *Botryodiplodia* Infection

The flowers of 20 fingers of green, harvest grade fruit were removed in a suspension of *Botryodiplodia theobromae* spores. The flower ends with the dried flower parts still intact of 20 other fingers were dipped into the same spore suspension. The fingers were then placed in moist chambers at 72° F. Fourteen days after inoculation viable and pathogenic *Botryodiplodia* could still be isolated from the flower ends of both the fingers with flowers attached and fingers with flowers removed. However, no finger rot appeared in either treatment. The high incidence of finger rot in the flower end of the fruit which is observed in commercial shipments is probably not due to infection through the wound created by flower removal or growth of Botryodiplodia on the dead flower parts which remain on the fruit. (ARNESON)

The Influence of CO_2 Pitting on Finger Rot in BANAVAC

Fifty boxes of fruit of the following classes were packed in the BANAVAC pack according to the usual commercial practice:

1) Twenty boxes of caliper grade less than 15. The fruit was processed normally except that all overgrade fruit was removed from the trays just before they were weighed.

2) Twenty boxes of caliper grade more than 15. The heaviest grade clusters were selected from the trays and delatexing tanks. Each box contained only fruit greater than 15 caliper and at least one cluster with fat, well-rounded fingers (caliper grade 20-27).

3) Ten boxes with pitting disease. Clusters with at least two pits were selected from the trays at the delatexing tanks. The pits were then circled with a red pencil. Caliper was ignored, but most of the fruit was light grade.

The fruit was held at ambient temperature outdoors for 48 hours, then transferred to 56°-58° F for holding. Half the fruit was held for 11 days and half for 35 days. At the end of the holding period, the CO_2 concentrations in each bag were determined and the fruit was given its green inspection. The fruit was then transferred to a 64° F ripening room, gassed, and ripened to color 4-5 (about 6 days). The ripe fruit was again examined.

The results are summarized in Table 33. The data represent means of 10 boxes in each class. As expected, the CO_2 concentrations increased markedly with time and were significantly higher in the bags containing heavy grade fruit than in the bags containing lighter grade fruit. The percent of fingers with pits is clearly correlated with the concentration of CO_2 in the bags. Finger rot caused by Botryodiplodia theobromae developed from many of the pits induced by high CO_2. This was especially evident in a single box which contained 15.0% CO_2. More than 40% of its pitted fingers had finger rot which appeared to originate from the pits.

Crown rot was also highest in the bags with high CO_2, and much of this severe crown rot could be attributed to Botryodiplodia infection. It would seem that high CO_2 either favors the fungus or renders the fruit more susceptible to invasion.

Table 33

CO_2 Pitting and Finger Rot in BANAVAC

	11 Days		35 Days	
	Light	Heavy	Light	Heavy
Green Inspection				
CO_2 concentration of bag (%)	3.42	4.24	7.58	10.32
% fingers pitted	0.8	1.2	4.2	11.3
% fingers with pits and finger rot	0	0	0.3	0.9
% fingers with finger rot and no pits	0	0.4	1.1	3.5
Ripe Inspection				
Crown Rot Index (nine-point system)	2.07	1.94	2.08	2.65
% fingers with finger rot	2.4	1.9	1.9	4.8

Fruit of light caliper grade (less than 15) and heavy caliper grade (more than 15) was held at 56°-58° F for 11 days and 35 days before inspection and ripening.

The pits associated with high CO_2 in BANAVAC, though often similar in appearance, are definitely not pitting disease caused by Pyricularia. Not only can the trained eye easily tell the difference, but the data show the difference as well. The heavy grade fruit which was virtually free of Pyricularia pitting when it was collected had 1.2% fingers pitted after 11 days and 11.3% fingers pitted after 35 days. Not counting circled pits, and making no attempt to distinguish between Pyricularia spots and CO_2 pitting, the fruit which was infected with Pyricularia from the start had 4.6% of the fingers with new pits after 11 days and only 7.7% of the fingers with new pits after 35 days. Finger rot did not develop from the Pyricularia pits. (ARNESON)

INSECT CONTROL

Defoliation Studies

Effects of Simulated Ceramidia Defoliation. From February 1965 to November 1968, an experiment was conducted on 12 acres in San Juan Farm, Honduras to determine the effects of defoliation on fruit weight and quality. Plots containing 30 mats each were arranged in a randomized complete block design with 5 treatments (0, 10, 20, 30, and 40 percent defoliation) replicated 14 times; total, 70 plots.

At 35-day intervals, which correspond to the length of a Ceramidia life cycle in nature, all plants were defoliated to the desired percentage of leaf area. Between cycles the plants without fruit recovered some of their leaf area, but this also happens in nature during the pupal, adult, egg, and early larval instars of Ceramidia.

The results of the first 3 years have been published (see 1967 Annual Report). There appeared to be a trend toward more fruit weight loss even at the 10 and 20% levels as the experiment progressed; this trend continued this year (Table 34). Although the main experiment was ended in November 1968, a smaller test is continuing in order to find a possible cumulative effect when the same mats are defoliated over the years.

In 1968 the lower fruit weight recorded even in check plots is partially due to the cutting of thinner fruit for the European and Japanese markets. This is recorded in Table 34 along with the average caliper grades for 1967 and 1968.

Four-year summary: A total of 12,528 stems were harvested from the 5 defoliation levels during the 45 months of this experiment. Although fruit weight gradually declined as the defoliation rate increased, the total fruit weight harvested was highest in the 20% defoliation plot:

	Percent Defoliation				
	0	10	20	30	40
Total fruit harvested (lbs.)	201,309	213,190	213,556	211,185	196,741

This was undoubtedly due to the greater losses through blowdown in the 0 and 10% defoliation plots (Figure 42), while fruit weight loss was significantly greater in the 30 and 40% defoliation plots (Figure 40).

Table 34

Summary of the Effects of Defoliation on Fruit Weight and Quality - 1968. San Juan Farm, Honduras

	Percent Defoliation				
	0	10	20	30	40
No. stems	793	867	867	940	940
Ave. stem weight (lbs.)	85.2	83.7	82.5	77.1	73.3
Ave. No. hands/stem	9.4	8.7	9.3	9.1	8.9
Ave. finger length (inches)					
Upper hand	9.0	9.0	9.0	8.8	8.8
Lower hand	7.8	8.1	8.1	8.0	7.9
Ave. caliper (mid-stem)					
1967	42.76	42.69	42.64	42.65	42.5
1968	41.39	41.50	41.27	41.30	41.2
Ave. time shooting to harvest (days)	106.8	106.5	106.2	106.7	108.2

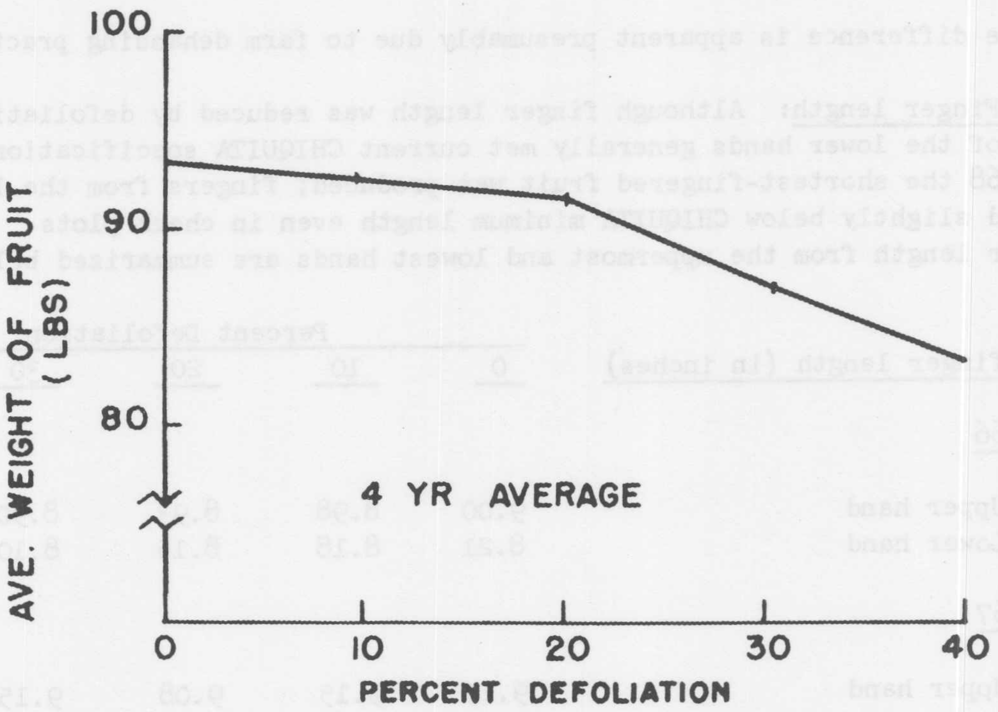


FIGURE 40. EFFECT OF DEFOLIATION ON AVE. FRUIT WEIGHT. SAN JUAN FARM - 1965 - 68.

Fruit weight: There was a slight (2.3 lb.) loss up through the 20% defolia tion level (Figure 40), after that the average stem weight drops sharply.

Days between shooting and harvest: Fruit hung only 3.2 days longer at the 40% defoliation level than check (0%) fruit (Figure 41).

No. of hands: The following is a 3-year average:

	Percent Defoliation				
	0	10	20	30	40
Ave. No. of hands	9.9	9.5	9.8	9.7	9.5

Little difference is apparent presumably due to farm dehanding practices.

Finger length: Although finger length was reduced by defoliation, the fingers of the lower hands generally met current CHIQUITA specifications of 8 inche In 1968 the shortest-fingered fruit was produced; fingers from the lowest hands dipped slightly below CHIQUITA minimum length even in check plots. The average finger length from the uppermost and lowest hands are summarized below by year:

	Percent Defoliation				
Ave. finger length (in inches)	0	10	20	30	40
1966					
Upper hand	9.00	8.98	8.93	8.90	8.80
Lower hand	8.21	8.18	8.15	8.10	8.02
1967					
Upper hand	9.17	9.15	9.08	9.15	8.93
Lower hand	8.38	8.32	8.24	8.19	8.13
1968					
Upper hand	9.01	8.96	8.95	8.79	8.76
Lower hand	7.80	8.13	8.08	7.97	7.92

Premature ripening: For the first 2 years of this experiment samples from defoliation levels were taken from time to time and held for two weeks under controlled conditions at 56° F to see if there was any premature ripening; there wa none at any defoliation level.

As for the application of this study to insect control, the 20% level of de foliation from any cause will continue to be the critical level, after which control of leaf-destroying insects becomes essential. (OSTMARK, MELENDEZ)

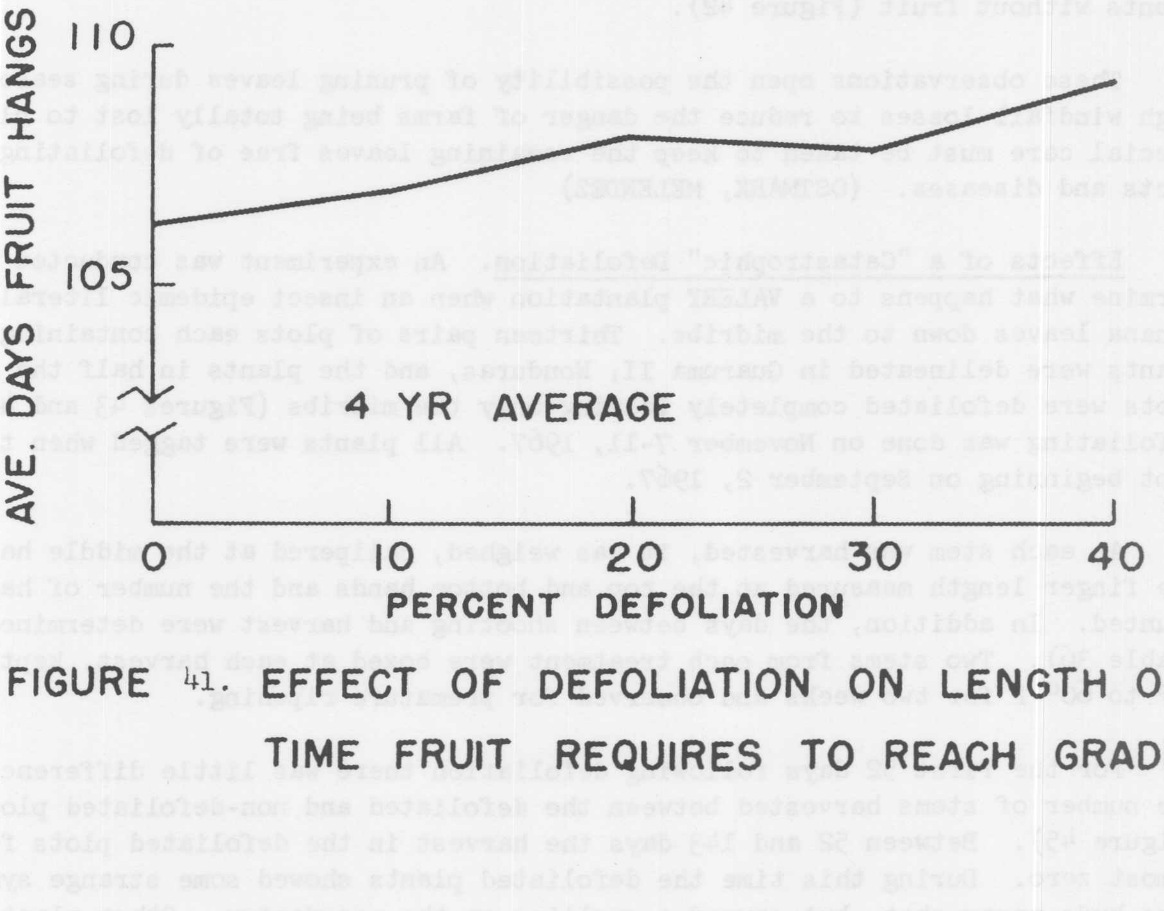


FIGURE 41. EFFECT OF DEFOLIATION ON LENGTH OF TIME FRUIT REQUIRES TO REACH GRADE.

Reduced Leaf Area Means Fewer Plants Blown Down. On September 22, 1967, May 27 and July 26, 1968 high winds blew down plants in the defoliation plots in San Juan Farm.

On the day following the blowdowns all wind-thrown plants were counted, tallied by plants with and without fruit, and the fruit weighed. Almost all plants doubled rather than uprooted.

Apparently, fruit weight did not influence plant losses since the average weight of stems lost did not vary much between the different defoliation plots (Table 35). Although more total fruit was lost in the plots with the least defoliation, the greatest effects of wind between defoliation treatments were on plants without fruit (Figure 42).

These observations open the possibility of pruning leaves during seasons of high windfall losses to reduce the danger of farms being totally lost to blowdown. Special care must be taken to keep the remaining leaves free of defoliating insects and diseases. (OSTMARK, MELENDEZ)

Effects of a "Catastrophic" Defoliation. An experiment was conducted to determine what happens to a VALERY plantation when an insect epidemic literally eats banana leaves down to the midribs. Thirteen pairs of plots each containing 30 plants were delineated in Guaruma II, Honduras, and the plants in half the paired plots were defoliated completely leaving only the midribs (Figures 43 and 44). The defoliating was done on November 7-11, 1967. All plants were tagged when they shot beginning on September 2, 1967.

As each stem was harvested, it was weighed, calipered at the middle hand, the finger length measured at the top and bottom hands and the number of hands counted. In addition, the days between shooting and harvest were determined (Table 36). Two stems from each treatment were boxed at each harvest, kept at 58° to 60° F for two weeks and observed for premature ripening.

For the first 52 days following defoliation there was little difference in the number of stems harvested between the defoliated and non-defoliated plots (Figure 45). Between 52 and 143 days the harvest in the defoliated plots fell to almost zero. During this time the defoliated plants showed some strange symptoms; some buds never shot, but caused a swelling on the pseudostem. Other plants shot fruit, but the stalks were weak and rotten. In others the stem broke and fell off or the fruit ripened on the plant without reaching grade.

There was no premature ripening of any fruit cut until the 59th and 62nd day after defoliation. Then some fruit from the defoliated plots ripened 6 days after cutting. There was only a 4-day difference in the length of time between shooting and harvest in the 2 treatments; defoliated fruit hung longer. Of course, fruit that was never harvested was not counted in this figure. Fruit from defoliated plants averaged 14 lbs. less than the check fruit. There was 0.7 hands less and fingers averaged 0.7 inches shorter on the fruit from the defoliated plots.

Table 35

The Effects of Wind on Artificially-Defoliated Plants.
San Juan Farm - Totals from 3 Blowdowns

	Percent Defoliation				
	0	10	20	30	40
Total plants lost	372	237	174	70	50
Without fruit	263	146	103	39	20
With fruit	109	91	71	41	30
Total fruit lost (lbs.)	4454	3997	3189	1927	1325
Ave. wt. of lost fruit (lbs.)	40.86	43.92	44.91	47.00	44.16

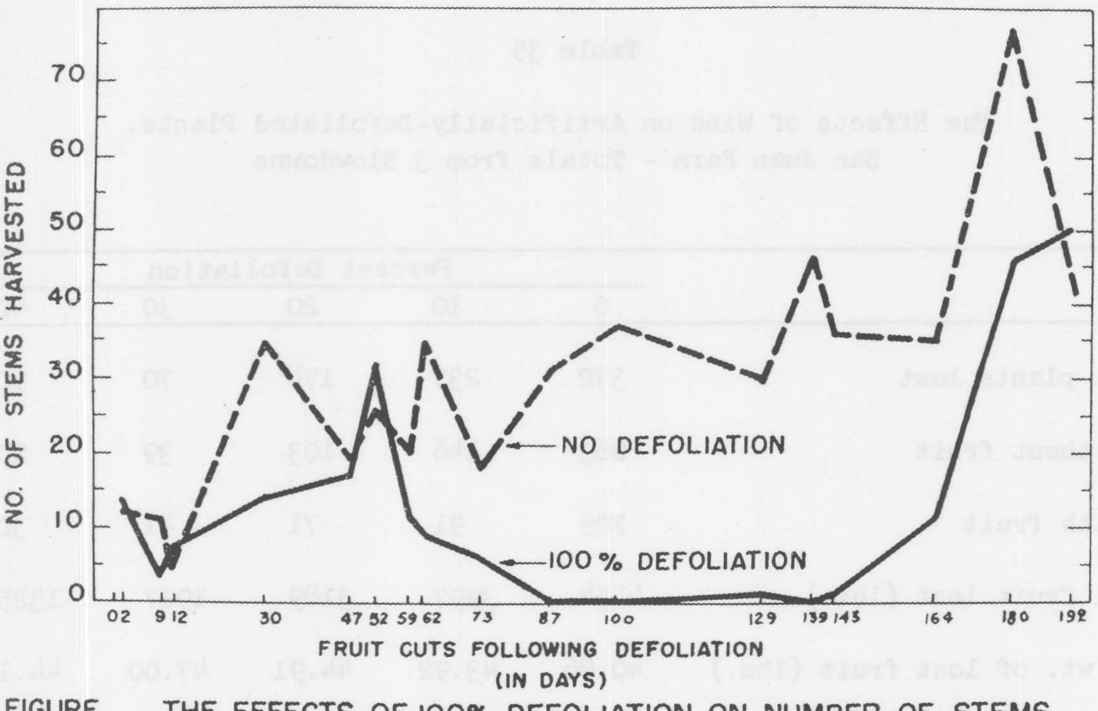


FIGURE 45.- THE EFFECTS OF 100% DEFOLIATION ON NUMBER OF STEMS HARVESTED-NOV. 1967- MAY 1968 GUARUMA II, HONDURAS.

In the past, severely-defoliated plants were cut down following an insect epidemic because premature ripes were feared. Based on the results of this experiment, VALERY fruit within 52 days from harvest grade can be left even after complete defoliation. (OSTMARK, MELENDEZ)

Bagworm Studies

The bagworm, Oiketicus kirbyi, presents the most vexing problems of any of our defoliating insects because:

1) Each adult female lays 5000 or more eggs (Figure 46).

2) Each caterpillar consumes large quantities of leaf area often causing severe defoliation.

3) When the caterpillars are more than ½ grown, they become difficult to kill with insecticides.

4) Since the caterpillar lives concealed within a bag made of silk and leaf pieces, the number of live bagworms/leaf may be obtained only by collecting and opening the bags.

5) Parasites may kill from 0 to almost 100% of the caterpillars at various times and in different areas, and

6) The only effective insecticides that we are permitted to use are Thuricide (Ca. $12 acre) and ULV Toxaphene (danger of resistance build-up).

Obviously, the ideal situation is an integrated control system that allows the maximum build-up of natural control agents with the minimum use of insecticides. Our studies were directed in 1968 toward that end.

Bagworm Life Cycles in Coto and Changuinola

	Coto, Costa Rica	Changuinola, Panama
Larvae emerged	February	April
Male pupation began	June	Early September
Female pupation began	June	Late September
Adults and eggs	July	October
Progeny began to emerge	August	November

This data confirm that larval development is completed in approximately 5-6 months. Although there was much overlapping of stages, the bagworm life cycle is apparently shorter in Coto than in Changuinola. (STEPHENS, OSTMARK)

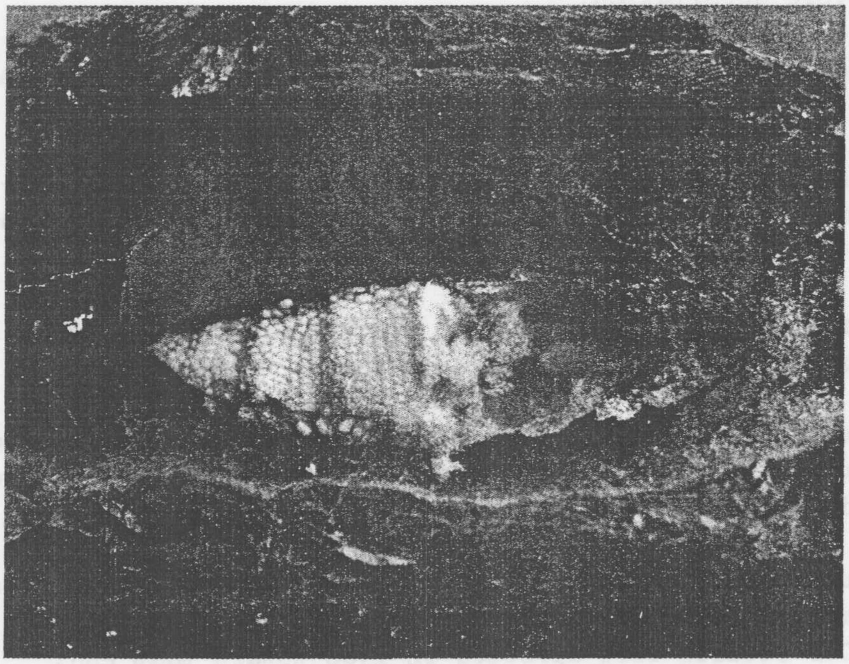


Figure 46

Opened bagworm bag showing pupal case of female packed with 5000 eggs. The shed larval skin is at the left.

Bagworm Parasites. A complex of insect parasites, predators, and diseases constitutes the biological control of the bagworm. Each has its own population dynamics, becoming abundant or scarce in different areas, at different times on various stages of growth of the bagworm caterpillar. No adult or egg parasites of the bagworm have been recorded. The following are brief notes on each parasite; the distinguishing feature of each parasite within the bagworm's bag is underlined.

Cryptinae - new species and genus

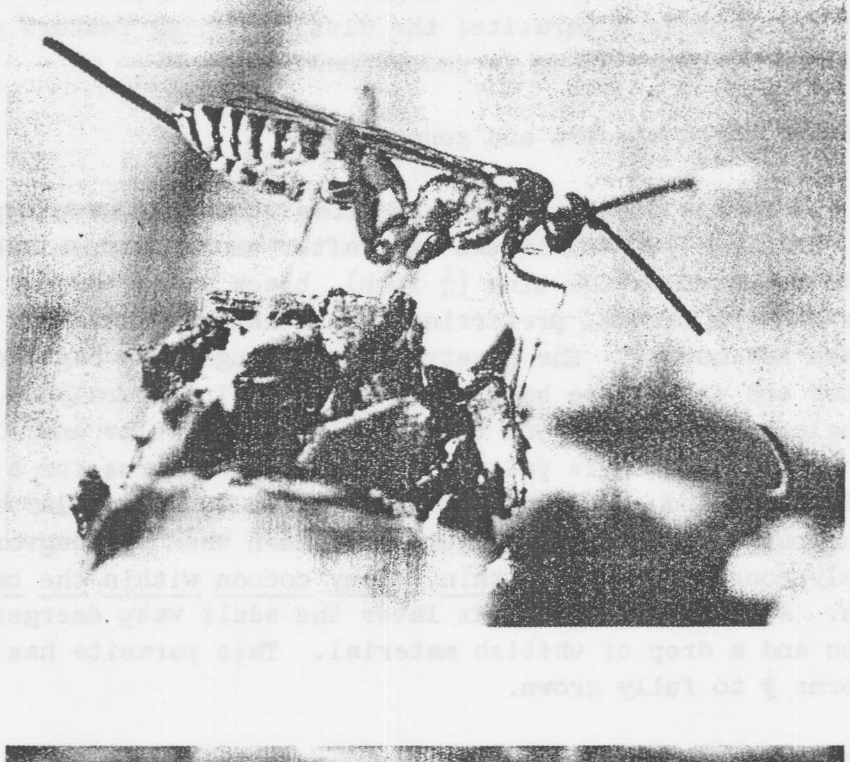
The female Cryptinid is a handsome ichneumon wasp approximately 3/4 inch long (Figure 47). Within two days after emerging from a bagworm's bag, the female is mated by the tiny ($\frac{1}{4}$ inch), black male. A day later, she actively seeks bagworm larvae, preferring those that have attached their bags to leaves and are not moving. She penetrates the tough silk bagworm bag with her ovipositor and stings the bagworm caterpillar into paralysis. Then she deposits a single egg externally on the immobile caterpillar and flies off to find another. The venon is potent; a stung finger burns for a few minutes, then remains sore and sensitive for a day. The Cryptinae larvae feed externally on the paralyzed bagworm (Figure 47), then when the bagworm has been completely consumed, spins a thin, shiny cocoon within the bagworm's bag and pupates. Approximately 2 weeks later the adult wasp emerges, leaving the shiny cocoon and a drop of whitish material. This parasite has been collected from bagworms $\frac{1}{2}$ to fully grown.

Psychidosmicra sp.

Psychidosmicra is a chalcid wasp, black, with yellow spots on its legs (Figure 48). Is the commonest bagworm parasite at times and the most important parasite of small (down to 3/4 inch) bagworms. *Psychidosmicra* apparently oviposits at night. A single egg is deposited probably internally in the bagworm caterpillar since this parasite's larva always feeds along the alimentary canal of the bagworm. The parasitized bagworm is agitated into spinning abnormal quantities of silk on the interior and exterior of its bag. Thus, a white-appearing bag is almost always a sign of a parasitized larva. The parasite eventually completely consumes the bagworm caterpillar, pupates within the bagworm bag and emerges as an adult wasp leaving its pupal skin with a strange hard "stone" attached. This "stone" is probably solidified waste products of pupation (Figure 48).

Iphiaulax sp.

Iphiaulax sp. is a black baconid wasp with a red abdomen. In 1968 it was common in Palmar, Changuinola, and Puerto Armuelles, but rare in Coto. It is the only bagworm parasite that feeds gregariously on a single host; from 3 to 55 cocoons of this parasite have been counted in a single bagworm bag (Figure 49).

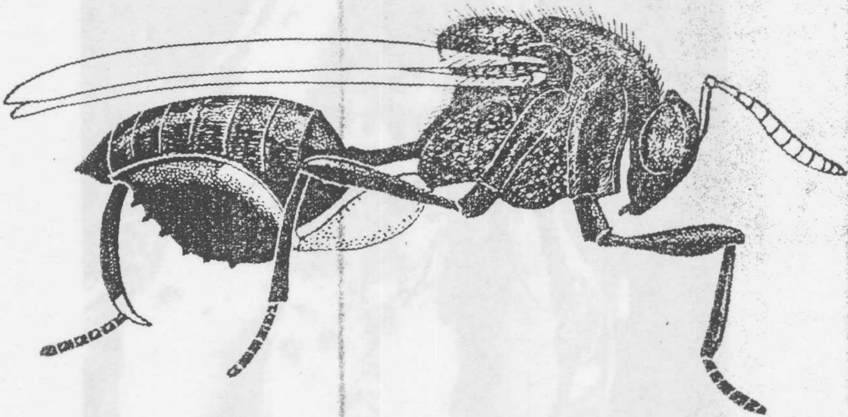


A.

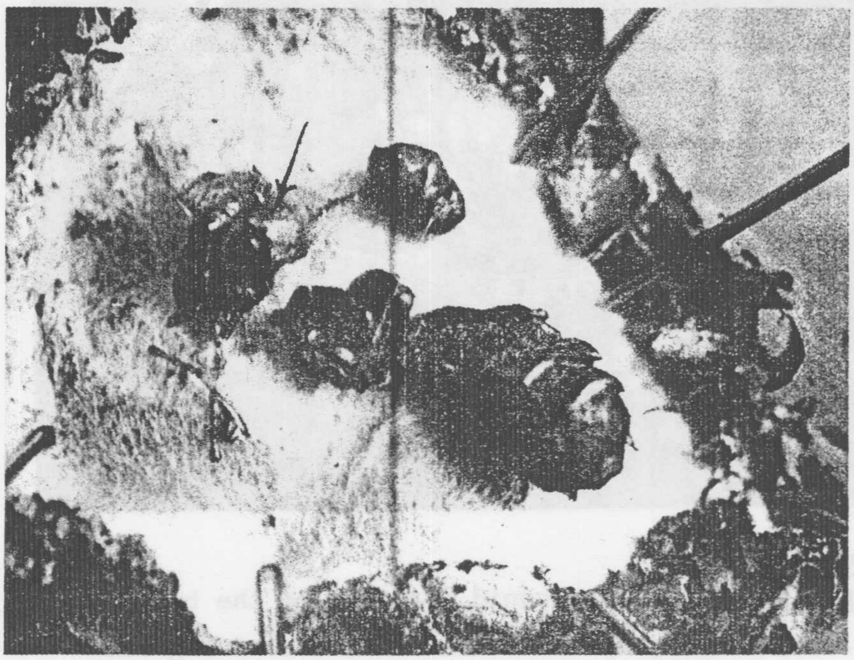
B.

Figure 47

Cryptinae ichneumon wasp, an important parasite of the bagworm. A. Adult female. B. Larva feeding on bagworm caterpillar.



A.



B.

Figure 48
Psychidosmicra sp., a chalcid parasite of the bagworm.
A. Adult wasp. B. Remains in bagworm bag after wasp has emerged; shed skin with "stone" attached (arrow).

A.

B.

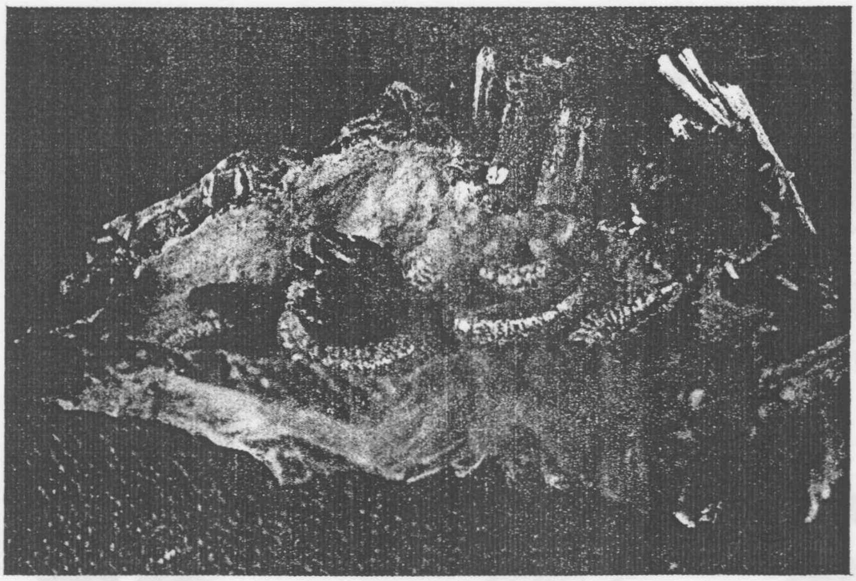


Figure 49

Iphiaulax sp., a braconid parasite of the bagworm.

A. Bagworm bag opened to show remains of bagworm caterpillar (below) Iphiaulax cocoons (above) and 2 emerged wasps (arrows).

B. Larvae ready to spin cocoons.

Swarms of hundreds of male Iphiaulax wasps were observed flying around erect upper banana leaves during September, October and November in Changuinola; there were no bagworms on the plants. This habit was also noted near live branches of madre de cacao fence posts. The white or tan cocoons spun by the Iphiaulax larvae near the top of the bagworm's bag is an unmistakable sign of this parasite (Figure 49). An attempt was made to increase the population of this parasite in the vicinity of Coto 49. Bagworms were collected in Palmar from a population with a relatively high (6%) percentage of Iphiaulax parasites. The bagworms were placed in wire cages which allowed the parasites to emerge (Figure 50). There was no increase in Iphiaulax parasitism in the vicinity of the cages.

Lespesia sp.

Lespesia sp. is a tachinid fly that oviposits into the bagworm's bag. The maggots kill the bagworm by feeding internally leaving only pieces of chitin (skin of the bagworm). The maggots have mouth hooks in place of mandibles so they are incapable of completely consuming the bagworm caterpillar as do the wasp parasites. This parasite is not as common on bagworms as it is on other defoliating pests such as Caligo, Opsiphanes, and pupae of Ceramidia.

Nosema sp.

Nosema sp. is a microsporidium disease that causes bagworm caterpillars to become flaccid and either die inside their bags or hang loosely from the bag and eventually fall to the ground. This disease is believed to be the cause of the empty bags that are frequently collected with no signs of parasitism. (OSTMARK, STEPHENS, EVERS)

Effects of Thuricide Spray on Natural Control. On July 29, 1968, 3 months after the first cycle of Thuricide was applied to control bagworms, a sample of 120 bagworms was collected from a 50.5-acre untreated area and 86 from a treated area in Coto 49. The bags were cut open and the following data taken:

	Untreated		Treated with Thuricide	
	No.	%	No.	%
LIVE BAGWORMS (Totals)	70	58.3	50	58.1
Larvae	18	15.0	22	25.5
Male pupae	26	21.7	20	23.2
Female pupae	12	10.0	6	7.0
Unhatched eggs	12	10.0	2	2.3
Hatched eggs	2	1.7	0	0.0
DEAD BAGWORMS (Totals)	50	41.7	36	41.9
Cryptinae parasite	26	21.7	12	15.1
Lespesia parasite	12	10.0	14	16.3

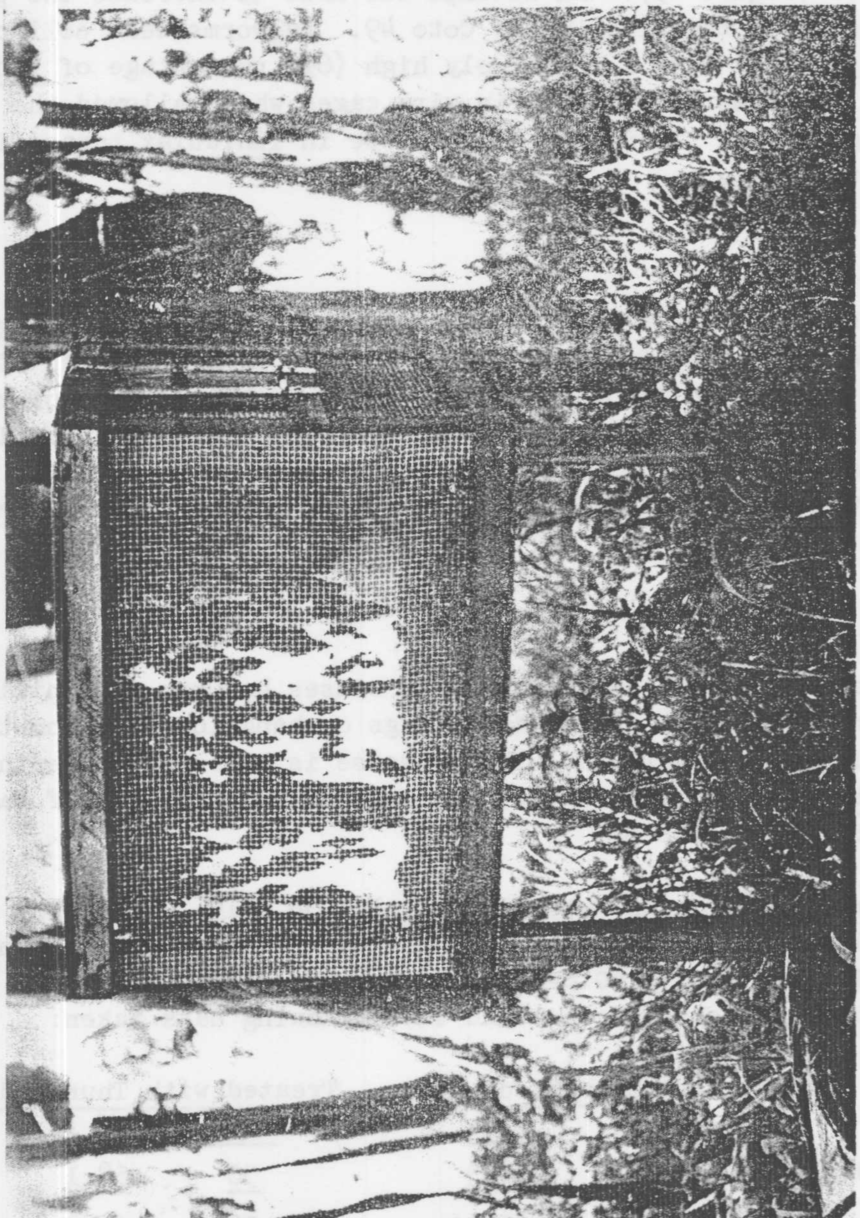


Figure 50
Cage containing parasitized bagworms from Palmar placed in Coto 49 to increase local population of Iphiaulax sp.

	Untreated No.	Untreated %	Treated with Thuricide No.	Treated with Thuricide %
Iphiaulax parasite	2	1.7	0	0.0
Psychidosmicra parasite	2	1.7	0	0.0
Diseases	2	1.7	8	9.3
Empty-unknown	6	5.0	0	0.0
Ants	0	0.0	2	2.3
	120	100%	86	100%

Note that the percentage of parasitism was approximately the same in both areas; Cryptinae were the most common, but the bagworm caterpillars were almost fully-grown and some were pupating. They were too large to be parasitized by the chalcid, *Psychidosmicra*.

Thuricide did not reduce the percentage of parasitism in the treated area. (OSTMARK)

Effects of Thuricide on Bagworms in Coto and Puerto Armuelles. On April 4 and 17, 1968, 565 acres of VALERY in Bogamani Farm were treated with .35 gal. of Thuricide in 4.65 gals. water plus 4 ozs. Plyac/100 gals.; swaths were 40 feet. A combination of the Thuricide and parasites killed 98% of the small bagworms and 60% of the large bagworms. (STEPHENS)

In Coto 48, Thuricide 90T (0.6 gal. + 4. ozs. Plyac/100 gals.) were applied to 600 acres on April 20. On May 17, 1968, .4 gals. of the new Thuricide formulation was sprayed on the same area. Seven days after the second spray, samples of large and small bagworms were collected and the mortality caused by Thuricide and natural control was determined. Thuricide killed 10% of the large bagworms in Coto 48, natural control agents killed 8% more; 28% of the small bagworms were killed by the Thuricide sprays, while parasites killed 57% of the total.

In Coto 49, sprayed about the same time, Thuricide killed 14%; parasites, 19% of the large bagworms. Of the small bagworms Thuricide killed 33%; parasites 57%. There was definitely some continuing mortality after the 7-day check. (CAID)

Toxaphene EC Vs. Toxaphene ULV for Bagworm Control. On April 24, 1968 Toxaphene EC (emulsifiable concentrate) at the rate of 30 ozs. (1.87 lbs. active) per acre and Toxaphene ULV (ultra low volume) at 26 ozs. (1.95 lbs. active) per acre were each applied to 50-acre bagworm-infested blocks in Coto 48. The purpose of the applications was to obtain fruit for a residue report.

On May 25, samples of bagworms remaining in the blocks were collected and examined to determine the cause of death. The results:

	Size of Bagworm	Live Bagworms %	Dead Bagworms % Toxaphene	Parasites
Toxaphene EC	Large	45	26	29
	Small	14	51	35
Toxaphene ULV	Large	66	6	28
	Small	23	30	47

Toxaphene is most lethal to small bagworms. Undoubtedly some of the dead bagworms listed under "Parasites" were killed by Toxaphene. (CAID)

Leaf Pruning Did Not Reduce Bagworm Populations. By early August, progeny of the bagworms that had been sprayed with Thuricide in April had just hatched. Approximately 60% of the newly-hatched bagworms were on hanging leaves and the two lowest erect leaves. Plans were made to cut these leaves in order to reduce the number of surviving larvae.

From August 26 to September 5, 1968 leaves were cut in 5 even-numbered sections in Coto 49; the plants in 6 odd-numbered sections were left untouched excep for normal pruning cycles. On October 15 and 16 the lowest 6 leaves on 5 plants (total 30 leaves) from each section were cut and the number of bagworms on the up per and lower sides of the leaves were counted. The bagworms were still in their first instars and only a few were over an inch long.

As shown in Table 37, there was almost no difference in the number of bagworms per leaf between the plants in the pruned (10.9/leaf) and unpruned (10.7/leaf) sections. There were approximately 2.5 times as many bagworms on the upper leaf surface as on the lower surface in all sections. This figure will reverse itself as the bagworms grow larger.

Two possible reasons for the failure of leaf pruning to reduce the numbers o newly-hatched bagworms is that the young bagworms were able to crawl back up on the plants before ants, lizards and other predators could intercept them and the normal leaf pruning cycle in check plots nullified the effects of the leaf-pruned plots. (OSTMARK)

Bagworms Migrate from Cut to Growing Plants. Two experiments were conducted in order to determine:

1) what percentage of bagworms on cut plants survive to re-infest growing plants,

2) how fast bagworms move,

3) how far they will travel to reach new host plants,

4) survival of bagworms on cut plants.

Table 37

Numbers of Bagworms on Leaf-Pruned and Unpruned Plants.
Coto 49, Costa Rica

		Leaf Number						Grand
		Lowest	2	3	4	5	6	Totals
Unpruned Plants	Upper side	214	253	213	243	229	181	1333
	Lower side	83	93	111	127	99	81	594
	Total bagworms	297	346	324	370	328	262	1927
	Total leaves sampled	30	30	30	30	30	30	180
	Bagworms/leaf	9.9	11.5	10.8	12.3	10.9	8.7	10.7
Leaf-Pruned Plants	Upper side	192	288	190	194	179	91	1134
	Lower side	69	96	106	97	74	62	504
	Total bagworms	261	384	296	291	253	153	1638
	Total leaves sampled	25	25	25	25	25	25	150
	Bagworms/leaf	10.4	15.4	11.8	11.6	10.1	6.1	10.9

In the first experiment strips of white, red, and blue polyethylene 1 x 6 inches were glued with Duco cement to the bags of bagworms 2 inches or more in length. Twenty bagworms were placed on cut leaves along the perimeters of concentric semi-circles with radii of 6, 12, and 18 feet. At the center of the radii was a banana plant growing near an 8-feet study tower.

The bagworms were placed on the ground at 9:00 a.m. At first, only 8 of the 60 bagworms began to move. At 1:00 p.m. a heavy rain fell in the area. By this time, all but 8 of the bagworms were moving (these 8 never moved far) and some had begun to climb plants; 12 had lost their plastic markers. Twenty-four hours later only 14 of the 60 were located (plus the 8 that remained on the cut leaves). These were as high as the uppermost leaf and some had crawled from the outermost circle. Too many polyethylene tags were lost so a new experiment was begun.

In a second experiment the bagworms were dyed with Day Glo, fire orange D-14, a Daylight Fluorescent Pigment produced by Switzer Brothers, Inc., Cleveland, Ohio A full cup of the Day Glo dust was placed in a polyethylene bag with 103 bagworms and shaken. This operation did not take more than 2 minutes and the dust was harmless to the larvae. The bagworms were placed on the lower side of 3 cut leaves on the ground surface. The area selected for this observation was at the corner of a farm section in order to use the roads as a barrier devoid of any ground cover. The cut leaves were placed among 6 marked mats simulating the same situation as pruned or cut leaves from harvested plants. Leaves of other banana mats touching the experimental plants were cut or bent to prevent overhead immigration of the bagworms, and to concentrate the dyed larvae within the restricted area of the 6 mats, if possible. The mats used in this experiment had 10 adult plants (3 of them bearing young fruit), three followers (height 3'-8'), and 21 suckers (height 3"-24").

The bagworms were closely watched right from the moment they were released on top of three cut banana leaves. The size of these insects varied as follows: 4.8% measured $\frac{1}{2}$"-3/4"; 77.7% measured 1"-2"; 17.5% measured $2\frac{1}{2}$"-2 3/4".

Three hours later the bagworms were seen moving from the releasing leaves to the following places:

23.3% crawled upward on pseudostems of adult plants and followers,
10.7% on suckers 3"-24" in height,
15.5% on old hanging leaves and first and fifth erect leaves.

49.5%

34.0% crawled on-ground surface and trash,
16.5% hid underside old cut leaves or trash.

40.5%

In 3 hours 49.5% of the bagworms had abandoned the ground surface and were crawling upwards on the pseudostems toward the leaves. After the first 3 hours of exposure a heavy (approx. 2") rain poured on the tinted caterpillars for five continuous hours. In spite of the rain the fluorescent dust remained visible on the bagworms. After 26 hours 80.6% of the bagworms were found up on the plants; the majority were on lower leaves and the pseudostems, the rest (19.4%) were still on the cut leaves or weeds. An inspection 4 days later disclosed the following information:

45.6% bagworms on first six erect leaves, larvae measured 1-2 3/4 but most of them were 2" in size; some were feeding,
6.8% on uppermost leaves,
1.0% on old hanging leaves,
2.0% on a 1' tall sucker.
55.4%

8.7% found dead on releasing leaves,
35.9% lost.

Actually, 52.4% of the bagworms found were on healthy banana leaves. The lost bagworms (35.9%) were not found after an intense search; they were probably hidden or on the upper erect leaves and difficult to see. The 8.7% mortality was confirmed by inspecting the interior of the larvae that never moved from the releasing leaves; they had been parasitized.

In general, large bagworms will travel 18 or more feet from cut leaves to growing plants. There is little bagworm mortality due to lizards or ants when the bagworms crawl over the plantation floor. Within 4 hours after cutting the majority (up to 80%) of the bagworms have deserted the cut leaves for growing plants. (EVERS, OSTMARK)

Bagworms Feed on at Least 18 Plants Other Than Bananas. A survey of plants in the banana plantations disclosed at least 18 plants being fed upon by young bagworms. These alternate host plants definitely enhance the survival of bagworms by providing a food source until the bagworms are large enough to migrate to bananas. The alternate hosts are:

Piper auritum	Mikania micrantha
Piper diandrum	Paspalum conjugatum
Cecropia peltata	Ipomea 3 spp.
Paullinia sp.	Amaranthus spinosus
Ciperus luzulae	Compositae (3 spp.)
Eupatorium ?	3 unidentified plants

The first 4 plants listed are the most important ones. (EVERS)

Root Borer Studies

The banana root borer, Cosmopolites sordidus, is found wherever bananas are grown. Although we know borer larvae tunnel in the rhizomes, tests were conducted this year to determine what effect this tunnelling has on banana roots.

Root Borers Reduce Number, Length of Banana Roots. Two experiments were conducted to see if we could develop a technique to determine what root borers do to banana roots when the larvae tunnel in the rhizome.

In the first test 20 six-inch diameter VALERY rhizomes (seeds) were placed in frames in the ceiling of a root chamber 7 feet high. A constant mist saturated the atmosphere within the chamber allowing the roots to grow without soil. When the roots had grown for 26 days, 30 unsexed root borers were placed on each of 10 seeds; 10 were left as checks. The roots were measured at 1-2 week intervals until 66 days after the introduction of the borers. There were fewer (61 vs. 75) roots produced by the plants with borers, but they averaged longer (53.8 vs. 49.5 inches). The borers did not oviposit and infest the seeds as expected.

The second test was similar except 10 seeds averaging 3.8 lbs. were punctured with a nail and 33 root borer eggs inserted into the perforations in each seed; 10 seeds averaging 3.7 lbs. were used as checks.

The roots were allowed to grow for 134 days. In the meantime, 3 seeds with borers were dissected in order to determine the success of the egg hatch and the progress of the larval tunnels; 2 checks were dissected for comparison.

At the end of 134 days the roots from the remaining 15 plants were counted and measured, then photographed and dissected. Figure 51 shows a typical borer-riddled seed compared to an uninfested seed; Figure 52 depicts the root growth from both infested and uninfested seeds.

Overall, the technique of artificially infesting seeds with borer eggs was successful. Seed dissection showed good egg hatch and larval development in almost all the seeds. One seed that had been infested with borer eggs was found to be completely clean upon dissection. The root data from this seed were included under "Borer-Free Seeds" in the following summary:

	Borer-infested seeds	Borer-free seeds
Plants	6	9
Roots	23	103
Tot. feet	138.2	783.1
Ave. root length (ft.)	6.0	7.6
Ave. No. roots/plant	3.8	11.4

In general, root borer damage has more effect on number rather than length of banana roots. (OSTMARK)

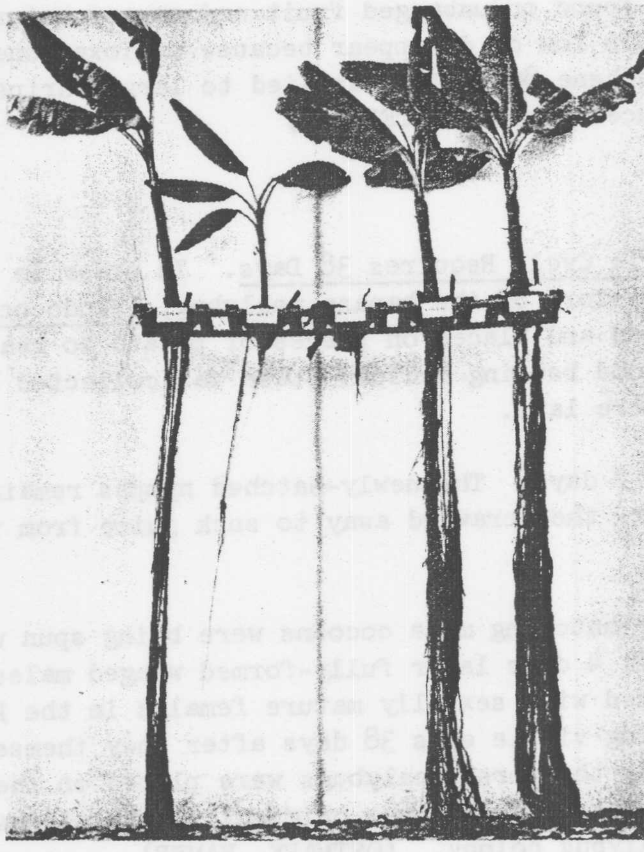


Figure 51

Plants grown for 134 days in a mist chamber.

Plant 1: Unsuccessfully infested with root borer eggs.

Plant 2 & 3: Each infested with 33 root borer eggs.

Plant 4 & 5: Checks.

both nymphs and adults, in hands protected from the spray by flower bracts. Within a few days after the second treatment, thrips counts on suckers and pseudostems dropped to zero (Table 38). Approximately 2 months after the treatments, the pest had been completely controlled.

The next step was to evaluate ULV Toxaphene for thrips control in an older more dense VALERY farm. The Cotes Farm was treated on October 10 and 23 with 28.9 ounces (2.17 lbs. act.) and 29.1 ounces (2.18 lbs. act.) of ULV Toxaphene 80 per acre, respectively. One month after the treatments, mortality rates were comparable to those in the Farm 52 trial. However, a few surviving thrips were still found on unbagged fruit and excess water suckers. Thrips will probably remain low or disappear because of Toxaphene's residual effects. If so, ULV Toxaphene 80 will be applied to large thrips infestations, mainly in Associate Producer farms. (STEPHENS)

Mealybug Studies

Complete Mealybug Life Cycle Requires 38 Days. In order to obtain more information on the life history of the banana mealybug, *Pseudococcus* new species, nymphs were field collected and placed on pieces of potato to rear; banana stalk rotted too fast to be a good rearing medium. Data was collected beginning with the time the first eggs were laid.

Eggs hatched in 6 to 7 days. The newly-hatched nymphs remained under the egg mass for almost a week, then crawled away to suck juice from the potato slices.

Exactly 29 days after hatching male cocoons were being spun under the potato slices in the Petri dishes; 4 days later fully-formed winged males appeared. These males apparently mated with sexually mature females in the Petri dishes because females began laying viable eggs 38 days after they themselves had hatched. Four months after the first mealybugs were placed on the potato pieces, there were nymphs still being produced; the original potato pieces were still sustaining life in the mealybug colony. (OSTMARK, HAMER)

Barriers on Stalks Do Not Stop Mealybugs. An experiment was conducted to determine if a 1-inch wide strip of cloth, impregnated with an insecticide or repellent, and tied around the stalk between the fruit and the pseudostem would prevent mealybugs from reaching the fruit.

Barriers tested were cloth strips soaked in oil, Toxaphene and Diazinon; plain cloth strips, and Stickem, a non-drying tanglefoot compound. Twenty mealybugs were placed below or above the barrier on 8-inch pieces of stalk. The lower end of the stalk stood in a Petri dish full of water to keep the stalk fresh and prevent the mealybugs from escaping. Only cloth strips dipped in Diazinon showed promise; the mealybugs crossed all the other barriers. The

Table 38

Effects of 2 Applications of ULV Toxaphene 80 on Red Rust Thrips in Farm 52 VALERY Plantilla in 1968 - Changuinola, Panama

	Date	Ave. Thrips on 40 Suckers1/ Nymphs	Adults	Comments
Pre-Appl.	May 16	31.9	5.9	
1st Appl.	May 23 2/			
	May 28	1.8	.6	Spot checks revealed nymphs and adults in young fruit.
2nd Appl.	June 7 3/			
	June 20	.0	.0	4 suckers (not included in survey) found with a few thrips during spot check.
	Aug. 14	.0	.0	4 suckers (not included in survey) found with a few thrips during spot check.
	Sept.	.0	.0	Entire area free of thrips on suckers and fruit.
	Sept. 10			No thrips or thrips damage seen on fruit or suckers during intense spot check.

1/ Counts were made on suckers with the most feeding marks caused by thrips.

2/ 29.3 fluid ounces (2.2 lbs. act.) per acre.

3/ 29.0 fluid ounces (2.18 lbs. act.) per acre.

Stickem prevented mealybugs from crossing at first, but they managed to tumble over. Also, stingless bees collected the Stickem and carried it off to their nests. (OSTMARK, CAID)

Cloth strips dipped in a solution of 10% Diazinon and attached to stalks in the field rapidly lost their repellency and stems so treated had just as many mealybugs as check stems. (CAID)

Diazinon Dusting Will Reduce Mealybug-Infested Stems. From October through December 1968, a five-man crew in La Curva Farm dusted stems within 3 weeks of harvest with a 10% Diazinon - 20% maneb mixture on a 2-week cycle. The purpose of incorporating the Diazinon was to try to keep the stems free of mealybugs for shipment to Japan. The results (Table 39) show that the percentage of stems with light mealybug infestations are significantly reduced and medium to severely infested stems are eliminated by the Diazinon dusting. (CAID)

Vapona Resin Strip Kills Aphids, Not Mealybugs. Cubes of Vapona resin strip weighing $\frac{1}{2}$ and 1 gram were attached below the 3rd hand on stems with a 2-ply chill bag covered by a perforated polyethylene bag. The test was conducted in one cayo of Guaruma II from December 1967 until March 1968. Diazinon-treated chill bags and untreated chill bag plots were in adjacent cayos.

After approximately 1200 stems were examined in each treatment, the following conclusions were drawn:

1) A 1-gram piece of 20 percent Vapona resin gave sooty mold control equal to 1 gram of 50 percent Diazinon WP spray inside the chill bag.

2) One-half gram Vapona resin was inferior to Diazinon or 1 gram of Vapona, but much superior to untreated fruit.

3) Cost of treating stems with Diazinon was approximately $0.005/stem as compared to $0.0075 to $0.01 for one gram Vapona resin strip. The attachment of the Vapona to the stalk presents a problem since the cube must be attached to a wire that can be forced into the stalk.

4) Vapona did not give adequate control of mealybugs. (CAID)

Dimecron in Fruit Spray Effective Against Aphids, Not Mealybugs. Fifty ml. of 50 percent Dimecron EC (a systemic phosphate insecticide of low mammalian toxicity) per 5 gallons of fruit spray gave control of sooty mold comparable to Diazinon-dusted bags. Mealybugs were not controlled by the spray. (CAID)

Mealybug Fauna and Their Hosts in Honduras. A total of 9 species of mealybugs were collected from 24 host plants on the ground cover in Honduras banana farms. Almost all the mealybugs were found on roots or root crowns; only *Lippia reptans* and *Piper tuberculatum* hosted mealybugs on leaves or stems.

Table 39

Mealybug Infestations on 12-Week-Old Stems After Dusting with a 10% Diazinon-20% Maneb Mixture. La Curva Farm, Honduras - October-December, 1968

	Treated Stems				Stems Not Treated			
Date	No.	Clean	Light	Med.-Severe	No.	Clean	Light	Med.-Severe
		(Percent)				(Percent)		
10/28	371	98.6	1.4	0.0	191	45.5	54.5	0.0
11/4	362	98.2	1.8	0.0	242	48.8	49.5	1.7
11/5	642	97.3	2.7	0.0	295	73.2	25.7	1.1
11/12	670	98.3	1.7	0.0	234	48.7	48.7	2.5
11/18	285	96.8	3.2	0.0	311	48.5	48.4	3.2
11/26	363	99.4	0.6	0.0	480	50.2	46.8	2.9
11/27	675	99.7	0.3	0.0	332	55.7	42.7	1.5
12/2	214	97.6	2.4	0.0	466	41.2	56.6	2.1
12/9	341	99.4	0.6	0.0	520	52.6	46.1	1.1
12/12	201	92.0	8.0	0.0	676	48.8	49.8	1.3
12/17	234	98.2	1.8	0.0	425	53.4	45.4	1.1
TOTALS	4358	98.3	1.7	0.0	4172	51.2	47.1	1.7

The banana mealybug, <u>Pseudococcus</u> n. sp., was collected from the following plants:

<u>Acalypha setosa</u>
<u>Blechum pyramidatum</u>
<u>Caperomia castainefolia</u>
<u>Cissus sicyoides</u>
<u>Physalis pubescens</u>
<u>Piper tuberculatum</u>
<u>Rivina humilis</u>
<u>Urera elata</u>

The striped mealybug, <u>Ferrisia virgata</u>, which constitutes about 25% of the mealybug populations on banana stalks was collected from the following plants: <u>Acalypha setosa</u>, <u>Pilea mycrophylla</u>, <u>Solanum torvum</u>.

Another potentially serious banana mealybug is <u>Dysmicoccus brevipes</u> which is a primary pest of pineapples.

In Formosa, Hawaii, and Florida, it is found on banana roots, leaf bases and fruit. In Honduras it is found on: <u>Cyperus tenuis</u>, <u>Ixophorus unisetus</u>, <u>Panicum fasciculatum</u>, <u>Pilea microphylla</u>.

Other mealybugs and their hosts are:

<u>Rhizoecus mayanus</u> found on:

<u>Blechum pyramidatum</u>
<u>Leptochloa filiformis</u>
<u>Physalis pubescens</u>
<u>Pilea microphylla</u>
<u>Solanum torvum</u>
<u>Syngonium podophyllum</u>
<u>Thelypteris normalis</u>
<u>Urera elata</u>

<u>Pseudococcus landoi</u> found on:

<u>Desmodium affine</u>, <u>Piper auritum</u>, <u>Solanum nigrum</u>.

<u>Rhizoecus cacticans</u> found on:

<u>Eleusine indica</u>

<u>Tridiscus</u> sp. found on:

<u>Ixophorus unisetus</u>

<u>Geococcus coffea</u> found on:

<u>Pilea microphylla</u>, <u>Urera elata</u>

<u>Phenacoccus</u> n. sp. (<u>Solani</u> group) found on:

<u>Lippia reptans</u>

(EVERS)

Peel-Scarring Beetle Studies

There have been localized outbreaks of the peel-scarring beetle, Colaspis sp., over the past year in Changuinola; these outbreaks always disappeared after a few months.

In 1967 beetle marks appeared in Farms 15 and 65, especially near the old river beds. The pest has now spread to nearly every farm in the Division. One of the worst areas, Lake 24 of Farm 65, was treated in 1968 with 2 cycles of Sevin, 2 cycles of Thuricide, and 1 ULV Toxaphene 80 spray, all of which produced negative results. Only beetles feeding on the unfurled candela were killed. This pest conceals itself in young stems, between fingers, and under the placenta and trash leaf, making it impossible to contact with insecticides from the air.

In July 1968 a Sevin fruit spray program was started. Farms 15, 24, 32, 33, 62, 63 and 65 were placed under this program which undoubtedly reduced beetle marks. However, some damage occurs before the first fruit spray because beetles invade young stems at the time of shooting. Also, it is extremely difficult to spray Sevin up into young hands still covered by the flower bract.

In September 1968 basic behavioral studies began in order to learn more about the breeding places and movements of the pest. Sticky traps placed over the soil in Farm 65 have caught adult beetles emerging from the bottom of barrow pits and dry canals, from the tops of well-drained canal banks, but none from the low edge of the old river bed. Only 11 beetles were caught during 4 weeks in 230 sticky traps made from banana boxes and maneb drums. New techniques are being investigated to improve trapping methods.

There is some question as to the correct scientific name of this beetle. We have always called the peel-scarring beetle Colaspis hypochlora. A similar-appearing beetle with more pronounced elytrial striae (line of pits) which was caught in net sweeps, soil traps, and found on banana candelas, but not on fruit was identified by Dr. R. White as C. hypochlora; the peel-scarring beetle was identified as Colaspis sp., a species that is not in the U. S. National Museum and perhaps has not yet been described. Observations in the laboratory indicate that C. hypochlora is slightly negatively geotropic and slightly positively phototropic.

Beauveria bassiana, a common insect pathogen, was identified from a single Colaspis hypochlora adult by Gerard M. Thomas, Division of Invertebrate Pathology, Berkeley. The fungus has been taken from several other banana insect pests in Changuinola. (STEPHENS)

Chalcid Wasp Studies

Kepone Dust Can Be Used As a Toxicant in Ant Bait. An experiment was conducted during September 1968 in Tacamiche Farm, Honduras to determine if 5% Kepone dust can be used as a substitute for Mirex in baits to control *Pheidole* ants, the host of the chalcid wasp, *Orasema costaricensis*. Previous tests comparing baits made with Mirex and Kepone showed that both were effective, but that Mirex baits eliminated ants in 7 days where Kepone baits required 21 days (see 1963 Annual Report). Since Kepone 5% dust is kept in all Divisions as a root borer insecticide and Mirex is occasionally difficult to obtain, the tests were rerun to see if Kepone dust could be used. Also, the effects of Kepone dust on the beneficial *Solenopsis* fire ants were never tested previously.

A total of 10 1-acre plots were established; 10 nests of *Pheidole* and 10 of *Solenopsis* were located and staked on each acre. Five of the 1-acre plots were each treated with 10 lbs. of .075% Kepone bait and 5 with 10 lbs. of bran and oil only. (To make 60 lbs. of bait, 15 ozs. 5% Kepone dust was stirred into 12 gals. boiling palm oil and mixed with 48 lbs. bran as a carrier.)

The night before the bait was applied there was a 1-inch rainfall which made an adverse but typical situation for bait application. The nests were examined weekly for 21 days then at the end of 38 days. The results (Figure 53) show that the Kepone bait controlled *Pheidole* ants after one month. At the end of 38 days, the beneficial *Solenopsis* ants were found to be less adversely affected; this may be considered a definite side benefit in favor of Kepone baits; Mirex baits generally kill all ants.

The number of marked ant nests also decreased somewhat in the check plots as the experiment progressed. There are several reasons for this:

1) Although precautions were taken to mark only ant nests near the center of the acre plots, some ants undoubtedly foraged into the bait-treated plots.

2) Some marked nests were deserted in both the treated and untreated plots.

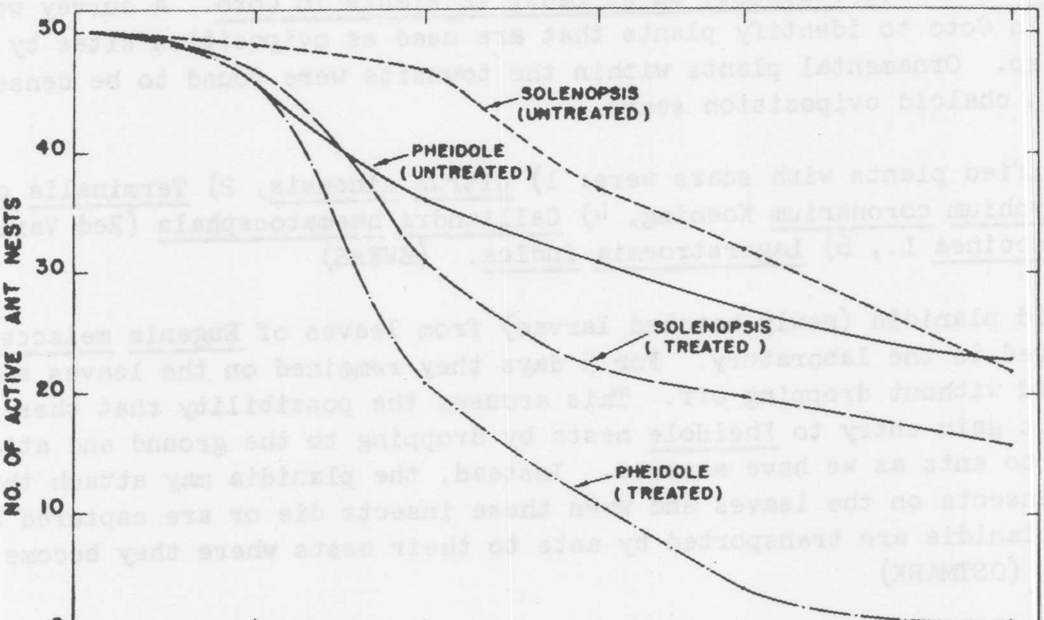
3) Some *Pheidole* nests were raided by *Solenopsis*; this was most common in the treated plots when the *Pheidole* ant colonies sometimes became too weak to defend their nests.

4) Some nests were lost because vandals pulled up the stakes.

In general, Kepone is still too slow-acting a toxicant to recommend when Mirex is available, although when Mirex is unavailable Kepone is now a proven substitute. (EVERS)

Chalcid Wasps Controlled in Changuinola. For the first time in the history of Changuinola, chalcid wasp treatments were made. During recent years, small

FIGURE 53 EFFECTS OF 10 Lbs. .075 % KEPONE BAIT PER ACRE ON *PHEIDOLE* AND *SOLENOPSIS* ANTS TACAMICHE FARM, HONDURAS. SEPTEMBER, 1968



isolated infestations were known in Changuinola, but diminished without serious fruit damage. During the last half of 1967 the incidence of chalcid marks on fruit increased. A special survey in December 1967 revealed that high chalcid populations existed in parts of Farms 24, 62, 63, 65, L. Flores, Alvarado, Vasquez and Segovia, totalling 725 acres. Lighter infestations were found in all other farms in the Changuinola District. Materials were immediately ordered and treatments with Mirex bait began in January. To date, treatments have been effective and the wasp is under control in all Company farms. Associate Producers have been slow in drawing out materials and most of these farms remain infested. Fortunately, fruit damage has been low in Associate Producer farms because they bagged early.

If chalcid damage is detected on harvested fruit, infested areas can quickly be mapped by examining oviposition marks on banana sucker leaves rather than on fruit. This technique is fast, reliable and avoids bruising fruit. This does not hold true for Honduras. (STEPHENS)

The Chalcid Wasp Oviposits on at Least 12 Plants in Coto. A survey was conducted in Coto to identify plants that are used as oviposition sites by the chalcid wasp. Ornamental plants within the townsite were found to be densely pitted with chalcid oviposition scars.

Identified plants with scars were: 1) *Citrus sinensis*, 2) *Terminalia cattapa* L., 3) *Hedychium coronarium* Koening, 4) *Calliandra haematocephala* (Red Variety), 5) *Ixora coccinea* L., 6) *Lagerstroemia indica*. (EVERS)

Chalcid planidia (newly-hatched larvae) from leaves of *Eugenia melaccensis* were observed in the laboratory. For 5 days they remained on the leaves and finally died without dropping off. This arouses the possibility that these planidia do not gain entry to *Pheidole* nests by dropping to the ground and attaching themselves to ants as we have assumed. Instead, the planidia may attach themselves to insects on the leaves and when these insects die or are captured by ants, the planidia are transported by ants to their nests where they become ant parasites. (OSTMARK)

Ant Hosts of Chalcid Wasp in Changuinola. Ants were collected in January 1968 from Farms 24, 63, 65, Alvarado, Vasquez, and Segovia in Changuinola. Chalcid wasps were found in only two of the ant species, *Pheidole hondurensis* and *Pheidole* sp. A. There were 70 ant larvae containing one chalcid planidia; 9 other parasitized ant larvae contained up to 6 planidia. Other ants collected were *Pheidole* (near *fallax*), *Pheidole* (near sp. B), *Ectatoma tuberculatum*, *Ponera* sp., *Typhlomyrmex*, *Atta* sp., *Cyphomyrmex rimosus minutus*, *Solenopsis geminata*, *Solenopsis* sp., and *Strumigenys louisianae*. (EVERS, STEPHENS)

Boisduval Scale Studies

Male Boisduval Scales Do Not Fly More Than 18 Feet. The boisduval scale, *Diaspis boisduvalii*, became a pest of bananas in 1965. In 1968 the presence of this insect on banana crowns caused bananas shipped to Japan to be fumigated. In order to learn more about the biology of this insect, a series of studies were planned. One of these involved the distance the delicate winged males can fly to fertilize females. The hallway in the Entomology Building was the site of this experiment. The hall was dark except for the light entering through a window in a door at one end of the hall. Male scales had been collected by placing infested banana crowns in an ice-cream carton with a test tube sticking out of one side. The male scales were attracted to the light and collected in the test tube.

Male scales were placed on a stool which was set at various distances from the window. The window was smeared with vaseline to trap the insects.

The results are tabulated below:

Insects Released	Flight Distance (Feet)	Insects Trapped on Window	Dead on Take off Area (%)	Never Reached Light Source (%)	Reached Light Source (%)	Temp.	Time A.M.
50	5.0	4	No data	No data	8.0	72°	8:00
150	9.0	10	21.3	72.0	6.7	78°	10:20
100	15.0	2	38.0	60.0	2.0	76°	9:10
66	18.0	2	15.1	81.8	3.0	74°	9:00
25	21.0	0	72.0	28.0	0.0	76°	9:15

Although the weak-flying male scales can undoubtedly be wind-disseminated for longer distances, 18 feet seems to be the maximum unassisted flight range. (EVERS)

Richardiid Fly Does Not Scratch Bananas

Observers in Changuinola said that the scratches on 5-15 day-old bananas were caused by the ovipositor of a fly in the family Richardiidae (Figure 54). This fly is a common associate of young bananas. Tests were conducted caging 30 flies on each of two stems of week-old fruit as well as placing flies in large Petri dishes with week-old fruit.

The flies did not mark the fruit in the field nor did they make any effort to oviposit on fruit in the Petri dishes. The scratches are probably caused by nectar-feeding bats. (OSTMARK)

Figure 54
A fruit fly (Diptera: Richardiidae) on banana bud.

Insecticide Usage in the Southern Divisions

During 1968 the amount of insecticide used in combating leaf-feeding caterpillars increased about fifty percent over the 1967 consumption. This increase was due in part to the unusually heavy outbreak of *Ceramidia* in Changuinola; in part to the severe infestations of bagworms in the Southern Divisions, and also because we reduced the number of *Ceramidia* per leaf that we can tolerate before spraying from 140 to 100.

The use of ULV Toxaphene was temporarily suspended during the early part of the year. Residues of Toxaphene were found in banana pulp because of an error in the analytical procedure from a private laboratory. Thuricide had to be substituted for Toxaphene for bagworm control. Control with Thuricide was inferior to ULV Toxaphene and costs $10+ per acre as compared to less than $1 per acre for Toxaphene.

A Sevin application costs approximately $1.00/acre for *Ceramidia* control but by using 20 ozs. of ULV Toxaphene, which gives excellent control, the cost can be reduced to $0.75/acre. (CAID)

BANANA BREEDING

Banana breeding during 1968 was confined largely to breeding at the diploid level. Although all the various breeding methods were employed to a limited extent, diploid breeding involving the preparatory stages of the Natural Triploid method was predominant.

Classical Method

A group of 58 Highgate x selected diploid seedlings is being grown in search of possible commercial hybrids. The selected diploid hybrid SH-580 was used as male parent in six of these hybrids and SH-868 in the remainder. Both of these male parents are excellent long-fingered types. It is expected that because of the Highgate parent the progeny will be shorter and stronger than the present Cocos-Lidi hybrids. About 300 additional Highgate bunches were pollinated during the year to provide a somewhat larger population for future selection. The same two male parents were used in these crosses.

No additional Cocos hybrids were produced or transplanted to the field this year. However, continued selection on earlier planted material yielded several promising clones (Table 40). All of these clones are presently being vegetatively propagated and tested for Fusarium wilt resistance. As a group, the Cocos x SH-254 hybrids are yielding very nice fruit and bunch types. Unfortunately, however, all are susceptible to Sigatoka disease. Unlike earlier hybrids involving banksii derived male parents, this series is relatively rapid in time from planting till shooting.

A group of 15 Gros Michel x diploid dwarf progeny were observed. Five plants were discarded because of early virus infection, seven were discarded because of tall plants, and the remaining three were discarded for poor bunch type. No Gros Michel progeny are currently under advanced testing.

The Classical method labors under the disadvantage of a weak-petioled condition peculiar to tetraploid progeny. For example, total leaf production of most of the Cocos x Lidi hybrids is two to four leaves more than VALERY. Nevertheless, in the adult stages VALERY always bears more leaves at any one time than comparable Cocos x Lidi hybrids, the petiole weakness of tetraploids being responsible for decreased leaf longevity. Consequently, petiole strength and leaf longevity are factors which should be considered in selecting diploid males for use in the Classical method. It is expected that the more extreme semi-dwarf level of the Highgate progeny with their shorter, broader leaves may result in considerably increased leaf longevity.

Table 40

Cocos Hybrids - 1968 Initial Selection

Pedigree	SH	Sigatoka	Hands	Fingers	Bunch Compactness	Days to Shooting (Plantilla)	Days to Shooting 1st Ratoon
Cocos x SH-254	2041	Bad	11	Long	Compactness	257	-
Cocos x SH-254	2042	Some	9-12	Long	Compactness	241	384
Cocos x SH-254	2043	Bad	10	Long	-	283	-
Cocos x SH-254	2044	Some	9	Long	-	272	428+
Cocos x SH-254	2045	Some	10	Long	Compactness	283	-
Cocos x SH-254	2056	Bad	11	Long	Compactness	283	-
Cocos x SH-254	2060	Bad	12	Med.-Long	Compactness	297	-
Cocos x SH-254	2062	Some	10-11	Med.-Long	-	302	384
Cocos x SH-254	2083	Bad	11	Medium	Compactness	-	-
Cocos x SH-263	2059	Bad	10-13	-	-	236	384
Cocos x SH-263	2061	None	8-10	Medium	Compactness	272	410
Cocos x SH-263	2075		9	Medium			
Cocos x SH-265	2057	Some	11	Med.-Long	Compactness	302	-
Cocos x SH-265	2081	Some	12	Short	Compactness	314	425
Cocos x SH-139	2058	Bad	8	Medium	-	241	318
Cocos x SH-139	2065	Bad	11-16	Medium	Compactness	317	404
Cocos x SH-447	2063	Bad	8	Long	-	-	-
Cocos x SH-447	2064	-	10	Long	-	-	-
Cocos x SH-396	2073	Little	11-15	-	-	247	422
Cocos x SH-396	2084	Some	10	Medium	-	247	-

A second disadvantage, which is less easily compensated for, is the tenuous nature of Fusarium wilt and Sigatoka disease resistance in the tetraploid products of the Classical method. That disease resistant tetraploid hybrids can revert to the susceptible condition has been shown. In the propagation of such tetraploid hybrids continued vigilance for the occurrence of susceptible sub-clones will have to be exercised.

In spite of these disadvantages, the Classical method can produce promising hybrids which approach existing commercial standards. The method is still considered to be the principal one in the Jamaican banana breeding program. In our program, a careful evaluation of the Highgate series of hybrids will be made before further work is attempted under the Classical method.

Diploid by Tetraploid Method

During the year, 100 triploid hybrids, produced by the Diploid by Tetraploid method, underwent observation for commercial potential. Fifteen of the hybrids were discarded for spindly, weak or abnormal plants, probably the result of unbalanced chromosomal constitution. Three plants were discarded for early virus infection and three others died. Twenty-three plants were discarded because of poor bunches or short fruits. Nearly half of the progeny were discarded because of incomplete parthenocarpy. Many of these plants bore fruit which resembled parthenocarpic diploid fruit, narrow in diameter but consisting of edible pulp. As parthenocarpy depends upon the action of a series of complementary genes, partial parthenocarpy is thought to represent the action of some but not all the genes required to produce full parthenocarpy. Eight hybrids were selected for more complete observation.

The occurrence of weakling, aneuploid types among the progeny is a shortcoming inherent in the Diploid by Tetraploid method which is caused by irregular meiotic pairing in the tetraploid male parent. The lack of full parthenocarpy, however, is a deficiency which can be corrected by a more suitable choice of fully parthenocarpic diploid seed parents.

Except for the absence of full parthenocarpy, many of the hybrids observed were very good in most agronomic characters. Several semi-dwarf hybrids were found which were promising in every other respect. Consequently, during the year some additional pollinations were made under this system and more crosses are planned for 1969.

Interspecific Method

The Interspecific method described in earlier reports involves the use of acuminata-balbisiana diploid hybrids for the production of diploid eggs which can be fertilized by 11 chromosomed acuminata sperm cells in the production of

AAB commercial hybrids. Two such interspecific hybrids (SH-66 and SH-67) have resulted from crosses involving wild <u>acuminata</u> and <u>balbisiana</u>. Present efforts are directed toward the production of fertile interspecific hybrids involving parthenocarpic, long-fruited <u>acuminata</u> parents. Twenty-nine <u>balbisiana</u> bunches were pollinated for this purpose, and 40 hybrids were transplanted to the field for observation. Attempts to use SH-67 to produce triploid hybrids using parthenocarpic <u>acuminata</u> males were also made by pollinating 33 bunches of fruit. A group of 130 triploid plants were transplanted to the field from these crosses during 1968.

We feel that the Interspecific method has considerable promise, especially in the production of hardy hybrids of both dessert and cooking types which can be grown under less than ideal environmental conditions.

<u>Natural Triploid Method</u>

The diploid breeding was directed toward the preparatory stages of the Natural Triploid method. Three separate phases of diploid breeding can be defined at this stage. Firstly, the breeding of superior diploid clones containing the meiotic restitution character which are useful as female parents in the Natural Triploid method. Secondly, the breeding of superior diploid clones containing the dwarf character which can be used as male parents in the same breeding system. Thirdly, the breeding of superior diploid clones which contain other indispensible characteristics such as Moko resistance, Pitting disease resistance, nematode resistance, agronomic excellence and high fruit quality. This classification is an artificial one that will exist only to this point. There is no reason, for example, that meiotic restitution or dwarf characters cannot appear on both the female and male sides of the ultimate cross, indeed there are advantages that they do.

Meiotic restituting clones presently number only 13 (Table 41). That more were not found during 1968, was one of the major disappointments of the year. Sixty-one Pitu hybrids were progeny-tested for meiotic restitution and only two were found with 6 and 10 percent diploid eggs, respectively. A third hybrid apparently yields some diploid eggs, but a larger population of progeny must be counted to verify this. Several other hybrids with a very low proportion of diploid eggs were also identified. The principal short-coming among the meiotic restituting lines is the scarcity of parthenocarpy, with only three clones exhibiting this characteristic. The best bunch type is shown by SH-1358 (Figure 55).

Meiotic restituting clones were involved in a large number of crosses with the following aims:

1) the introduction of the meiotic restituting character into diverse <u>acuminata</u> subspecies,

Table 41

Meiotic Restituting Diploids

Pedigree	Designation	Sigatoka	Parthe-nocarpy	Seeds Per Bunch	Pollen	Bearing	Hands	Fruit	Vigor	Diploid Eggs (%)
II-205, III-206, III-251	Pitu	Some	Full	300	1.5	45° - Pen-dulous	7	Long	Good	18
itu x Lidi	SH-555	Some	None	Many	1.0	45°	6-8	Medium-Long	Good	18
itu x II-4	SH-1356	Some	None	Many	1.5	Horizontal	9	Short	Very Good	28
itu x V-34	SH-1357	Some	None	Many	-	45°	7-9	Medium	Fair	16
Zeb. x Schiz.) x Pitu	SH-1358	Little	None	Many	-	Pendulous	8-11	Long	Excellent	16
I-344 x Pitu	SH-1359	Some	None	Many	2.5	Pendulous	7	Short	Very Good	10
I-175 x Pitu	SH-1553	Little	None	Many	1.0	Horiz. 45°	7-9	Medium-Long	Very Good	15
itu x II-195	SH-1554	Some	None	Many	1.5	Horiz. 45°	7-8	Medium-Long	Good	19
itu x V-34	SH-1562	Little	None	Many	2.0	Horizontal	7-8	Short	Good	18
I-287 x Pitu	SH-1563	None	None	Many	2.0	Horizontal	6-7	Very Short	Good	18
Zeb. x K. H. Keo) x Pitu	SH-1891	Bad	Partial	Some	-	-	-	-	-	8
I-329 x Pitu	SH-2070	-	Partial	Some	-	-	-	-	-	6
itu x II-195	SH-2072	-	Partial	Many	-	-	-	-	-	10

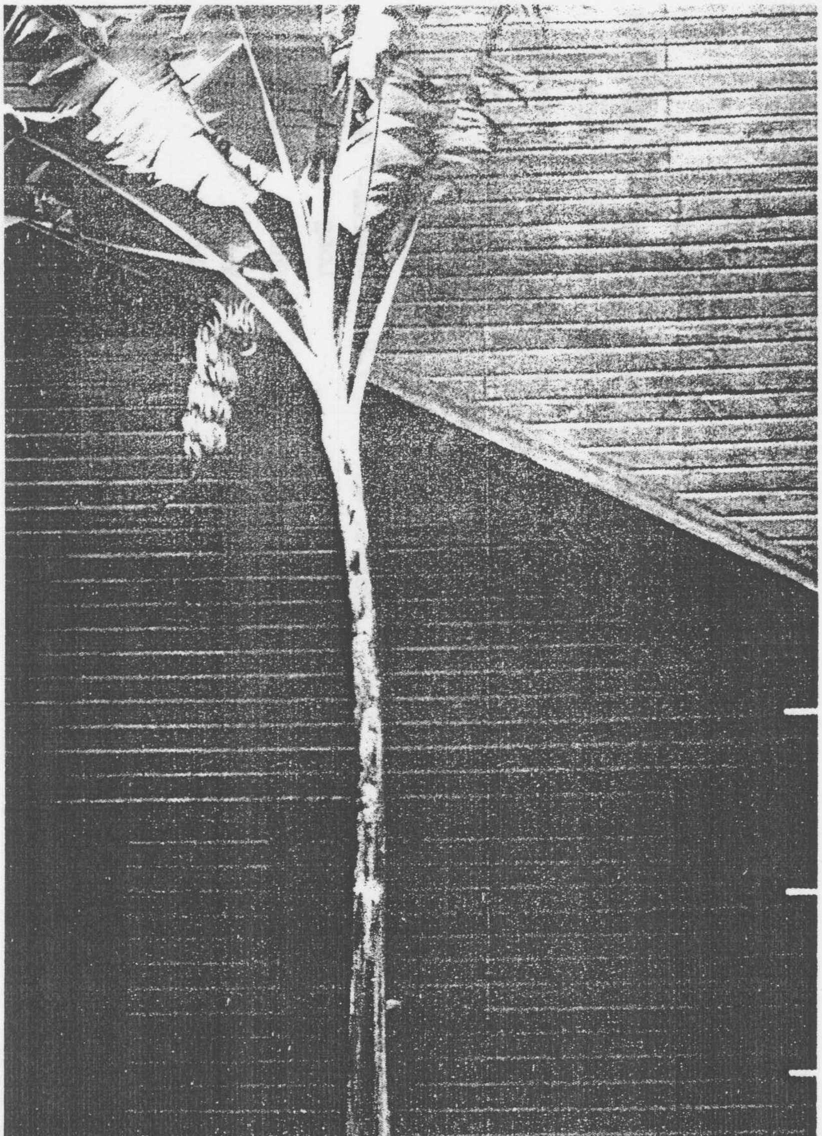


Figure 55

A good quality clone SH-1358 yields 16 percent diploid egg cells during meiosis.

2) the production of agronomically superior meiotic restituting clones,

3) the production of meiotic restituting lines with higher percentages of diploid eggs,

4) the combination of the meiotic restitution character with Moko and Fruit spot resistance.

A large number of hybrids involving meiotic restituting clones as one of the parents were transplanted to the field during the year.

The dwarf phase of diploid breeding progressed satisfactorily during the year, largely because of the ease of transmission of this dominant character (Figures 56 and 57). All told 46 selected dwarf diploids are being used in crosses (Table 42). Combinations with Moko resistant and Fruit spot resistant lines were made as well as a large number of crosses designed to produce agronomically superior dwarf types.

The genetics of the different semi-dwarf and dwarf height levels can now be elucidated since these different levels have been identified in fertile dwarf material. Presumably, it will be necessary to carry the three dwarf levels along in the breeding process, so that whatever level is deemed necessary is immediately available.

The combination of disease resistance characters into single clones was begun this year by crossing the various resistant clones (Table 43). A few plants of this material reached the field transplanting stage (Table 44).

A few final crosses under the Natural Triploid method were made. The clone SH-555 was used as the female parent and various superior diploids were the pollen parents. It cannot be expected that triploid progenies of this mediocre female parent will contain excellent commercial segregates. Nevertheless, it is important that this exercise be made early in case unexpected difficulties appear.

The natural division of breeding under the Natural Tetraploid method, and one which is getting underway, is based on subspecific categories. To realize the maximum benefits from heterosis in the final cross, diploids containing meiotic restitution, dwarfness, resistance to *Fusarium* wilt, Sigatoka disease, Moko disease, Pitting disease and nematodes along with good fruit quality and agronomic characters should be developed for each of the four major *acuminata* subspecies. To accomplish this, four individual breeding programs are being set up for the *banksii*, *malaccensis*, *microcarpa* and *sumatrana* subspecies. Other minor subspecies will be included as follows: *errans* with *banksii*, *siamea* with *malaccensis*, *truncata* with *microcarpa*, and *zebrina* with *sumatrana*. Examples of the allocation of germplasm to these four breeding projects is given in Tables 45 through 48. (RICHARDSON)

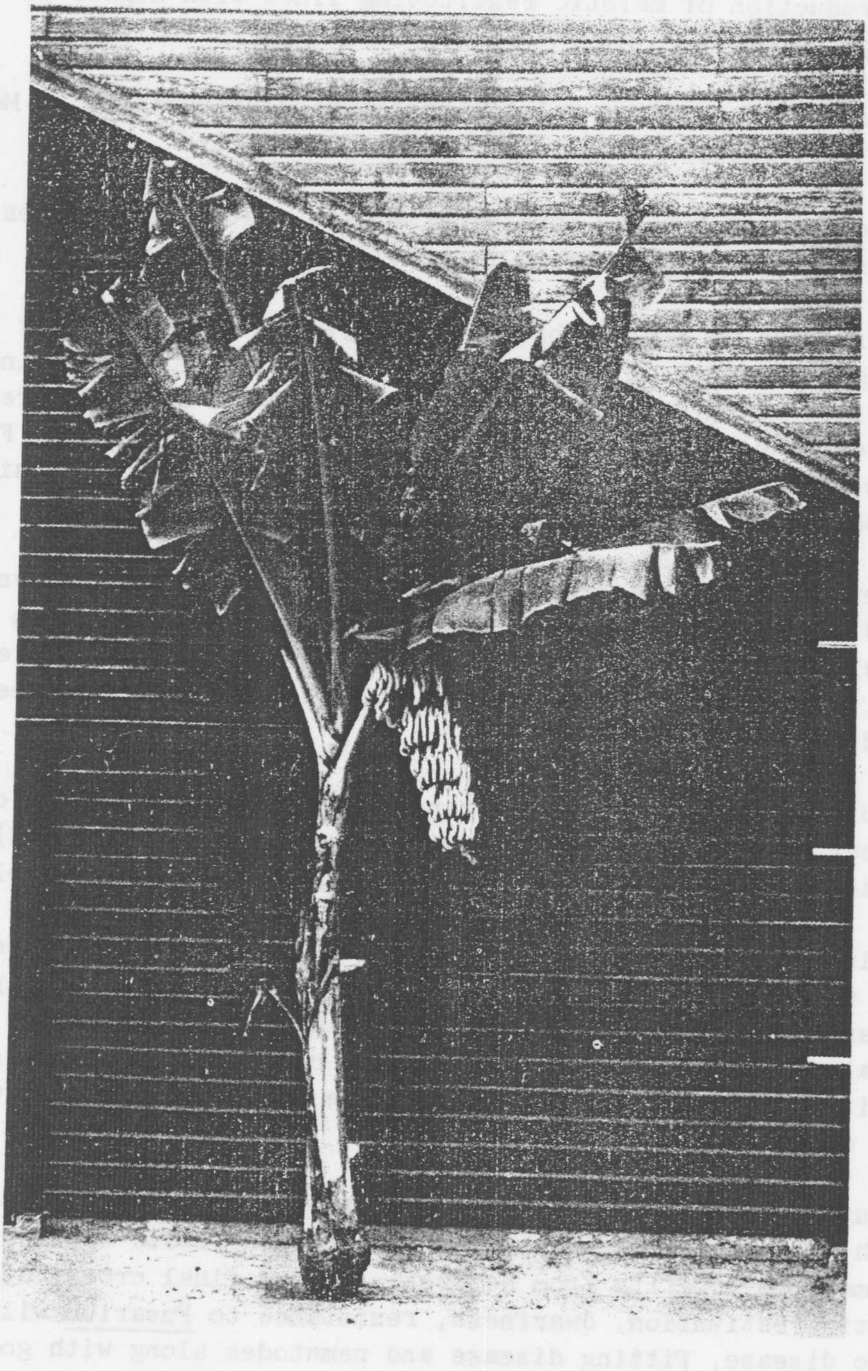


Figure 56
Select hybrid 1614 is a semi-dwarf clone of the "Giant" level with excellent bunch characteristics.

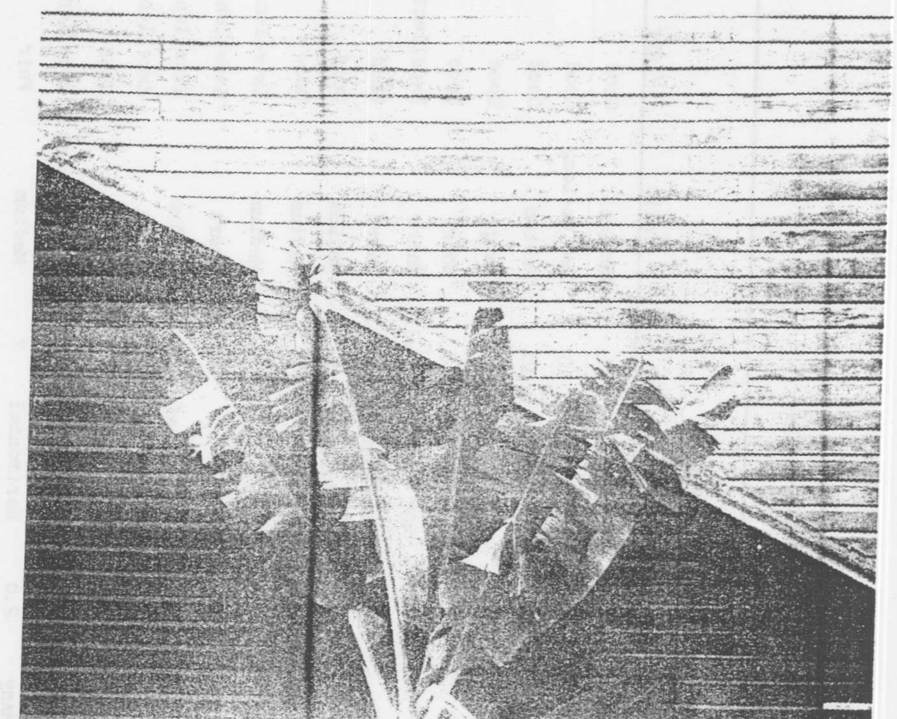


Figure 57
Select hybrid 1615 is a semi-dwarf clone of the "Robusta" level with a large bunch of long fruits.

Table 42

Additional Superior Diploid Dwarf Hybrids - 1968

	SH	Sigatoka	Parthe-nocarpy	Good Seeds Per Bunch	Pollen	Bearing	Hands	Fruit	Vigor	Dwarf Level
(Zeb. x Congo) x (II-30 x Lidi)	1614	None	Full	0	2.0	Pendulous	11	Medium	Good	Robusta
(Zeb. x Congo) x (II-30 x Lidi)	1615	None	Partial	0	1.0	Pendulous	10	Medium-Long	Good	Robusta
(Zeb. x Congo) x (II-30 x Lidi)	1616	Little	None	Many	1.5	Pendulous	10	Medium	Good	Robusta
(Zeb. x Congo) x (II-30 x Lidi)	1617	None	Partial	0	2.0	Pendulous	10	Long	Good	Robusta
(Zeb. x Congo) x [I-9 x (Zeb. x Lidi)]	1630	None	Full	0	1.0	45°	8	Short	Good	Giant
(Zeb. x Congo) x [I-9 x (Zeb. x Lidi)]	1637	None	Partial	0	1.5	45°	10-11	Short	Excellent	Giant
(Zeb. x Congo) x [I-9 x (Zeb. x Lidi)]	1640	Little	None	Many	2.0	Horizontal	8	Short	Good	Robusta
(Zeb. x Congo) x (II-30 x Lidi)	1682	None	Partial	0	2.5	Pendulous	9	Medium	Good	Giant
(Zeb. x Congo) x (II-30 x Lidi)	1683	Some	Partial	0	2.5	45°	9	Medium	Good	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1684	None	None	Many	-	45°	9	Medium	Excellent	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1685	Much	None	Some	-	45°	12	Short	Excellent	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1686	None	None	Many	2.0	Horizontal	9	Medium	Excellent	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1721	Some	None	Many	-	Horizontal	11	Short	Excellent	Dwarf
(Zeb. x VALERY) x (III-133 x Lidi)	1722	Little	None	Many	3.0	Horizontal	10	Medium	Good	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1723	Some	None	Many	2.5	45°	10	Medium-Long	Excellent	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1724	None	None	Many	2.0	Horizontal	7	Medium	Fair	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1725	Some	None	Many	1.0	45°	8-10	Medium	Excellent	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1747	Some	None	Many	1.0	45°	9-12	Short	Good	Giant

(Zeb. x VALERY) x (III-133 x Lidi)	1748	None	None	Many	2.0	45^{o}	10	Medium	Excellent	Giant
(I-9 x II-108) x (Zeb. x Congo)	1750	Some	Partial	Few	3.5	Pendulous	7	Short	Excellent	Robusta
(Zeb. x VALERY) x III-133	1874	Some	None	Many	2.0	45^{o}	9	Medium	Good	Giant
(Zeb. x VALERY) x III-133	1875	Some	None	Many	2.0	Horizontal	8	Medium	Excellent	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1878	Little	None	Many	2.0	Horizontal	13	Short	Excellent	Dwarf
(Zeb. x VALERY) x (III-133 x Lidi)	1879	Some	None	Many	-	Horizontal	10	Medium	Good	Dwarf
(Zeb. x VALERY) x (III-133 x Lidi)	1885	Little	None	Many	-	Horizontal	7	Short	Good	Giant
(Zeb. x VALERY) x (III-133 x Lidi)	1886	Little	None	Many	2.0	Horizontal	7	Medium-Short	Fair	Robusta
(Zeb. x VALERY) x (III-133 x Lidi)	1887	None	None	Many	2.0	Horizontal	7	Medium	Fair	Giant
(Zeb. x C. C. Trang) x (Cocos x Lidi)	1888	Much	Partial	0	-	Pendulous	6	Medium	Poor	Robusta
(Zeb. x C. C. Trang) x (Cocos x Lidi)	1889	Very bad	Partial	0	4.0	Pendulous	6-8	Medium	Good	Robusta
(Zeb. x VALERY) x (III-133 x Lidi)	1890	Much	None	Many	1.5	Horizontal	8	Short	Fair	Giant

Table 43

Bunches Pollinated - 1968

Classical Method	
Highgate x Selected Diploid Hybrids	299
Diploid x Tetraploid Method	
Selected Diploid Hybrids x Tetraploid Hybrids	53
Interspecific Method	
SH-67 x Selected Diploid Hybrids	33
Balbisiana x Selected Diploid Hybrids	29
Natural Triploid Method	
SH-555 x Selected Diploid Hybrids	17
Diploid Breeding	
Selected Diploid Hybrids x Diverse Subspecies	195
Superior Diploid Varieties x Diverse Subspecies	145
Selected Dwarf Hybrids x Selected Diploid Hybrids	203
Selected Dwarf Hybrids x Moko Resistant Clones	89
Selected Dwarf Hybrids x Fruit Spot Resistant Clones	6
Meiotic Restituting Clones x Diverse Subspecies	208
Meiotic Restituting Clones x Superior Diploid Varieties	75
Meiotic Restituting Clones x Meiotic Restituting Clones	80
Meiotic Restituting Clones x Moko Resistant Clones	74
Meiotic Restituting Clones x Fruit Spot Resistant Clones	6
Fruit Spot Resistant Clones x Fruit Spot Resistant Clones	33
Fruit Spot Resistant Clones x Moko Resistant Clones	6
Fruit Spot Resistant Clones x Nematode Resistant Clones	12
TOTAL POLLINATIONS	1,563

Table 44

Plants Transplanted to Field - 1968

Classical Method	
Highgate x Selected Diploid Hybrids	55
Diploid x Tetraploid Method	4
Interspecific Method	
SH-67 x Selected Diploid Hybrids	130
Balbisiana x Selected Diploid Hybrids	40
Natural Triploid Method	
SH-555 x Selected Diploid Hybrids	81
Diploid Breeding	
Selected Diploid Hybrids x Diverse Subspecies	2,479
Selected Dwarf Hybrids x Selected Diploid Hybrids	3,406
Selected Dwarf Hybrids x Moko Resistant Clones	167
Meiotic Restituting Clones x Selected Diploid Hybrids	2,100
Meiotic Restituting Clones x Moko Resistant Clones	55
Moko Resistant Clones x Moko Resistant Clones	156
Moko Resistant Clones x Nematode Resistant Clones	30
TOTAL	8,703

Table 45

Banksii Crosses

Designation	Pedigree	Combination of Characters	Progeny, % Banksii Germplasm
SH-1554 x III-206	(Pitu x II-195) x Pitu	Meiotic Rest. x Meiotic Restitution	75
SH-1553 x SH-555	(II-175 x Pitu) x (Pitu x Lidi)	Meiotic Rest. x Meiotic Restitution	50
SH-1358 x SH-1874	[(Z. x Schiz.) x Pitu] x [(Z. x VALERY) x III-133]	Meiotic Rest. x Dwarf	50
SH-1358 x SH-1566	[(Z. x Schiz.) x Pitu] x [(III-133 x (Z. VALERY)]	Meiotic Rest. x Dwarf	50
SH-669 x SH-1358	(II-311 x Manang) x [(Z. x Schiz.) x Pitu]	Meiotic Rest. x Moko	50
SH-254 x SH-555	(V-10 x III-125) x (Pitu x Lidi)	Meiotic Rest. x Agronomic	75
SH-1356 x III-41	(Pitu x II-4) x III-41	Meiotic Rest. x Agronomic	100
SH-669 x SH-1559	(II-311 x Manang) x [(Z. x V-10) x (Z. x VALERY)]	Dwarf x Moko	37
SH-1185 x SH-1350	(III-133 x III-3) x [(I-9 x II-108) x (Z. x Congo)]	Dwarf x Agronomic	75
SH-1148 x SH-1567	(III-9 x Lidi) x [(Z. x Congo) x (V-3 x I-9)]	Dwarf x Agronomic	50
SH-669 x SH-688	(II-311 x Manang) x (II-240 x III-41)	Moko x Agronomic	50
SH-704 x SH-677	(II-263 x II-33) x [(Z. x Guyuran) x III-133]	Agronomic x Agronomic	50
II-98 x SH-868	Lonsing x [(Z. x Lidi) x II-33]	Agronomic x Agronomic	75

Table 46

Malaccensis Crosses

Designation	Pedigree	Combination of Characters	Progeny, % Banksii MALACC Germplasm
SH-1359 x SH-1554	(II-344 x Pitu) x (Pitu x II-195)	Meiotic Rest. x Meiotic Restitution	50
SH-1563 x SH-1554	(II-287 x Pitu) x (Pitu x II-195)	Meiotic Rest. x Meiotic Restitution	50
AVP-52 x SH-555	Sixaola Malaccensis x (Pitu x Lidi)	Meiotic Rest. x Meiotic Restitution	75
SH-555 x SH-1350	(Pitu x Lidi) x [(I-9 x II-108) x (Z. x Congo)]	Meiotic Rest. x Dwarf	37
SH-1563 x II-334	(Pitu x II-287) x II-334	Meiotic Restitution x Moko	75
SH-669 x SH-1359	(II-311 x Manang) x (II-344 x Pitu)	Meiotic Restitution x Moko	50
SH-1563 x II-342	(Pitu x II-287) x II-342	Meiotic Restitution x Pitting	75
SH-555 x II-276	(Pitu x Lidi) x II-276	Meiotic Restitution x Pitting	75
SH-1359 x II-195	(II-344 x Pitu) x II-195	Meiotic Restitution x Nematode	75
SH-555 x II-195	(Pitu x Lidi) x II-195	Meiotic Restitution x Nematode	75
SH-555 x SH-1209	(Pitu x Lidi) x (II-357 x Lidi)	Meiotic Restitution x Agronomic	75
SH-1359 x SH-552	(II-344 x Pitu) x (II-316 x Lidi)	Meiotic Restitution x Agronomic	75
SH-669 x SH-1544	(II-311 x Manang) x [(III-133 x Lidi) x (Z. x VALERY]	Dwarf x Moko	50
SH-1544 x S.M.R.-9	[(III-133 x Lidi) x (Z. x VALERY)] x S.M.R.-9	Dwarf x Moko	75
II-276 x SH-1350	II-276 x [(I-9 x II-108) x (Z. x Congo)]	Dwarf x Pitting	63

(Continued on next page...)

Table 46 (Cont.)

Designation	Pedigree	Combination of Characters	Progeny, % MAL Germplasm
II-342 x SH-1360	II-342 x /(I-9 x II-108) x (Z. x Congo)_/	Dwarf x Pitting	63
II-943 x SH-1550	(II-332 x Lidi) x /(III-133 x Lidi) x (Z. x VALERY)_/	Dwarf x Agronomic	75
SH-669 x II-276	(II-311 x Manang) x II-276	Moko x Pitting	75
SH-669 x II-342	(II-311 x Manang) x II-342	Moko x Pitting	75
II-195 x II-334	P. Batuau x Rangis	Moko x Nematodes	100
SH-1184 x II-334	(-182 x II-92) x Rangis	Moko x Agronomic	75
II-276 x II-342		Pitting x Pitting	100
II-276 x II-195		Pitting x Nematode	100
II-342 x II-195		Pitting x Nematode	100
SH-644 x II-342	(II-137 x Lidi) x II-342	Pitting x Agronomic	75
SH-214 x II-276	(III-3 x P. Mas) x II-276	Pitting x Agronomic	50

Table 47

Microcarpa Crosses

Designation	Pedigree	Combination of Characters	Progeny, % ~~Banksii~~ MICROCAR Germplasm
SH-1553 x SH-1562	(II-175 x Pitu) x (Pitu x V-34)	Meiotic Rest. x Meiotic Restitution	50
SH-1357 x SH-1562	(Pitu x V-34) x (Pitu x V-34)	Meiotic Rest. x Meiotic Restitution	50
SH-669 x SH-1357	(II-311 x Manang) x (Pitu x V-34)	Meiotic Restitution x Moko	25
II-252 x SH-555	P. Jari Buaya x (Pitu x Lidi)	Meiotic Restitution x Nematode	50
SH-1562 x II-175	(Pitu x V-34) x II-175	Meiotic Restitution x Agronomic	75
SH-1357 x II-182	(Pitu x V-34) x II-182	Meiotic Restitution x Agronomic	75
II-239 x SH-555	P. Tongat x (Pitu x Lidi)	Meiotic Restitution x Agronomic	50
SH-2051 x SH-723	[(III-133 x V-34) x (Z. x VALERY)] x (II-158 x III-41)	Dwarf x Agronomic	37
II-321 x II-334	P. Jari Buaya x Rangis	Moko x Nematode	50
II-158 x II-334	P. Tongat x Rangis	Moko x Agronomic	50
II-155 x II-342	P. Jari Buaya x II-342	Pitting x Nematode	50
II-275 x I-96	P. Jari Buaya x I-96	Nematode x Nematode	50
III-116 x II-182	P. Jari Buaya x II-182	Nematode x Agronomic	100
SH-826 x II-182	(AVP-34 x III-133) x II-182	Agronomic x Agronomic	75
SH-644 x V-34	(II-137 x Lidi) x V-34	Agronomic x Agronomic	75

Table 48

Sumatrana Crosses

Designation	Pedigree	Combination of Characters	Progeny, % ~~Banksii~~ Sumatrana Germplasm
SH-555 x I-96	(Pitu x Lidi) x I-96	Meiotic Restitution x Nematode	50
SH-1562 x I-96	(Pitu x V-34) x I-96	Meiotic Restitution x Nematode	50
SH-1890 x I-96	[(Z. x VALERY) x (III-133 x Lidi)] x I-96	Dwarf x Nematode	50
I-96 x AVP-28	I-96 x D. Mas	Pitting x Nematode	100
II-342 x I-96		Pitting x Nematode	50
I-94 x II-75	I-94 x P. Mas	Pitting x Agronomic	100
II-53 x I-96	P. Jari Buaya x I-96	Nematode x Nematode	50
SH-214 x AVP-36	(III-3 x P. Mas) x Mundan	Nematode x Agronomic	75
SH-1117 x I-96	(III-133 x II-205) x I-96	Nematode x Agronomic	75
SH-214 x II-205	(III-3 x P. Mas) x P. Madu	Agronomic x Agronomic	75

Disease Resistance Testing

Although considerable disease resistance testing of clones and hybrids was done during the year, the only positive result was the identification of the *M. a. siamea* accession II-317 as Moko resistant. (GARCIA)

Evaluation of Commercial Hybrids

The trials designed to identify the best Cocos series tetraploid hybrids continued this year. The 6 entry tetraploid trial with VALERY check which was started in September 1966 continued through 1968. A new 6 entry tetraploid trial with VALERY and SH-22 checks was initiated this year.

The evaluation of 6 Cocos hybrids for Institutional Pack was a new project started in June 1968. Boxes of SH-22 Institutionally-packed were shipped to the Research Department, New York for ripening and flavor evaluation, whenever enough fruit of this variety was available.

Tetraploid Replicated Trial. This plot was planted in September 1966, with 108 plants per variety (12 replications of 9 plants per plot, spaced 10 x 11 feet). Vegetative data appear in Table 49. The production of suckers was recorded at monthly interval during the pruning operation. The method arbitrarily admitted regrowth of suckers after pruning and only additional suckers to the ones already recorded were counted. SH-19 for example produced 10.5 suckers in plantilla, but 15.8 were pruned during first ratoon, and 24.7 in second ratoon. Bunch analysis is shown in Table 50. The finger length has been calculated by the standard system of measuring one representative outer whorl finger per hand. The same method was used for CHIQUITA and PETITE classification (Table 51).

Yield increase for each hybrid is dependent of two main factors: speed to fruiting and increase in weight in succeeding crop. SH-22 and SH-26 increased in fruit weight of second ratoon by 44 and 36 o/o, respectively over their first ratoon weight. SH-19 only by 10 o/o. However, SH-19 yielded more than SH-26 for the period and as both varieties have approximately the same rate of speed to fruit, the actual advantage of SH-19 is due to the better crop in plantilla. But as SH-26 was already a better performer in second ratoon, it will eventually overtake SH-19 on a longer run. This will place SH-26 next to SH-22 in yield. SH-26 is also the lowest plant among the Cocos hybrids in this trial and, therefore, is less subject to blowdown. SH-22 remains the best Cocos hybrid at this time, mainly for resistance to Sigatoka and good yield performance, producing in second ratoon 89 o/o of VALERY.

For SH-22 the average numbers of fingers per hand and finger length, for each hand position, for first and second ratoon are given in Table 52. Finger length was computed by the standard method of measuring one representative finger per hand of the outer whorl. For both crops there is also

Table 49

Tetraploid Performance, Replicated Trial

Vegetative Data

First and Second Ratoon

Hybrid	Plant Height (cm.)		Pseudostem Diameter (cm.)		Leaves at Shooting		Leaves at Harvest		Suckers*		
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	Plan-tilla	1st	2nd
SH-19	389.3	449.0	26.5	29.3	12.4	13.0	5.1	6.6	10.5	5.3	8.9
SH-22	368.0	453.8	25.0	27.9	12.6	12.8	5.0	6.3	9.6	4.0	5.0
SH-26	340.0	433.6	25.0	28.3	12.4	12.9	4.3	6.5	7.7	4.9	5.9
SH-30	394.0	451.7	27.3	29.0	12.1	13.2	5.1	6.6	9.4	5.4	5.2
SH-32	384.0	459.0	26.8	29.5	12.1	13.0	5.3	6.9	12.4	5.5	8.5
SH-371	419.0	461.2	27.0	29.5	12.3	13.2	5.4	6.0	9.0	6.0	4.0
VALERY	350.6	381.8	21.9	22.5	14.7	16.9	7.3	8.8	8.5	7.1	6.5

* Suckers in 1st and 2nd ratoon are additional to the one produced in plantilla.

Table 50

Tetraploid Performance Replicated Trial

Bunch Analysis - First and Second Ratoon

Hybrid	Bunch Weight 1st	Bunch Weight 2nd	Fruit Weight 1st	Fruit Weight 2nd	Stalk Weight 1st	Stalk Weight 2nd	Number of Hands 1st	Number of Hands 2nd	Fingers/Hand 1st	Fingers/Hand 2nd	Relicts/Hand 1st	Relicts/Hand 2nd	Finger Length 1st	Finger Length 2nd	Pedicel Length 1st	Pedicel Length 2nd	Bunch Caliper 1st	Bunch Caliper 2nd
SH-19	72.3	79.7	63.2	70.9	9.1	8.8	11.2	12.6	19.0	18.8	6.1	3.5	7.3	7.2	.75	.78	9.4	9.4
SH-22	66.0	94.8	57.3	85.2	8.7	9.6	11.1	13.0	19.8	20.2	2.7	3.6	6.8	7.4	.55	.63	9.1	11.3
SH-26	66.0	89.5	57.8	80.7	8.2	8.8	11.5	12.8	19.5	19.5	9.0	8.4	6.9	7.7	.60	.83	9.0	11.6
SH-30	70.5	77.4	63.0	69.8	7.5	7.6	12.2	12.2	20.0	20.0	7.8	6.0	6.9	6.7	.69	.69	9.9	9.7
SH-32	77.5	74.3	70.0	66.5	7.5	7.8	11.2	13.1	19.8	20.0	6.3	3.9	7.3	6.9	.74	.71	10.4	8.3
SH-371	80.2	57.1	72.9	50.8	7.3	6.3	13.2	15.2	19.0	18.3	5.7	3.7	7.1	6.1	.71	.66	10.0	5.3
VALERY	92.1	109.8	82.9	101.4	9.2	8.4	12.3	13.5	20.1	19.5	13.7	13.5	8.3	8.7	1.14	1.14	10.6	13.4

Table 51

Tetraploid Performance Replicated Trial

Fruit Production

Hybrid	Plan-tilla	Total Fruit Harvested - Lbs. First Ratoon	Second* Ratoon	Third Ratoon	Period	Blowdown Second Ratoon	Harvest Second Ratoon	Hanging Fruit 2nd Ratoon	Hanging Fruit 3rd Ratoon	CHIQUITA Class First Ratoon 8"+	7.5"	-7"	PETITE Class First Ratoon 8.5"+	6.5-8"	-6"
										Percentage					
SH-19	7182.0	7808.4	6377.7		21368.1	26	54	27		46.3	20.4	33.3	18.3	75.9	5.8
SH-22	5558.2	7128.0	10059.7	78.2	22824.1	36	70	2	32	18.2	17.6	64.2	3.2	80.0	16.8
SH-26	5968.8	7128.0	6981.7		20078.5	16	62	30		22.8	17.5	59.7	3.9	84.3	11.8
SH-30	6595.7	7614.0	5109.2		19318.9	32	34	42		20.5	18.0	61.5	3.9	81.3	14.8
SH-32	7520.3	8370.0	4533.0		20423.3	47	14	28		47.0	16.5	36.5	17.9	75.6	6.5
SH-371	6777.9	8661.6	1427.5		16867.0	21	4	51		38.7	19.5	41.8	10.4	80.8	8.8
VALERY	8618.4	9946.8	11311.9	84.0	29961.1	21	82	5	43	80.9	9.0	10.1	59.6	39.5	0.9

* Blowdown fruit adjusted.

Table 52

Relationship Between Hand Position on the Stem, Number of Fingers and Finger Length Per Hand for Coli 22

Hand	1st Ratoon* Fingers / Hand	1st Ratoon* Finger Length	2nd Ratoon** Fingers / Hand	2nd Ratoon** Finger Length
1	22.28 ± .86	7.56 ± 0.09	25.01 ± .47	8.17 ± 0.13
2	21.82 ± .17	7.59 ± 0.11	23.01 ± .25	8.09 ± 0.12
3	21.23 ± .23	7.25 ± 0.11	22.11 ± .24	7.92 ± 0.11
4	20.54 ± .21	7.13 ± 0.10	21.31 ± .32	7.75 ± 0.10
5	20.21 ± .21	6.91 ± 0.09	20.68 ± .31	7.72 ± 0.10
6	19.65 ± .22	6.82 ± 0.11	20.05 ± .26	7.57 ± 0.12
7	19.00 ± .19	6.58 ± 0.10	19.34 ± .26	7.43 ± 0.11
8	18.93 ± .24	6.49 ± 0.10	19.14 ± .19	7.32 ± 0.12
9	19.16 ± .18	6.42 ± 0.09	18.87 ± .22	7.23 ± 0.11
10	18.77 ± .31	6.11 ± 0.10	18.47 ± .18	7.02 ± 0.08
11	17.79 ± .78	5.79 ± 0.11	18.56 ± .20	6.81 ± 0.09
12	16.61 ± 1.98	5.50 ± 1.93	18.53 ± .53	6.59 ± 0.14
13			17.64 ± .76	6.19 ± 0.19
14			15.38 ± 1.29	5.42 ± 0.23

* Based on 100 stems of fruit.

** Based on 70 stems of fruit.

given the percent of fruit occurring in different finger length classes, comparing SH-22 to VALERY (Figure 58). The amount of small fruit in first ratoon (more than plantilla) was attributed at the time to slow development during the cold months.

Institutional Pack. SH-22 was considered the best candidate for Single Finger Pack (SFP) fruit. Small amounts of this variety were shipped to the Research Department in New York at the end of 1967 and early this year. Ripening and flavor test appear satisfactory. Since June 1968, shipments were made according to S.F.P. specifications. Since this time, fruit classification was also carried and recorded for SH-22 according to S.F.P. specifications. Furthermore, the same information was taken and recorded for all the varieties in the Tetraploid Replicated Trial. This information consisted in measuring each finger of the bunch according to S.F.P. specifications (Table 53). In this classification SH-19 and SH-26, in term of marketable fruit (S.F.P. plus CHIQUITA, $7\frac{1}{2}$" and above), appear superior to SH-22. Because of better yield, SH-22 remains a slightly better candidate for S.F.P.

Cocos x Lidi Replicated Trial - Section 4-A

This experiment was started in December 1967 with 8 entries replicated 9 times, in randomized plots of nine plants spaced 10' x 10' hexagonal. The new varieties are 6 selections of Cocos x Lidi; VALERY and SH-22 were also included as comparative value. Buffer rows were planted with 2 selected Cocos hybrids of good quality. The varieties are SH-763, 769, 927, 1101, 1104, 1107 and SH-979 and 1106 in the buffer row. At this stage, SH-927 shows better performance over the others. However, not until the plantilla crop is completed will there be results of value.

Cocos x banksii. Table 54 gives performance of three of these hybrids; data was based on 27 plants for each variety. SH-371 was also tested in the Tetraploid Replicated Trial reported above. In both experiments it gave poor performance. Part of the first ratoon was destroyed by blowdown and no data of the second ratoon is available. However, 369 is faster to shoot but would have to be tested in randomized plots with SH-370, the latter being of possible better yield. These hybrids are susceptible to Sigatoka. Their fruit must be harvested at a lighter grade than the Cocos x Lidi group.

Nursery Plot. A total of 93 plants of new hybrids were under observation. The following crosses were represented: Cocos x Lidi, Cocos x III-133, Cocos x II-210, Cocos x I-79, Cocos x SH-139, Cocos x SH-263, Cocos x SH-254, Cocos x SH-265, Cocos x SH-396, Cocos x SH-447, Cocos x SH-461, Cocos x SH-475, SH-559 x SH-586. Vegetative data were taken for each plant as well as bunch analysis and fruit quality data, this last information included classification for CHIQUITA and Institutional Pack.

Hybrids were discarded, in particular, for the following reasons: Sigatoka susceptibility, short finger, and hard central core of fruit. After evaluation,

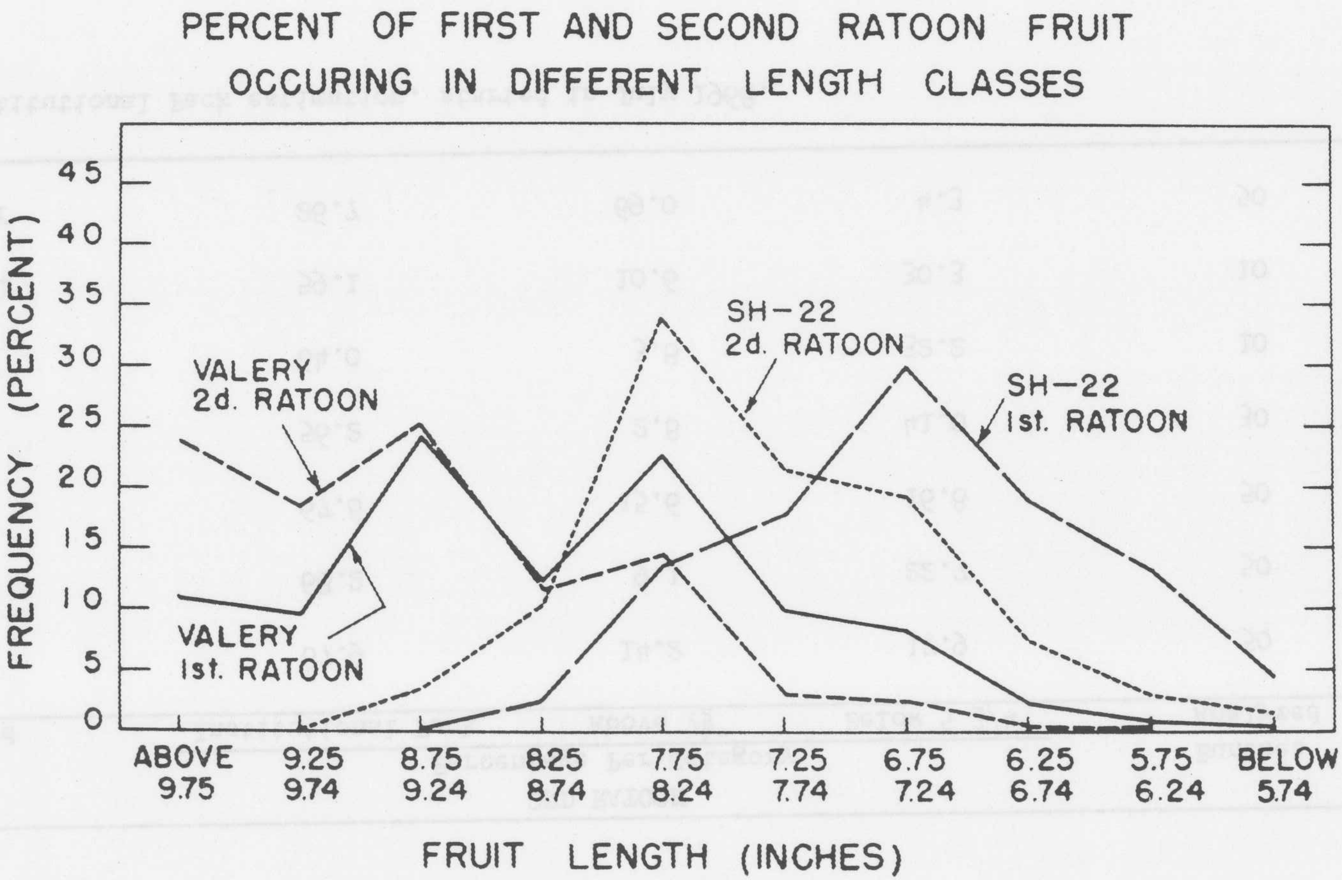

PERCENT OF FIRST AND SECOND RATOON FRUIT
OCCURING IN DIFFERENT LENGTH CLASSES
FREQUENCY (PERCENT)
45
40
35
30
25
20
15
10
5
0
VALERY
2d. RATOON
VALERY
Ist. RATOON
SH-22
2d. RATOON
SH-22
Ist. RATOON
ABOVE 9.75
9.25 9.74
8.75 9.24
8.25 8.74
7.75 8.24
7.25 7.74
6.75 7.24
6.25 6.74
5.75 6.24
BELOW 5.74
FRUIT LENGTH (INCHES)

Figure 58

Table 53

Institutional Pack*

Fruit Classification

Hybrid	2ND RATOON Percentage Per Category: Institutional Pack	Above $7\frac{1}{2}$"	Below 5 3/4"	Bunches Analyzed
SH-19	67.9	14.2	17.9	50
SH-22	68.2	9.1	22.7	50
SH-26	67.6	15.6	16.8	50
SH-30	56.2	2.8	41.0	30
SH-32	64.0	3.8	32.2	10
SH-371	59.1	10.6	30.3	10
VALERY	26.7	69.0	4.3	50

* Institutional Pack estimation, started in July 1968.

Table 54

Cocos x Banksii[1] - Plantilla and First Ratoon

Vegetative Data

Hybrid	Plant Height (cm.) Plan-tilla	Plant Height (cm.) First Ratoon	Pseudostem Diameter (cm.) Plan-tilla	Pseudostem Diameter (cm.) First Ratoon	Leaves at Shooting Plan-tilla	Leaves at Shooting First Ratoon	Leaves at Harvest Plan-tilla	Leaves at Harvest First Ratoon	Time Planting to Shooting (Weeks) Plan-tilla	Time Planting to Shooting (Weeks) First Ratoon [2]
SH-369	344	408	22.0	27.1	12.4	13.0	5.8	4.6	42.1	75.8
SH-370	355	406	21.6	25.5	11.6	12.4	4.5	5.1	45.2	81.5
SH-371	326	476	21.6	28.0	11.3	13.0	4.1	5.1	45.8	83.4

Bunch Analysis

ybrid	Bunch Weight Plan-tilla	Bunch Weight First Ratoon	Number of Hands Plan-tilla	Number of Hands First Ratoon	Fingers/Hand Plan-tilla	Fingers/Hand First Ratoon	Relicts/Hand Plan-tilla	Relicts/Hand First Ratoon	Finger Length (inches) Plan-tilla	Finger Length (inches) First Ratoon	Pedicel Length (inches) Plan-tilla	Pedicel Length (inches) First Ratoon	Bunch Caliper Plan-tilla	Bunch Caliper First Ratoon
H-369	71.3	72.3	10.1	13.9	17.9	18.2	5.4	2.2	7.3	6.5	0.81	0.67	11.8	9.5
H-370	69.2	78.0	10.8	13.9	18.2	18.3	7.1	2.7	7.4	6.5	0.68	0.63	10.1	9.1
H-371	64.5	74.1	10.3	14.2	17.8	18.3	9.1	3.4	7.1	6.8	0.64	0.67	9.7	7.4

(Continued on next page...)

Table 54 (Cont.)

Fruit Production - Classification (First Ratoon)

Hybrid	Plantilla [3/]	First Ratoon [4/]	CHIQUITA Classification: CHIQUITA 8"+	Special 7.5"	Small 7"-	PETITE Classification: CHIQUITA 8.5"+	PETITE 6.5-8"	Reject 6"-
SH-369	1926	1157	11.8	11.6	76.6	-	80.7	19.3
SH-370	1869	1326	25.1	16.4	58.5	3.5	80.9	15.6
SH-371	1741	667	19.3	18.2	62.5	3.9	78.8	17.3

1/ Experiment with 27 plants for each variety.

2/ Estimated on 18 first fruit shot.

3/ Adjusted to 27 fruits.

4/ Sixteen fruits harvested for SH-369, 17 for SH-370, and 9 for SH-371.

the best hybrids are transplanted into the Fusarium wilt test plot and into an increase nursery where they are further observed for their commercial potential. (HARI)

AGRONOMY and SOILS

Variety Studies

VALERY, Cocos-Lidi and Poyo. The biometric comparisons among VALERY, Cocos-Lidi (SH-19) and Poyo bananas were terminated on December 31, 1967, after completing 32 months from planting.

The two-year cumulative production, losses and fruit quality distribution are given in Table 55. Poyo and VALERY continued to outyield Cocos-Lidi but VALERY still was a better producer than Poyo. A comparison of certain yield characteristics among these varieties, expressed as percent of the response obtained for Cocos-Lidi, is given in the following table:

	Stems Shot	Stems Harvested	Net Yield Tons/A	Mean Bunch Wt. Lbs.
Cocos-Lidi (SH-19)	100	100	100	100
Poyo	120	139	173	121
VALERY	123	148	190	127

The net yield of VALERY was 11 percent higher than that obtained with Poyo. Also, the VALERY fruit bunches were 10 percent heavier than those produced by Poyo. The total losses in Cocos-Lidi were significantly higher than those recorded for the other two varieties. The high losses in the SH-19 hybrid were due primarily to doublings, premature ripening and heart rot. At the moment there is no explanation for the higher losses due to doublings in Cocos-Lidi, unless the pseudostem tissue of this variety is made up of fibers of lower tensile strength; the same would apply to Poyo when doubling losses are compared with those registered in VALERY.

Poyo and VALERY produced about two-thirds more CHIQUITA than Cocos-Lidi. However, when the yield of the four quality categories was expressed as percent of net fruit, the distribution was as follows:

	CHIQUITA	PETITE	Specials	Garbage
Cocos-Lidi (SH-19)	75	6	9	10
Poyo	70	2	11	16
VALERY	69	2	12	16

The higher percentage of CHIQUITA and lower percentages of Specials and Garbage in Cocos-Lidi may be due to a higher resistance of this variety to handling damage.

Table 55

Variety Trial - Los Limones Farm
Summary of Production, Losses and Fruit Quality
From April 1965 Through December 1967[1/]

Variety	Stems Shot/A	Stems Reaped/A	Weight, Tons Per Acre Total	Stalk	Net	Mean Bunch Weight Lbs.	Stems Hanging/A as of Dec. 31, 1967	Stems Lost Per Acre Total	Uproot	Double	Break-neck	Blow-down	Ripe	Heart rot	As % of Shot
Cocos-Lidi	1415.6	970.7	38.53	3.53	35.00	78.65	205.1	239.8	5.8	130.0	5.8	11.6	66.4	20.2	16.9
Poyo	1704.4	1349.1	65.41	4.85	60.56	95.16	208.0	147.3	---	144.4	2.9	----	----	----	8.6
VALERY	1744.9	1438.7	71.81	5.30	66.51	99.64	219.5	86.7	---	80.9	2.9	2.9	----	----	5.0
LSD[3/] .05	79.3	111.4	5.87	0.45	5.43	3.57	NS[4/]	74.6	*	*	*	*	*	*	*
LSD .01	106.5	149.7	7.88	0.61	7.30	4.79	NS	100.2	*	*	*	*	*	*	*
Coefficient of Variation	7%	13%	15%	15%	15%	6%	41%	70%	*	*	*	*	*	*	*

Variety	Fruit Quality, Tons Per Acre[2/] CHIQUITA	PETITE	Special	Discard
Cocos-Lidi	26.10	2.16	3.25	3.49
Poyo	42.69	1.27	6.55	10.05
VALERY	46.15	1.27	8.11	10.98
LSD[3/] .05	4.41	0.33	0.97	1.23
LSD .01	5.92	0.45	1.31	1.66
Coefficient of Variation	17%	31%	24%	22%

1/ Planted 11' x 11' hexagonal, which gives 416 production units per acre.
2/ On basis of official quality control finger length specifications for American fruit.
3/ Least significant difference at 95 and 99 percent probability level.
4/ Non-significant.
* Not computed.

A summary of certain plant and bunch characteristics of the three varieties studied are given in Table 56. On the average, VALERY bunches had one more hand than the other varieties. The height of the Poyo and VALERY plant was essentially the same, while Cocos-Lidi was about 1.5 feet taller than either one. The average number of leaves at shooting and harvesting was significantly higher in VALERY than in Poyo or Cocos-Lidi. There was a difference of approximately two leaves, at either time, between the latter varieties. Maturation period in Cocos-Lidi and Poyo was essentially the same. A two-day difference existed between VALERY and the other varieties. (SIERRA, ROSA)

Some Bunch Characteristics of the SH-30 Hybrid Banana. To determine some of the bunch characteristics of this hybrid, 143 plantilla stems were processed in 1967. The area where the plants were growing was seriously affected by the windstorms of May 27 and July 26, 1968, resulting in very high losses of first ratoon fruit. Therefore, the bunch characteristics of ratoon fruit were obtained from 56 stems only.

The average bunch weight and the distribution of fruit, expressed as percent of net, for both plantilla and first ratoon fruit was as follows:

	Plantilla	First Ratoon
Bunch weight, lbs.	59	80
Net fruit per bunch, lbs.	53.5	73
Percent CHIQUITA	30	66
Percent PETITES	49	25
Percent Specials	12	1
Percent Garbage	9	8

There was an average increase of 21 pounds in the bunch weight from plantilla to ratoon fruit. The latter also gave a two-fold increase in the amount of CHIQUITA and a 50 percent reduction in PETITES. The increase in CHIQUITA was associated with change in the minimum finger length which was lowered from 8" to 7.5", and also with the gain of two hands measuring more than 8" in finger length. The average potential number of hands in plantilla and ratoon fruit was 10 and 12, respectively; the average harvested hands (after removing the false + one hand) per stem were 9 and 11.

The most common bunch defects in the ratoon fruit were small hands and deformed fingers. There was an average of 4.24 and 0.35 pounds per stem of small hands and deformed fingers, respectively

The relationship between hand position on the stem and number of fingers per hand was proportional to the age of the hand (Table 57). The first six hands of ratoon fruit gained about two fingers per hand, while the largest hands had an increase of only one finger over that of a similar hand in plantilla fruit.

Table 56

Variety Trial - Los Limones Farm
Summary of Some Plant and Bunch Characteristics
from April 1965 Through December 1967 1/

Variety	Hands Per Bunch	Degree of Leaning 2/	Plant Height Feet 3/	Plant Diameter Inches 4/	Plant Radius Feet 5/	Stalk Length Inches 6/	Functional Leaves 7/ At Shot	Functional Leaves 7/ At Reaped	Maturation Period in Days 8/
ocos-Lidi	10.39	9.74	13.34	9.69	10.71	43.02	12.87	6.56	112.36
oyo	10.46	12.41	11.76	7.92	9.71	46.05	14.25	8.23	111.73
ALERY	11.04	11.41	11.66	7.99	9.63	47.28	14.50	8.50	114.19
SD 9/ .05	0.24	0.78	0.27	0.18	0.19	1.03	0.20	0.22	1.69
SD .01	0.32	1.04	0.36	0.24	0.26	1.38	0.26	0.30	NS 10/
oefficient of Variation	3%	10%	3%	3%	3%	3%	2%	4%	2%

/ Planted 11' x 11' hexagonal, which gives 416 production units per acre.
/ Prior cutting from vertical.
/ At time of shooting from ground level to point of emergence of last leaf.
/ At 3' above ground level.
/ Distance along the ground from base of mat to tip of longest leaf.
/ After trimming to 4" beyond top of hand on flower end and 4" beyond tips of fingers of last hand on butt end.
/ Leaf pruning omitted in the experimental area.
/ Days from shooting to harvesting.
/ Least significant difference at 95 and 99 percent probability level.
/ Non-significant.

Table 57

Relationship Between Hand Position on the Stem
and Number of Fingers Per Hand in the SH-30 Hybrid

Hand 1/ Number	Fingers Per Hand Plantilla Fruit	First Ratoon Fruit
1	16.76 ± 1.115	18.98 ± 1.036
2	16.53 ± 1.221	18.61 ± 1.231
3	16.46 ± 1.067	18.59 ± 1.290
4	16.72 ± 1.024	18.78 ± 1.398
5	17.10 ± 0.991	18.93 ± 1.333
6	17.60 ± 1.273	19.37 ± 1.273
7	18.88 ± 2.540	19.70 ± 1.413
8	20.40 ± 2.939	20.46 ± 2.449
9	22.09 ± 3.652	21.11 ± 1.802
10	21.24 ± 6.016	22.10 ± 2.950
11		22.68 ± 4.731
12		22.77 ± 5.644

1/ Hand number 1 is the youngest on the stem.

Table 58 shows the relationship between hand position on the stem and finger length. An increase in age of the hand (i.e. hand position) was accompanied by an increase in finger length. The average increase per hand position increment, in both plantilla and ratoon fruit, was 0.20 inches.

The average plant height for plantilla and first ratoon was 10.9 and 14.6 feet, respectively. The average maturation period of ratoon fruit was 109 days. (SIERRA, RODRIGUEZ)

Some Characteristics of VALERY Bananas

Growth of the Inflorescence. In commercial plantations the banana bunch is generally protected from 18 to 21 days after the flower bud becomes visible at the crown of the plant. The knowledge of the time required by the inflorescence to attain full exposure of all potential hands may be helpful in the planning of control measures for certain fruit diseases. Therefore, a set of plants at "shooting"[1/] stage were tagged weekly to determine the days needed by the inflorescence to become fully exposed. The measurements were taken in Laurel Farm, Honduras and Farm 11, Palmar, Costa Rica. Since there was no large variation from week to week, the data were grouped by month and are presented in Table 59. In Honduras, the banana flower took an average of 13.5 to 15 days to reach full exposure, whereas in Palmar, Costa Rica an average of 12 to 13 days was required.

Peeping to Shooting Characteristics. The seasonal fluctuations from peeping to shooting in VALERY were determined in ratoon plants in Los Limones Farm, Honduras. Plant spacing was 11' x 11' hexagonal. Every month, peepers were tagged and the time elapsed from this stage to shooting was measured. The data were arranged in two fashions: (1) by peeping month and (2) by shooting month.

Table 60 and Figure 59 show the average number of days required by the peepers to come to shooting. The solid line gives the days to shooting and the broken lines show the confidence limits to the 95 percent probability level. The shape of the curve indicates that there is a seasonal fluctuation which is undoubtedly influenced by certain environmental factors. The fluctuations in growth may be associated with temperature and cloudiness during flower initiation and development. For instance, plants peeping in May-July took a longer period of time to come to shooting, whereas plants peeping in the early Spring and late Summer-early Fall took the least. It is possible that the May-July peepers take longer to shoot because flower initiation and bud development may take place during days of lower temperatures and overcast skies (December, January and February). On the other hand, peepers from the

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1/ "Shooting" stage refers to the time when the tip of the inflorescence bud is first visible at the crown of the plant.

Table 58

Relationship Between Hand Position on the Stem and Finger Length in the SH-30 Hybrid

Hand Number	Finger Length in Inches 1/ Plantilla Fruit	First Ratoon Fruit
1	6.43 ± .474	6.37 ± .493
2	6.69 ± .394	6.58 ± .489
3	6.84 ± .321	6.79 ± .486
4	7.15 ± .393	7.10 ± .474
5	7.37 ± .405	7.25 ± .512
6	7.62 ± .442	7.54 ± .517
7	7.85 ± .422	7.79 ± .525
8	8.03 ± .415	7.94 ± .514
9	8.17 ± .345	8.13 ± .520
10	8.36 ± .312	8.31 ± .519
11		8.41 ± .504
12		8.15 ± .427

1/ The middle finger of outer whorl was measured.

Table 59

Time Elapsing from "Shooting" Stage to Complete Exposure of the Inflorescence in VALERY - Honduras and Costa Rica

	Laurel Farm, Honduras		Farm 11, Palmar, Costa Rica	
Month	Sample Size	Days to Full Exposure	Sample Size	Days to Full Exposure
1968				
April	150	14.98 ± .09		
May	160	13.74 ± .06		
June	131	13.44 ± .14	39	12.74 ± .34
July	233	13.52 ± .10	117	12.69 ± .57
August	200	13.43 ± .10	101	13.42 ± .24
September	249	13.49 ± .09	69	12.19 ± .24
October	200	13.67 ± .11	125	12.37 ± .23

"Shooting" stage refers to that when the flower bud is first visible at the apex of the plant.

Table 60

Time Elapsing from Peeping to Shooting in VALERY - Honduras

Peeping Month	Days to Shooting	Confidence Limits1/ Upper	Lower	Coefficient of Variation, %
January	297.3	312.2	282.4	11
February	294.9	309.9	279.9	11
March	288.9	301.4	276.4	9
April	300.9	322.4	279.5	11
May	317.1	335.1	299.1	6
June	337.4	357.1	317.7	8
July	320.2	330.2	310.2	7
August	279.8	291.9	267.6	9
September	284.5	293.0	276.0	6
October	278.5	286.5	270.5	6
November	293.5	312.4	274.6	11
December	294.9	306.9	282.8	8

1/ To the 95 percent probability level.

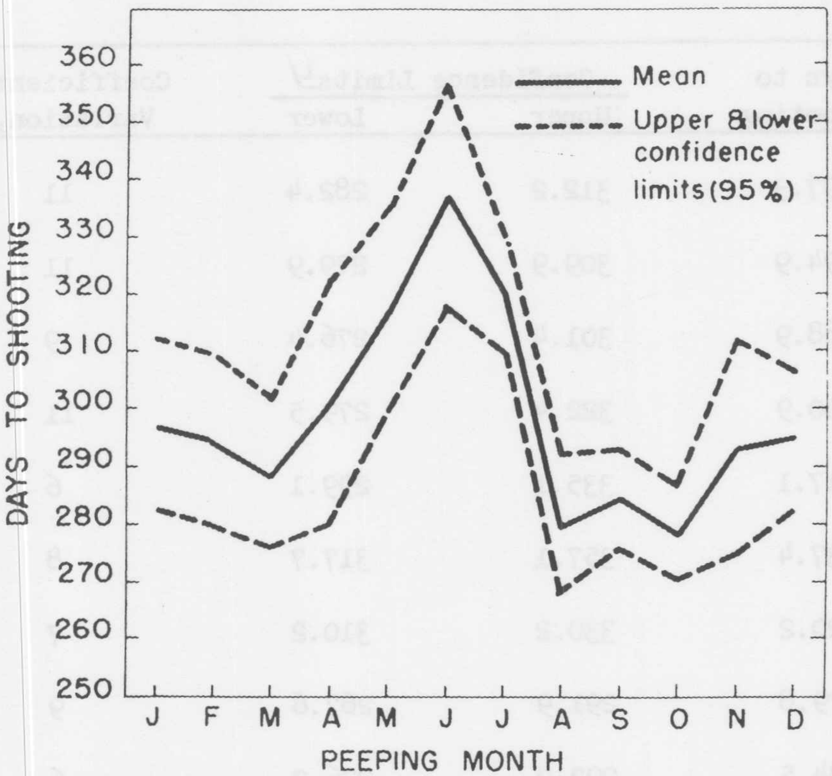

FIGURE 59. Time elapsing from peeping to shooting in VALERY — HONDURAS.

other months of the year undergo these processes when temperatures are higher and the skies are clearer.

The data were also arranged by shooting month (Table 61 and Figure 60) to determine if the same curve was obtained. A shift of the peak of the curve towards the winter months would be expected because of the time required by those peepers to shoot. The curve did shift to the winter months but the magnitude of the peak (days to shooting) was much reduced. This reduction was attributed to a mixed population of peepers emerging at different months of the year but shooting on the same month. Peepers emerging in any one month eventually shot over a period of 2 - $3\frac{1}{2}$ months. Thus, when peepers are grouped on the basis of months of emergence, shot differences are generally reduced. (SIERRA, ROSA)

Production Timing Studies

Guaruma II, Honduras. On May 27 and July 26, 1968, strong winds seriously damaged the experimental area. The combined losses during the two storms were of considerable magnitude but the damage was more severe on July 26 than on May 27 (Tables 62 and 63). Pooled losses of plants left for extra production amounted to 19, 20, and 15 percent (as percent of additional suckers) for treatments 2, 3 and 4, respectively. The extent of the losses places a restriction to the interpretation of the data collected. In spite of this, however, there is a definite positive response which validates the presentation of the data.

Production data from April 1967 through September 1968 are given in Table 64. Up to treatment 3 the stems shot, harvested and gross yield increased. This indicated that the optimum number of additional suckers that can be left per acre is about 200. Average stem weight decreased by increasing population density but this reduction was not statistically significant. Maturation period increased approximately one day with each treatment increment.

When the production data were analyzed through July 1968, it was found that the yield from treatment 3 was statistically higher (to the 99 percent probability level) than that of treatment 1, but different from that of treatment 2 only to the 95 percent probability level.

Production of stems and gross yield by months are given in Tables 65 and 66, respectively. Production was significantly increased during April-July 1968, in spite of the blowdowns and the time needed to select the extra suckers. The data also indicate that harvesting of additional stems began 12 months after selection. The harvesting distribution of additional bunches was dependent on the time required to attain the necessary levels of extra suckers (Table 67).

Table 61

Time Elapsing from Peeping to Shooting in VALERY - Honduras

Shooting Month	Days to Shooting	Confidence Limits[1/] Upper	Lower	Coefficient of Variation, %
January	311.9	339.7	284.1	10
February	319.5	333.7	305.3	6
March	312.1	324.4	299.8	6
April	285.5	316.6	254.4	15
May	300.9	316.3	285.5	10
June	301.8	313.6	290.0	11
July	290.4	300.4	280.4	8
August	281.1	292.3	269.9	5
September	285.2	296.6	273.8	8
October	287.2	300.6	273.8	10
November	281.3	297.6	265.0	11
December	302.6	314.6	290.6	10

1/ To the 95 percent probability level.

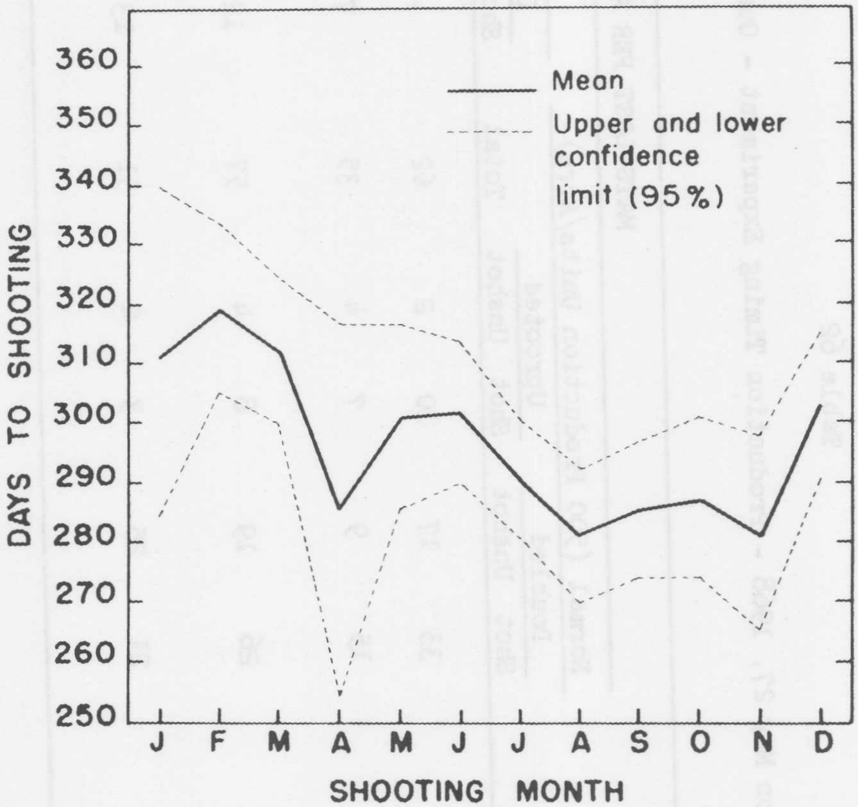

Figure 60. Time elapsing from peeping to shooting in VALERY - HONDURAS

Table 62

Blowdown Losses on May 27, 1968 - Production Timing Experiment - Guaruma II, Honduras

Treatment	MATS LOST PER ACRE									
	Normal (500 Production Units/Acre)					Extra Plants				
	Doubled		Uprooted			Doubled		Uprooted		
	Shot	Unshot	Shot	Unshot	Total	Shot	Unshot	Shot	Unshot	Total
1. 500 production units/acre	33	17	10	2	62	-	-	-	-	-
2. 500 production units/acre + 100 extra plants	15	9	7	4	35	7	1	3	-	11
3. 500 production units/acre + 200 extra plants	26	19	8	4	57	12	1	3	-	16
4. 500 production units/acre + 300 extra plants	21	25	3	2	51	13	7	2	1	23

Table 63

Blowdown Losses on July 26, 1968 - Production Timing Experiment - Guaruma II, Honduras

Treatment	MATS LOST PER ACRE									
	Normal (500 production units/acre)					Extra Plants				
	Doubled		Uprooted			Doubled		Uprooted		
	Shot	Unshot	Shot	Unshot	Total	Shot	Unshot	Shot	Unshot	Total
1. 500 production units/acre	50	135	3	1	189	-	-	-	-	-
2. 500 production units/acre + 100 extra plants	49	74	4	5	132	6	1	1	-	8
3. 500 production units/acre + 200 extra plants	66	148	6	5	225	17	6	1	-	24
4. 500 production units/acre + 300 extra plants	75	120	1	2	198	15	5	2	-	22

Table 66

Monthly Gross Yield - Production Timing Experiment - Guaruma II, Honduras

Month	Treatment[1/] 1	2	3	4
			Tons/A	
1967				
July	2.49	2.66	3.04	2.68
August	2.12	2.22	2.74	2.07
September	2.16	1.96	2.25	2.06
October	4.34	2.79	2.53	2.79
November	1.66	1.55	2.46	2.11
December	2.47	2.68	2.51	2.60
1968				
January	1.36	2.16	1.57	1.80
February	1.78	1.96	1.40	2.09
March	2.97	2.55	3.21	2.48
April	4.09	4.95	4.91	4.58
May	4.23	4.17	4.23	3.64
June	2.52	3.40	4.14	3.75
July	2.26	2.74	3.37	3.73
August	1.15	1.70	1.11	1.30
September	0.63	1.03	0.89	1.00
TOTAL	36.23	38.52	40.36	38.68

1/ Treatment 1: 500 production units/acre.
Treatment 2: 500 production units/acre + 100 extra plants.
Treatment 3: 500 production units/acre + 200 extra plants.
Treatment 4: 500 production units/acre + 300 extra plants.

Table 67

Harvesting Distribution of Extra Plants
Production Timing Experiment - Guaruma II, Honduras

Treatment	March	April	May	June	July	August	September	Total
	Month							
	Stems/A							
2. 500 production units/acre + 100 extra plants	-	14	23	20	8	2	1	68
3. 500 production units/acre + 200 extra plants	2	11	29	35	27	9	9	122
4. 500 production units/acre + 300 extra plants	1	13	28	34	31	12	9	128

Yield from each production unit in the experiment was kept during the 15-month harvest period, and the average production per acre by crops is given in Table 68. The average stem weight for each crop is also given in this table. The average bunch weight from the additional plants was generally lower than that of the mother or follower (daughter). Nevertheless, the reduction in bunch weight was more than compensated by the increase in stems harvested.

Table 69 shows the time elapsed from selection date to harvesting of mother plants, followers and extra suckers. Although harvesting of extra plants began 12 months after selection, the majority of extra plants were harvested approximately 14 months after selection. These results indicate that under conditions similar to those prevailing in this experiment, selection should be made in February-March to obtain maximum production in the Spring.

A follow-up of the extra suckers left in each treatment is given in Table 70. Only 68, 122 and 128 stems from the extra plants were harvested in treatments 2, 3 and 4, respectively. The failure in harvesting all fruit from the additional plants was due primarily to blowdown losses. Losses due to poor vigor of suckers were only 3, 7 and 37 for treatments 2, 3 and 4, respectively. In the 1967 Annual Report it was stated that 3, 18 and 55 poor suckers were observed in treatments 2, 3 and 4, respectively. Of these, however, 11 recovered in treatment 3 and 18 in treatment 4.

Biweekly growth measurements showed a difference in plant height between treatment 1 and any of the other treatments. On the average, plants in treatment 1 were about one foot taller than those from other treatments. Differences in plant height among treatments 2, 3 and 4 were insignificant.

Although results from this study are not conclusive enough because of blowdown damage, the overall production data are in support of leaving 200 extra suckers per acre. The positive response obtained gave a clear indication on the feasibility of this method for timing an additional production for a predetermined season.

<u>Laurel Farm, Honduras</u>. Because of the land limitations in Guaruma II, an identical experiment was started on February 1968 in Section 15, Laurel Farm. In this location the experiment will be conducted in alternate years, i.e. one-half of the section in 1968 and 1970, and the other half in 1969 and 1971. This arrangement will allow the evaluation of any after-effects of the treatments by maintaining records during and after the application of the various sucker levels.

Plots are one-fourth of an acre in size and each plot contains 125 production units. Sucker selection was made as follows:

Table 68

Production Data by Crops
Production Timing Experiment - Guaruma II, Honduras

	MOTHER		NORMAL DAUGHTER		GRAND DAUGHTER		EXTRA DAUGHTER	
Treatment	Stems Harvested Per Acre	Mean Stem Weight	Stems Harvested Per Acre	Mean Stem Weight	Stems Harvested Per Acre	Mean Stem Weight	Stems Harvested Per Acre	Mean Stem Weight
500 production units/acre	410	91.7	350	96.6	12	85.8	---	----
500 production units/acre + 100 extra plants	397	91.6	372	91.5	11	81.9	68	83.8
500 production units/acre + 200 extra plants	413	91.7	359	90.9	5	88.5	122	80.2
500 production units/acre + 300 extra plants	408	90.6	320	91.7	6	91.6	128	82.0

Table 69

Time Elapsed from Selection Date to Harvesting of Mother, Follower and Extra Follower Production Timing Experiment - Guaruma II, Honduras

Treatment	Days to Harvest from Selection Date of Extra Suckers					
	MOTHER		FOLLOWER		EXTRA FOLLOWER	
	Range	Average	Range	Average	Range	Average
2. 500 production units/acre + 100 extra plants	92-289	160	305-519	410	359-543	422
3. 500 production units/acre + 200 extra plants	35-311	184	317-526	415	350-543	434
4. 500 production units/acre + 300 extra plants	12-327	180	249-522	407	330-529	428

Table 70

Biometrics of Extra Suckers
Production Timing Experiment - Guaruma II, Honduras

eatment	Additional Suckers/A	Stems Per Acre Shot	Harvested	Hanging	Lost	Mean Bunch Weight Lbs.	Maturation Period Days	Yield Tons/A	Poor Suckers	Unshot Plants Lost	Unshot Plants Remaining	Total
2	100	90	68	--	22	84.1	102.2	2.8	3	5	1	99
3	200	178	122	5	51	79.0	102.5	4.9	7	12	4	201
4	300	206	128	16	62	82.3	103.1	5.3	37	45	12	300

Treatment 2: February 1 - 15, 1968 (2 weeks)
Treatment 3: February 1 - March 1, 1968 (4 weeks)
Treatment 4: February 1 - March 15, 1968 (6 weeks).

(SIERRA, RODRIGUEZ, ROSA)

Stem Weight Comparison Between Fruit from Bare Ground Plots (Herbicide Treatments) and from Plots with Natural Vegetation

In order to determine if the stem weight differences found last year between the herbicide and non-herbicide plots were due to the use of Karmex, applications of this herbicide were discontinued in June 1967. From this date through May 1968, weed control was accomplished with Gramoxone. During this period a total of 4.6 pints per acre of Gramoxone were applied in four cycles. The stems harvested from January 1968 through July 1968 from the two treatments were analyzed statistically and it was found that the differences were non-significant. The average stem weight from non-treated plots was 90 pounds and from the treated plots 94 pounds. Since this difference was not statistically significant, all stems harvested from each treatment from June 1967 to July 1968 were compared by the group comparison test. Results of the analysis indicated that the difference in stem weight between bare ground plots and natural vegetation plots was not statistically significant. Average stem weight was 90.7 and 93.8 pounds for treated plots and non-treated plots, respectively. The number of stems harvested and average stem weight per replication are given in Table 71. The variation in average stem weight per replication was the same as last year. The overall range in stem weight was from 21 to 144 pounds in non-treated plots and from 39 to 146 in herbicide treated plots.

An astonishing range in stem weight has been observed in the past. The sample observations collected in this study consisted of 2,649 stem weights with a range from 21 to 146 pounds. A frequency distribution of stem weights was constructed and the dispersion around the mean was determined with the use of the standard deviation of the sample. Figure 61 shows a frequency histogram which gives the general nature of the distribution of the 2,649 stem weights. It was found that 96 percent of the sample fell within a range of 54 to 130 pounds, i.e. two standard deviations on either side of the mean. Within one standard deviation on either side of the mean 70 percent of the sample was included. Three percent of the sample had less than 54 pounds per stem and 1 percent had a weight over 130 pounds.

In the Honduras Division, approximately 15 stems weighing less than 54 pounds are produced on an acre per year. This raises the question: What is the economical minimum bunch weight that can be allowed to break even with respect to production cost? (Cost of stem placed at boxing plant.)
(SIERRA, RODRIGUEZ)

Table 71

Stems Harvested and Average Stem Weight from Natural Vegetation and Bare Ground Plots[1/]

NATURAL VEGETATION			BARE GROUND		
Plot No.	Stems Harvested	Ave. Stem Weight Lbs.	Plot No.	Stems Harvested	Ave. Stem Weight Lbs.
CB1	132	97.4	UB1	135	97.6
CB2	131	93.0	UB2	137	93.6
CB3	109	90.0	UB3	128	88.1
CB4	134	94.3	UB4	129	94.5
CB5	108	80.9	UB5	154	98.8
CB6	145	97.7	UB6	132	75.6
CB7	126	98.4	UB7	142	93.3
CB8	115	95.5	UB8	147	81.8
CB9	126	96.3	UB9	144	90.4
CB10	134	92.2	UB10	141	92.6
TOTAL	1260	93.9		1389	90.7

1/ Stems harvested from June 1967 through July 1968.

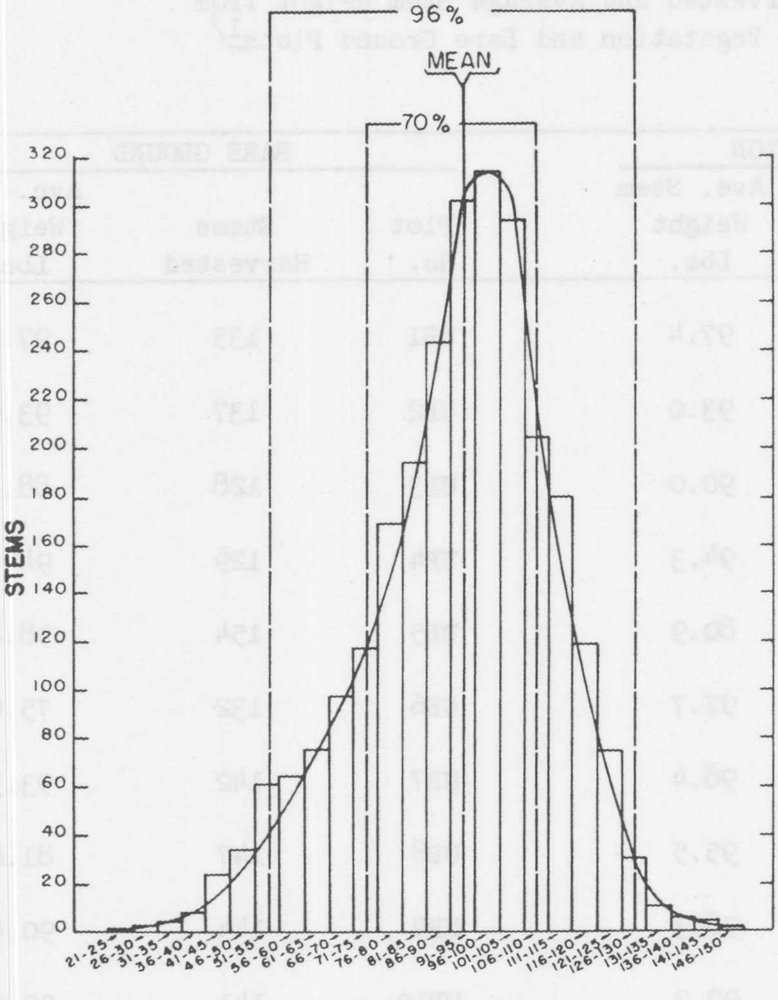

FIGURE 61. FREQUENCY HISTOGRAM OF STEM WEIGHTS MOPALA FARM, HONDURAS

Plant Population Density Studies

Plant Population Density x Soil Textural Group - Ceibita Farm, Honduras. On May 27 and July 26, 1968, the experimental area was severely damaged by two windstorms. The blowdown losses which occurred during the two storms are given in Table 72. Because of the high blowdown losses, results included in this report are those obtained from January 1966 through May 1968. Therefore, the data represent 29 months of shooting and 26 months of harvesting.

Tables 73 and 74 show the influence of soil and population density level on stems shot and harvested, respectively. Although the average effect of soil on stems shot was non-significant, there were more stems shot in the loam soil, at each level of population, than in the light clay soil. In order of population from 400 to 700 production units per acre, there were 78, 78, 16 and 29 more stems shot in the loam soil. It appears that the failure to measure a statistically significant difference between soils was again influenced by the greater number of stems hanging in the loam soil plots (Table 75).

Stem shot differences between means of plant populations, and differences between populations at the same level of soil were statistically significant. The same relationship was found for stems harvested. However, contiguous population treatment means were non-significant. The high incidence of losses at the first increment of population probably reduced the possibility of significant yield differences. The cumulative losses are shown in Table 76. Losses appear to be more severe between the first and second, and between the third and fourth plant population levels. It is difficult to explain why the magnitude of losses between the second and third levels of population was about the same. A factor that has inflated losses is the fact that on many occasions the farm cutters harvested fruit from the experimental plots without giving any advanced notice. This, naturally, resulted in a dilution effect of production when results were converted to per-acre basis. Cumulative losses, expressed as percent of shot, were as follows:

	Plant Population Density			
	400	500	600	700
Loam	14	19	18	19
Light Clay	20	22	20	25

The influence of soil and plant population on gross and net yield are given in Tables 77 and 78, respectively. Both expressions of yield were significantly higher in the loam soils than in the light clay soils. The cumulative gross yield difference between soils was 10.7 and the net yield difference was 9.7 tons per acre. Differences in yield among population means were significant only to the 90 percent probability level. However, there was a cumulative gain of 5 tons per acre of net fruit by increasing the plant population from 400 to 500 production units per acre. For some unknown reason

Table 72

Average Blowdown Losses Per Acre in the Plant Population Density x Soil Textural Group Experiment
Ceibita Farm, Honduras

Soil Textural Group	Plant Population Density 1/			
	400	500	600	700
		Blowdown May 27, 1968		
Loam	35	68	41	33
Light Clay	84	115	89	99
		Blowdown July 26, 1968		
Loam	5	17	49	57
Light Clay	11	30	81	47

1/ Production units per acre.

Table 73

Effect of Soil and Population Density on the Number of Stems Shot[1/]

Soil Textural Group	Plant Population Density[2/]				Average Effect of Soil
	400	500	600	700	
	Stems/A				
Loam	1535.1	1804.1	1925.7	2081.1	1836.5
Light Clay	1456.8	1726.4	1909.5	2052.7	1786.3
Average Effect of Population Density	1495.9	1765.2	1917.6	2066.9	

1/ From January 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	NS	NS
2) Among population density means	122.8	89.7
3) Among means for population densities at same soil....	173.7	126.8

Coefficient of Variation for soils: 5%

Coefficient of Variation for population densities: 4%

Table 74

Effect of Soil and Population Density on the Number of Stems Harvested[1]

Soil Textural Group	Plant Population Density[2] 400	500	600	700	Average Effect of Soil
		Stems/A			
Loam	1205.4	1320.9	1398.6	1480.4	1351.3
Light Clay	1108.1	1273.6	1431.1	1390.5	1300.8
Average Effect of Population Density	1156.7	1297.2	1414.8	1435.4	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	NS	NS
2) Among population density means	203.5	148.6
3) Among means for population densities at same soil ..	287.8	210.1

Coefficient of Variation for soils: 8%

Coefficient of Variation for population densities: 11%

Table 75

Effect of Soil and Population Density on the Number of Stems Hanging[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
	Stems/A				
Loam	116.2	131.8	174.3	193.9	154.1
Light Clay	59.5	70.9	89.2	141.9	90.4
Average Effect of Population Density	87.8	101.3	131.7	167.9	

1/ As of May 31, 1968.

2/ Production units per acre.

Non-significant soil and population density effects.

Coefficient of Variation for soils: 85%

Coefficient of Variation for population densities: 59%

Table 76

Effect of Soil and Population Density on the Number of Stems Lost[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
	Stems/A				
Loam	213.5	351.4	352.7	406.8	331.1
Light Clay	289.2	381.8	389.2	520.3	395.1
Average Effect of Population Density	251.3	366.6	370.9	463.6	

1/ From January 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	NS	NS
2) Among population density means	115.7	84.4
3) Among means for population densities at same soil ...	163.6	119.4

Coefficient of Variation for soils: 36%

Coefficient of Variation for population densities: 22%

Table 77

Effect of Soil and Population Density on Gross Yield1/

Soil Textural Group	Plant Population Density2/ 400	500	600	700	Average Effect of Soil
			Tons/A		
Loam	69.75	75.01	75.11	77.32	74.30
Light Clay	57.42	62.68	68.43	65.66	63.55
Average Effect of Population Density	63.58	68.84	71.77	71.49	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05	.10
1) Between soil means	9.85	6.50	----
2) Among population density means	NS	NS	5.53
3) Among means for population densities at same soil ..	NS	NS	7.82

Coefficient of Variation for soils: 11%

Coefficient of Variation for population densities: 9%

Table 78

Effect of Soil and Population Density on Net Yield[1]

Soil Textural Group	Plant Population Density[2] 400	500	600	700	Average Effect of Soil
	Tons/A				
Loam	64.19	69.18	69.44	71.46	68.57
Light Clay	53.08	58.03	63.56	60.89	58.89
Average Effect of Population Density	58.63	63.60	66.50	66.17	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05	.10
1) Between soil means	9.11	6.01	----
2) Among population density means	NS	NS	5.15
3) Among means for population density at same soil	NS	NS	7.28

Coefficient of Variation for soils: 11%

Coefficient of Variation for population densities: 9%

we have not been able to obtain the expected yield increases between contiguous population treatments.

Plants growing in loam soils continue to produce heavier bunches than those from clay soils (Table 79). There was an average difference of about 12 pounds per bunch between the two soil textural groups. A population increase resulted in a stem weight reduction. The average number of hands per bunch was independent of either soil or population treatment (Table 80).

Cumulative yield of CHIQUITA, Specials, PETITES and Garbage are shown in Tables 81 through 84. Transport by cableways from field to boxing plant was not adopted until August 1968. Therefore, quality distribution figures reported here are not comparable with those obtained by the farms in which cableway transport is being used.

Soil type had no influence on maturation period. However, maturation period increased with increasing plant population levels (Table 85). There was about a 5-day difference between the lowest and highest population treatments.

There was one-foot difference in plant height between plants growing in loam and light clay soils (Table 86). Plant height was essentially the same for all population levels. Pseudostem diameter of plants grown in loams was 0.8 inches larger than plants growing in light clay soils (Table 87).

Plant Population Density, Demonstration Trial - Guaruma II, Honduras. Windstorms of May 27 and July 26, 1968 caused sizeable losses in the experimental area. Doubling and uproot losses during the storms are shown in Table 88. The total losses during the two storms amounted to 67, 44, 47 and 27 percent (percent of plant population density) for the 503, 621, 786 and 894 production units per acre, respectively. Irrespective of population density, about 90 percent of the losses were due to doublings and 10 percent to uproots. The following table gives a breakdown of losses by population, expressed as percent of total plants lost:

	Plant Population Density							
	503		621		786		894	
Doublings	90		89		87		89	
With fruit		52		43		33		42
Without fruit		38		46		54		47
Uproots	10		11		13		11	
With fruit		8		6		7		6
Without fruit		2		5		6		5
	100		100		100		100	

Table 79

Effect of Soil and Population Density on Mean Bunch Weight[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
			Pounds		
Loam	115.9	113.6	107.6	105.0	110.5
Light Clay	103.7	98.3	95.9	95.0	98.2
Average Effect of Population Density	109.8	105.9	101.7	100.0	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	11.5	7.6
2) Among population density means	7.5	5.5
3) Among means for population densities at same soil ..	10.6	7.7

Coefficient of Variation for soils: 8%

Coefficient of Variation for population densities: 5%

Table 80

Effect of Soil and Plant Population
Density on the Average Number of Hands Per Bunch[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
	Hands/Bunch				
Loam	11.97	11.92	11.48	11.53	11.73
Light Clay	11.56	11.33	11.07	11.15	11.28
Average Effect of Population Density	11.76	11.62	11.27	11.34	

1/ Fruit harvested from April 1966 through May 1968.

2/ Production units per acre.

Non-significant soil and population density effects.

Coefficient of Variation for soils: 6%

Coefficient of Variation for population densities: 4%

Table 81

Effect of Soil and Population Density
on Yield of CHIQUITA[1/]

Soil Textural Group	Plant Population Density[2/]				Average Effect of Soil
	400	500	600	700	
		Tons/A			
Loam	45.00	47.37	46.43	47.74	46.63
Light Clay	39.40	42.80	44.53	42.23	42.24
Average Effect Population Density	42.20	45.08	45.48	44.98	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	NS	3.66
2) Among population density means	NS	NS
3) Among means for population densities at same soil ..	NS	NS

Coefficient of Variation for soils: 9%

Coefficient of Variation for population densities: 11%

Table 82

Effect of Soil and Plant Population Density on Yield of Specials[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
		Tons/A			
Loam	6.51	7.24	7.50	8.21	7.37
Light Clay	4.60	4.94	6.63	6.60	5.69
Average Effect of Population Density	5.56	6.09	7.06	7.40	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	NS	1.55
2) Among population densities means......................	1.37	1.00
3) Among means for population densities at same soil	1.94	1.41

Coefficient of Variation for soils: 27%

Coefficient of Variation for population densities: 15%

Table 83

Effect of Soil and Population Density
on Yield of PETITE[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
			Tons/A		
Loam	.33	.46	.36	.49	.41
Light Clay	.39	.45	.54	.50	.47
Average Effect of Population Density	.36	.45	.45	.49	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Non-significant soil and population density effects.

Coefficient of Variation for soils: 36%

Coefficient of Variation for population densities: 48%

Table 84

Effect of Soil and Population Density on Yield of Garbage[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
			Tons/A		
Loam	12.34	14.11	15.15	15.03	14.16
Light Clay	8.68	9.84	11.86	11.56	10.48
Average Effect of Population Density	10.51	11.97	13.50	13.29	

1/ From April 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	2.55	1.68
2) Among population density means	1.73	1.26
3) Among means for population densities at same soil	2.45	1.79

Coefficient of Variation for soils: 16%

Coefficient of Variation for population densities: 10%

Table 85

Effect of Soil and Population Density on Maturation Period[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
		Days			
Loam	110.7	111.4	115.0	115.0	113.0
Light Clay	109.6	110.2	114.3	115.0	112.3
Average Effect of Population Density	110.1	110.8	114.6	115.0	

1/ From January 1966 through May 1968.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	NS	NS
2) Among population density means	4.0	2.9
3) Among means for population densities at same soil ...	5.6	4.1

Coefficient of Variation for soils: 2%

Coefficient of Variation for population densities: 2%

Table 86

Effect of Soil and Population Density on Plant Height[1/]

Soil Textural Group	Plant Population Density[2/] 400	500	600	700	Average Effect of Soil
		Feet			
Loam	14.3	14.5	14.3	14.3	14.3
Light Clay	13.3	13.3	13.3	13.3	13.3
Average Effect of Population Density	13.8	13.9	13.8	13.8	

1/ Height at shooting time.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	.6	.3
2) Among population density means	NS	NS

Coefficient of Variation for soils: 3%

Coefficient of Variation for population densities: 2%

Table 87

Effect of Soil and Population Density on Pseudostem Diameter[1]

Soil Textural Group	Plant Population Density[2]				Average Effect of Soil
	400	500	600	700	
			Inches		
Loam	10.3	10.5	10.2	10.2	10.3
Light Clay	9.6	9.4	9.4	9.4	9.5
Average Effect of Population Density	9.9	9.9	9.8	9.8	

1/ Taken at shooting time and approximately 3 feet above ground surface.

2/ Production units per acre.

Least Significant Difference	.01	.05
1) Between soil means	.6	.4
2) Among population density means	NS	NS

Coefficient of Variation for soils: 5%

Coefficient of Variation for population densities: 3%

Table 88

Windstorm Losses - Plant Population Density, Demonstration Trial
Guaruma II, Honduras

Population Density	Doubling Shot	Doubling Unshot	Doubling Total	Uproot Shot	Uproot Unshot	Uproot Total	Grand Total
			Plants Lost Per Acre				
Windstorm - May 27, 1968							
503	139	68	207	28	7	35	242
621	96	101	197	12	14	26	223
786	110	160	270	22	17	39	309
894	91	90	181	12	9	21	202
Windstorm - July 26, 1968							
503	36	60	96	-	1	1	97
621	22	27	49	4	-	4	53
786	13	38	51	4	6	10	61
894	9	22	31	3	2	5	36
Total Windstorm Losses							
503	175	128	303	28	8	36	339
621	118	128	246	16	14	30	276
786	123	198	321	26	23	49	370
894	100	112	212	15	11	26	238

Losses of plants with fruit were higher at the lowest population level than in any of the other levels. Apparently, there is no relationship between blowdown losses and plant population level. Percentwise, however, blowdown losses are higher at the lowest level of population (67 percent).

In spite of the blowdowns, production records were taken through October 31, 1968. Biometric data are presented in Table 89. There are plant growth differences among population densities. Plants in the two highest plant densities have spindly followers and thinner pseudostems than those in the two lowest treatments. Crops shot and harvested give a clear indication of the effect of plant population density on cropping patterns. The crops shot were 4.0, 3.7, 3.3 and 3.1 for populations of 503, 621, 786 and 894 production units per acre, respectively. In the same sequence of population, the crops harvested were 3.0, 2.8, 2.2 and 2.3. With respect to yield, the third level of population (786) is lagging behind the second (621). This probably results from the higher blowdown losses of shot plants, stolen stems and lower stem weight. The area where the 786 population is planted has a higher infestation of banana root borer, <u>Cosmopolites sordidus</u>, Germar. This, together with some soil factors, may be responsible for higher incidence of uprooted plants.

Net yield during 25 months of harvesting was 70.3, 78.7, 73.1 and 86.6 tons per acre for the first, second, third and fourth level of plant population, respectively. The expected retardation in production of the highest populations over the lowest did not occur during the 34-month duration of the experiment (Figure 62 and Table 90). This indicates that a longer period of time may be required for the lowest populations to outyield the highest. Unfortunately, it will not be possible to determine this because of the termination of the experiment on October 31, 1968. Blowdown damage was responsible for termination.

In order to evaluate the effect of population density on fruit quality, measurements were taken for a period of 12 months (November 1967-October 1968). Stems were transported to boxing plant by means of cableways. Table 91 shows the breakdown of fruit into CHIQUITA, Specials, PETITES and Garbage.

Except for the highest population level, there appears to be no reduction on the yield of CHIQUITA by increasing population. Yield of Specials was slightly higher for the highest population. The amount of PETITES produced appears to be independent of population level. Garbage, however, increased slightly with plant density. When the different quality categories are expressed as percent of net fruit, the following results are obtained:

Plant Population	CHIQUITA	Specials	PETITES	Garbage
503	87	6	3	4
621	88	6	1	5
786	90	4	2	4
894	85	7	2	6

Table 89

Yield Comparisons of the VALERY Population Density Demonstration Trial
Guaruma II, Honduras1/

Spacing Hexagonal	Population Density2/	Stems Per Acre				Mean Weight, Lbs.			Tons Per Acre		Hands Per Stem	Maturation Period (Days)
		Shot	Harvested	Hanging	Lost	Stem	Stalk	Net	Gross	Net		
10' x 10'	503	2031	1522	165	344	100.56	8.20	92.36	76.52	70.29	10.44	108.0
9' x 9'	621	2311	1771	218	322	96.70	7.79	88.91	85.63	78.73	10.23	110.5
8' x 8'	786	2577	1757	312	508	90.61	7.37	83.24	79.60	73.13	9.83	113.0
7.5' x 7.5'	894	2794	2071	308	415	91.01	7.35	83.66	94.25	86.63	9.99	113.5

1/ From planting in December 1965 through October 1968.

2/ Production units per acre.

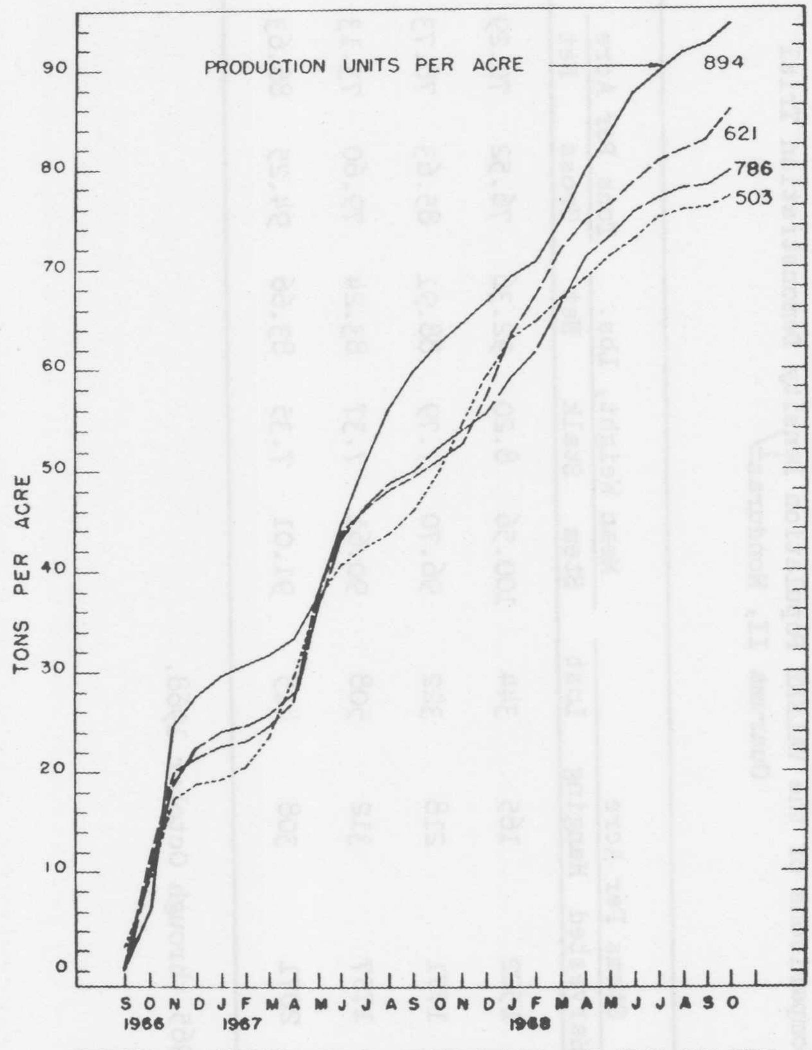

FIGURE 62. GROSS YIELD COMPARISON OF THE VALERY PLANT POPULATION DENSITY DEMONSTRATION TRIAL — GUARUMA II, HONDURAS. From planting in December, 1965 through October, 1968.

Table 90

Gross Yield Comparisons of the VALERY Plant Population Density, Demonstration Trial - Guaruma II, Honduras[1/]

	Plant Population Density			
	503	621	786	894
	Tons/A			
September, 1966	2.49	0.40	0.12	0.13
October	9.17	11.77	9.88	6.28
November	17.34	20.02	20.07	24.71
December	18.85	21.50	22.46	27.53
January, 1967	19.23	22.62	24.01	29.58
February	20.64	23.13	24.60	30.79
March	23.68	24.73	25.76	31.60
April	29.54	26.99	27.71	33.20
May	37.25	37.65	36.67	37.69
June	40.45	43.62	42.89	44.71
July	42.32	46.19	46.30	50.89
August	43.63	47.97	48.66	56.11
September	45.94	49.31	49.82	59.85
October	49.93	50.84	52.20	62.57
November	54.76	52.68	53.98	64.55
December	59.40	57.18	55.76	66.68
January, 1968	63.15	63.61	59.32	69.13
February	64.70	67.32	61.82	70.65
March	67.09	71.87	66.80	74.70
April	69.05	74.76	71.19	79.63
May	71.38	76.34	73.08	83.35
June	72.86	78.45	75.57	87.39
July	75.07	80.59	76.90	89.34
August	75.65	81.71	77.84	91.37
September	75.96	82.66	78.19	92.10
October	76.52	85.63	79.60	94.25

1/ From planting in December 1966 through October 1968.

Table 91

Fruit Quality - Plant Population Density, Demonstration Trial
Guaruma II, Honduras[1/]

Population Density	Stems Harvested Per Acre	Average Weight			Tons Per Acre					
		Stem	Stalk	Net	Gross	Net	CHIQUITA	Specials	PETITES	Garbage
503	493	106.95	8.57	98.38	26.36	24.25	21.14	1.40	0.80	0.91
621	633	102.68	7.82	94.86	32.52	30.04	26.37	1.72	0.47	1.48
786	550	97.01	7.23	89.78	26.69	24.70	22.21	1.03	0.40	1.06
894	644	96.50	7.14	89.36	31.06	28.76	24.30	1.96	0.66	1.85

1/ From November 1967 through October 1968.

On the other hand, if the CHIQUITA produced is expressed as percent of shippable fruit, the percentage is increased to 94, 94, 96 and 93 for the 503, 621, 786 and 894 population levels, respectively.

Discarded fruit (Garbage) was grouped by reasons for rejection (Table 92). Except for pitting disease, none of the defects appear to be related to population density. Pitting disease incidence, expressed as percent of net yield, amounted to 0.04, 0.16, 0.36 and 1.63 for populations of 503, 621, 786 and 894 production units per acre, respectively.

Plant Population Density Studies - Other Divisions. Experiments were initiated in Panama (Farm 32, Changuinola) and Costa Rica (Farm 11, Palmar) to determine the optimum plant population density for VALERY bananas under conditions typical of the areas.

The experimental design is a 4 x 2 factorial with six replications. Treatments are 4 population density levels and 2 soil textural groups. Plant spacings were:

1) 10' x 10' hexagonal (503 production units per acre)
2) 9.5' x 9.5'hexagonal (556 production units per acre)
3) 9' x 9' hexagonal (621 production units per acre)
4) 8.5' x 8.5' hexagonal (700 production units per acre).

Experimental plots are one acre in size and a sampling plot consisting of 45 production units per acre is located at the center. The field layout of plots was that of a randomized block.

Almirante Division. The experiment was planted in August 21-31, 1967, using heat-treated seed. Seed varied in size from 6" to 8" in diameter. The growing point was not removed. Most of the area was poorly drained and, consequently, a considerable amount of replanting was necessary. Drainage problems were more prevalent in the area where the loam plots were planted (lower elevation).

In July 1968, three replications in each soil type were treated with 5.5 pounds of Dowpon per acre. The replications treated in the light clay area were A, E and F, and in the loam soil B, D and E.

A summary of production data from planting in August 1967 through October 1968 is shown in Table 93. These data include plantilla fruit only. At any level of plant population, yield from the light clay soils was higher than that obtained from the loam soil. This is probably a reflection of the poor drainage conditions in the loam area.

Golfito Division. This experiment was planted on May 24-31, 1968. Seed was heat-treated and varied in size from 5.5" to 8" in diameter. The growing

Table 92

Major Defects Found at Boxing Station - Plant Population Density, Demonstration Trial
Guaruma II, Honduras

Population		Fingers				Neck		Spots			
Density	Bruised	Scarred	Mutilated	Fused	Deformed	Injury	Sunburn	Pitting	Diamond	Others	Total
					Tons Per Acre						
503	0.11	0.04	0.03	0.05	0.17	0.15	0.07	0.01	0.16	0.12	0.91
621	0.24	0.04	0.06	0.10	0.43	0.22	0.10	0.05	0.14	0.10	1.48
786	0.13	0.04	0.07	0.05	0.30	0.18	0.01	0.09	0.15	0.04	1.06
894	0.16	0.06	0.05	0.12	0.44	0.25	0.06	0.47	0.14	0.10	1.85

Table 93

Effect of Soil and Plant Population Density on Yield

Farm 32, Changuinola, Panama1/

	Plant Population Density2/	Stems Harvested Per Acre	Gross Yield Tons/A	Ave. Stem Weight Lbs.
Loam				
	503	346.5	11.11	64.1
	556	383.0	11.88	62.0
	621	425.5	13.11	61.6
	700	458.9	13.40	58.4
Light Clay				
	503	389.3	14.06	72.2
	556	403.6	14.35	71.1
	621	464.6	16.81	72.3
	700	518.5	18.22	70.3

1/ From planting August 1967 through October 1968.

2/ Production units per acre.

point was not removed. Several cases of Moko appeared in the replants and each case was treated accordingly. (SIERRA, ROSA, RODRIGUEZ, STEPHENS)

Complete Fertilizer Studies - Other Divisions

Early experimental work with complete fertilizers (Nitrogen, Phosphorus and Potassium) on Gros Michel and more recent studies on VALERY in Honduras have indicated that these types of bananas do not respond to fertilizer applications of phosphorus and potassium when grown in soils formed from sediments of the Ulua and Chamelecón Rivers. However, in all instances a significant response was obtained to nitrogen fertilization.

Soil chemical analyses show that most soils in areas where the Company operates contain sufficient amounts of phosphorus and potassium for the normal growth of the banana plant. Nevertheless, the content of these nutrients in the "available" form shows considerable variability.

High yields are characteristic of the VALERY plant. This fact, in conjunction with reduced plant spacing and continuous cropping, may eventually decrease the soil phosphorus and potassium to a critical level. Consequently, complete fertilizer trials were initiated in areas where the soil phosphorus and potassium may not be in an ample supply to meet the long-term requirements under the VALERY production system.

The objectives of this study are: (1) to evaluate the response of the VALERY plant to applications of various rates of nitrogen, phosphorus and potassium fertilizers in areas of relatively low supply of phosphorus and potassium, and (2) to determine the most economical rate of nitrogen under the present spacing system.

The experimental design is a Central Composite with 21 treatments representing five levels of nitrogen, phosphorus and potassium. The rates of these nutrients in each treatment are given in Table 94. These combinations are based on the characteristics of the design and on the suitability to evaluate the interrelationships of these nutrients on the response of VALERY bananas.

The experimental plots are one-fourth of an acre in size. Plant spacing is 10' x 10' hexagonal (503 production units/acre). Fertilizer will be applied quarterly.

Field plot layout was that of a randomized complete block, replicated four times.

Experiments were established in Palmar, Costa Rica (Farm 11) and Changuinola, Panama (Farm 32).

Table 94

Treatment Description
Complete Fertilizer Experiment
Palmar, Costa Rica and Changuinola, Panama

Treatment	Pounds Per Acre Per Year[1/]		
No.	N	P	K
1	250	25	100
2	250	25	300
3	250	75	100
4	250	75	300
5	500	25	100
6	500	25	300
7	500	75	100
8	500	75	300
9	375	50	200
10	250	50	200
11	500	50	200
12	375	25	200
13	375	75	200
14	375	50	100
15	375	50	300
16	125	50	200
17	625	50	200
18	375	0	200
19	375	100	200
20	375	50	0
21	375	50	400

1/ To be applied in quarterly cycles.

Almirante Division. The experiment area was planted in August 1967. Treatments were first applied on January 19 and 20, 1968. Subsequent applications were made every three months -- April, July and October.

Even though response will be determined only in ratoon fruit, production from plantilla is given in Table 95. Results give no indication that fertilizer level had any influence on production from plantilla.

Golfito Division. The experimental area was planted in August 1967. First application of complete fertilizer mixtures was made on February 19 and 20, 1968. Subsequent applications were made in May and August. Response of plantilla crop was independent of fertilizer level (Table 96). (SIERRA, RODRIGUEZ, STEPHENS)

Fruit Chill Protection

Winter Bags. Ten different types of winter bags were tested during the 1967-68 chill season. A description of the bag treatments is given in Table 97. The study was conducted in Mopala Farm on the same area and having the same ground treatments as those described in the 1967 Annual Report (p. 235). Eight hundred bags per treatment were placed within a 20-week period. Bagging started on October 17, 1968 and was terminated on February 27, 1969. A five-month harvesting period was necessary to collect the data.

The average stem weight by treatment is shown in Table 98. There was an average difference of two pounds between stems harvested from bare and cover ground. This difference, however, was non-significant. Stems protected with tissue bag were from 3.5 to 10.2 pounds heavier than those protected with perforated polyethylene bag alone. Not in all instances was the difference statistically significant. Most of the stems protected with tissue bags containing a polyethylene tube were significantly heavier than stems bagged with polyethylene tube only (treatments 2, 3, 5, 6, 10 and 11). The inclusion of a polyethylene tube inside the tissue bag resulted in heavier stems (treatments 10 and 11). The average days from bagging to harvest is given in Table 99.

The criteria used in studying bag suitability, besides degree of insulation, were the incidence of scarring expressed as percentage of the total hands examined, and resistance to weathering. Table 100 shows the bag performance with respect to bag scarring and other fruit blemishes.

The inclusion of a polyethylene bag in the inside of both the 2-ply 14# sulphite and 14# sulphate tissue tubes resulted in the highest percentage of non-scarred hands (approximately 5700 hands were examined in each treatment). However, this advantage was offset by the number of stems showing latex stain and sunburn. It should be mentioned that most of the hands included in the "trace" category may be included in CHIQUITA if the finger length specifications are met, and no other blemishes and defects are present.

Table 95

Effect of Fertilizer Treatment on Gross Yield of Plantilla
Farm 32, Changuinola, Panama[1/]

Treatment No.	Pounds Per Acre Per Year N	P	K	Average Stem Weight Lbs.	Gross Yield Tons/A
1	250	25	100	64.1	12.5
2	250	25	300	72.9	13.9
3	250	75	100	66.9	12.1
4	250	75	300	66.8	12.9
5	500	25	100	67.6	12.5
6	500	25	300	66.2	12.9
7	500	75	100	69.9	13.7
8	500	75	300	68.0	12.5
9	375	50	200	69.1	13.5
10	250	50	200	68.7	13.1
11	500	50	200	69.7	12.9
12	375	25	200	66.0	12.4
13	375	75	200	73.1	14.6
14	375	50	100	64.6	10.5
15	375	50	300	68.4	13.0
16	125	50	200	70.1	13.7
17	625	50	200	73.0	13.8
18	375	0	200	71.2	14.5
19	375	100	200	67.2	12.5
20	375	50	0	68.9	13.3
21	375	50	400	66.5	11.3

1/ From planting in August 1967 through October 1968.

Table 96

Effect of Fertilizer Treatment on Gross Yield of Plantilla
Farm 11, Palmar, Costa Rica[1/]

Treatment No.	Pounds Per Acre Per Year N	P	K	Average Stem Weight Lbs.	Gross Yield Tons/A
1	250	25	100	66.2	12.5
2	250	25	300	66.0	12.7
3	250	75	100	67.0	12.3
4	250	75	300	63.1	13.5
5	500	25	100	59.6	10.7
6	500	25	300	65.3	13.2
7	500	75	100	61.6	12.1
8	500	75	300	67.9	12.8
9	375	50	200	65.7	11.8
10	250	50	200	60.7	11.9
11	500	50	200	63.5	11.8
12	375	25	200	64.5	12.4
13	375	75	200	66.0	13.0
14	375	50	100	66.1	12.6
15	375	50	300	65.1	12.8
16	125	50	200	64.5	11.7
17	625	50	200	66.7	13.6
18	375	0	200	66.9	12.1
19	375	100	200	64.5	12.4
20	375	50	0	66.9	13.4
21	375	50	400	68.8	12.3

1/ From planting August 1967 through August 1968.

Table 97

Description of Bag Treatments

Treatment[1/] No.	Bag Treatment
1	Two-ply 20# sulphate tissue tubes, size 30" x 72" + outside polybag.
2	Two-ply 14# sulphate tissue tubes, size 30" x 72" + outside polybag.
3	One-ply 14# sulphate inner, one-ply 20# sulphate outer, tube size 30" x 72" + outside polybag.
4	One-ply 14# sulphate inner, one-ply 20# sulphate outer treated with wet strength additive, tube size 30" x 72" (no polybag).
5	Two-ply 14# sulphate tissue tubes, size 31" x 72" + outside polybag.
6	Two-ply 14# sulphate tissue tubes, size 32" x 72" + outside polybag.
7	One-ply 14# sulphate inner and one-ply 20# sulphate outer waxed, tube size 30" x 72" (no polybag).
8	Check - polyethylene bag standard.
9	Control - Two-ply 14# sulphite tissue, size 30" x 72" + outside polybag.
10	Two-ply 14# sulphite tissue, size 30" x 72" + polybag inside and outside.
11	Two-ply 14# sulphate tissue tube, size 30" x 72" + polybag inside and outside.

1/ Treatments 1, 2, 3, 4, 5, 6, 7 and 11 - Plyboard Industries.
Treatments 9 and 10 - Chase Bag Company.

Table 98

Effect of Ground Treatment and Winter Chill Bag on Bunch Weight

Bag Treatment No.	Bare Ground	Natural Vegetation	Bag Mean
		Pounds	
1	93.2	96.2	94.7
2	95.9	97.8	96.8
3	94.5	97.0	95.7
4	91.4	94.5	92.9
5	97.1	97.7	97.4
6	97.4	95.9	96.6
7	93.8	96.3	95.0
8	88.7	90.2	89.4
9	94.0	96.9	95.4
10	96.3	99.4	97.8
11	98.5	100.8	99.6
Ground Treatment Mean	94.6	96.6	

Least Significant Difference	.01	.05
1) Between ground treatment means	NS	NS
2) Among bag means	8.1	6.1
3) Among means for bags at same ground treatment	3.6	2.7

Coefficient of Variation for ground treatment: 9%

Coefficient of Variation for bags: 3%

Table 99

Effect of Ground Treatment and Winter Chill Bag on Days from Bagging to Harvest

Bag Treatment No.	Bare Ground	Natural Vegetation	Bag Mean
		Days	
1	97.6	98.1	97.8
2	97.4	96.8	97.1
3	97.8	97.9	97.8
4	96.9	99.5	98.2
5	98.0	98.1	98.0
6	97.6	97.5	97.5
7	96.6	98.2	97.4
8	96.8	97.9	97.3
9	99.3	99.7	99.5
10	98.1	98.9	98.5
11	96.7	97.7	97.2
Ground Treatment Mean	97.5	98.2	

Least Significant Difference	.01	.05
1) Between ground treatment means	NS	NS
2) Among bag means	1.1	.8
3) Among means for bags at same ground treatment	1.6	1.2

Coefficient of Variation for ground treatment: 4%

Coefficient of Variation for bags: 1%

Table 100

Effect of Bag Type on the Incidence of Bag Scars on the Fruit

Treatment	Stems	Percent Hands Scarred*					Defects, Stems Affected		
No.	Examined	None	Trace	Light	Medium	Severe	Animal Scratches	Latex	Sunburn
1	580	8.83	51.77	27.76	9.47	2.17	10	7	12
2	580	13.24	56.21	22.49	6.21	1.85	1	8	11
3	580	15.13	57.28	20.80	5.49	1.30	7	7	10
4	580	21.71	57.40	16.40	3.63	0.86	9	3	2
5	580	13.14	57.04	22.40	5.90	1.52	1	6	11
6	580	12.20	56.17	22.74	6.91	1.98	3	10	13
7	580	18.21	57.82	18.30	4.60	1.07	2	6	14
8	580	67.40	28.55	3.36	0.53	0.16	-	28	60
9	580	14.66	58.38	20.81	5.03	1.12	-	8	9
10	580	63.80	33.08	2.89	0.19	0.04	-	194	31
11	580	62.49	33.81	3.42	0.26	0.02	-	257	61

* Severity rating on basis of Quality Control specifications:

Trace = Up to 0.6 sq. in. of area affected/hand scarred.
Light = 0.7 to 1.2 sq. in. of area affected/hand scarred.
Medium = 1.3 to 2.0 sq. in. of area affected/hand scarred.
Severe = Over 2.0 sq. in. of area affected/hand scarred.

If both the "none" and "trace" scarred percentages are added in treatments 3, 4, 7 and 9, it is evident that the performance of these bags was essentially the same. However, treatment 4 gave the lowest occurrence of "light" and "medium" scarring probably because of the presence of 20# tissue containing a wet strength additive. It is possible that this reduction in scarring was a result of less fluttering of the bag when dry, and less crinkling when moist.

The difference in the amount of "light" to "severe" scarring between treatments 3 and 4 was about seven percent. This indicates that if a bag is made of a 14# sulphate tissue inside and a 20# sulphate tissue outside, the latter should contain the wet strength additive.

Lowering the width of the tube from 32" to 31" resulted in a reduction of "medium" and "severe" scarring. Further reduction in width tended to increase the incidence of these scarring categories (treatments 2, 5 and 6).

The 2-ply sulphate tissue bag (treatment 1) gave the highest occurrence of "light", "medium" and "severe" scarring. This suggests that bags made of 20# 2-ply tissue should not be used, even though higher insulation is obtained.

Field performance of bags is shown in Table 101. According to weathering susceptibility, bags tested may be grouped into five categories. This grouping is given in the following table:

Weathering Resistance Category	Treatment
1 (most resistant)	1 and 4
2	3 and 11
3	6 and 7
4	2, 5 and 10
5 (least resistant)	9

The weathering resistance of the paper appears to be related to its weight and surface finishing. The sulphate tissue has a smoother surface than the sulphite paper. Therefore, the latter tends to absorb moisture more readily. (SIERRA, ROSA)

Temperature Report - Honduras Division (October 1967 through March 1968). For the past four years, maximum and minimum temperatures have been recorded during months of probable occurrence of fruit chilling temperatures.

Table 101

Field Performance of Chill Bags

Treatment No.	Intact	Torn	Tearing Distribution Slight	Moderate	Excessive
1	74.8	25.2	22.8	2.1	0.3
2	65.9	34.1	30.2	3.6	0.3
3	72.4	27.6	25.0	2.4	0.2
4	73.8	26.2	22.8	2.9	0.5
5	61.4	38.6	35.2	3.1	0.3
6	69.7	30.3	28.6	1.2	0.5
7	69.0	31.0	27.4	2.6	1.0
9	52.9	47.1	41.2	5.5	0.4
10	64.1	35.9	31.7	3.5	0.7
11	71.4	28.6	26.2	2.2	0.2

After four years no definite pattern of cold areas has been found in the Ulua Valley. However, areas which are more likely to experience chilling temperatures are centered around Ceibita Farm on the west side of the Ulua River and Las Flores Farm on the east side.

Two short cool periods, when temperatures dropped below 56° F, were experienced on February 8 and 28, 1968 in certain farms. Following are the farms that recorded the lowest temperatures, the duration and the approximate elevation of the area:

Farm	Date	Temperature °F	Duration (Hrs:Min)	Elevation (Feet)
Ceibita	2/8/68	54	1:45	65
Mopala*	2/8/68	52	1:00	84
Las Flores	2/8/68	54	2:00	78
Copen	2/8/68	54	0:20	74
Las Flores	2/28/68	55	1:15	78
Cobb	2/28/68	54	0:35	82

* Recorded at the Chill Bag experimental site.

Figure 63 shows the average maximum and minimum temperatures recorded from October 1967 to mid-March 1968 in the Honduras Division. (ROSA)

Herbicide Studies

Karmex Experiment. The description and experimental design of the Karmex Experiment are described on page 289 of the 1967 Annual Report. Data sampled from this experiment include: mean bunch weights, weed aliquots, phytotoxicity ratings, rate of growth, maturation period, soil residue and percent organic matter. Data have been analyzed statistically when the quantity was sufficient to justify its use.

Mean Bunch Weights: A statistical analysis of fruit yield data taken from the Karmex Experiment for the period July 27, 1967 to September 1, 1968 indicates no statistically significant differences resulting from applied rates or frequencies of Karmex (diuron) or from "Dowpon" vs. "No Dowpon" treatments. Yield differences, expressed in terms of mean bunch weight (pounds) and production per acre (tons), are reported with respect to rates and frequencies in Tables 102 and 103. The analysis of variance procedure presented in Table 104 denotes statistically significant differences between replications only at the 1 percent level of significance.

Differences in mean bunch weights between "Karmex" and "No Karmex" plots are correspondingly decreasing with time. Rates of Karmex ranging from 4 to 12 pounds actual per acre per year have not been shown to adversely affect fruit production to any significant degree.

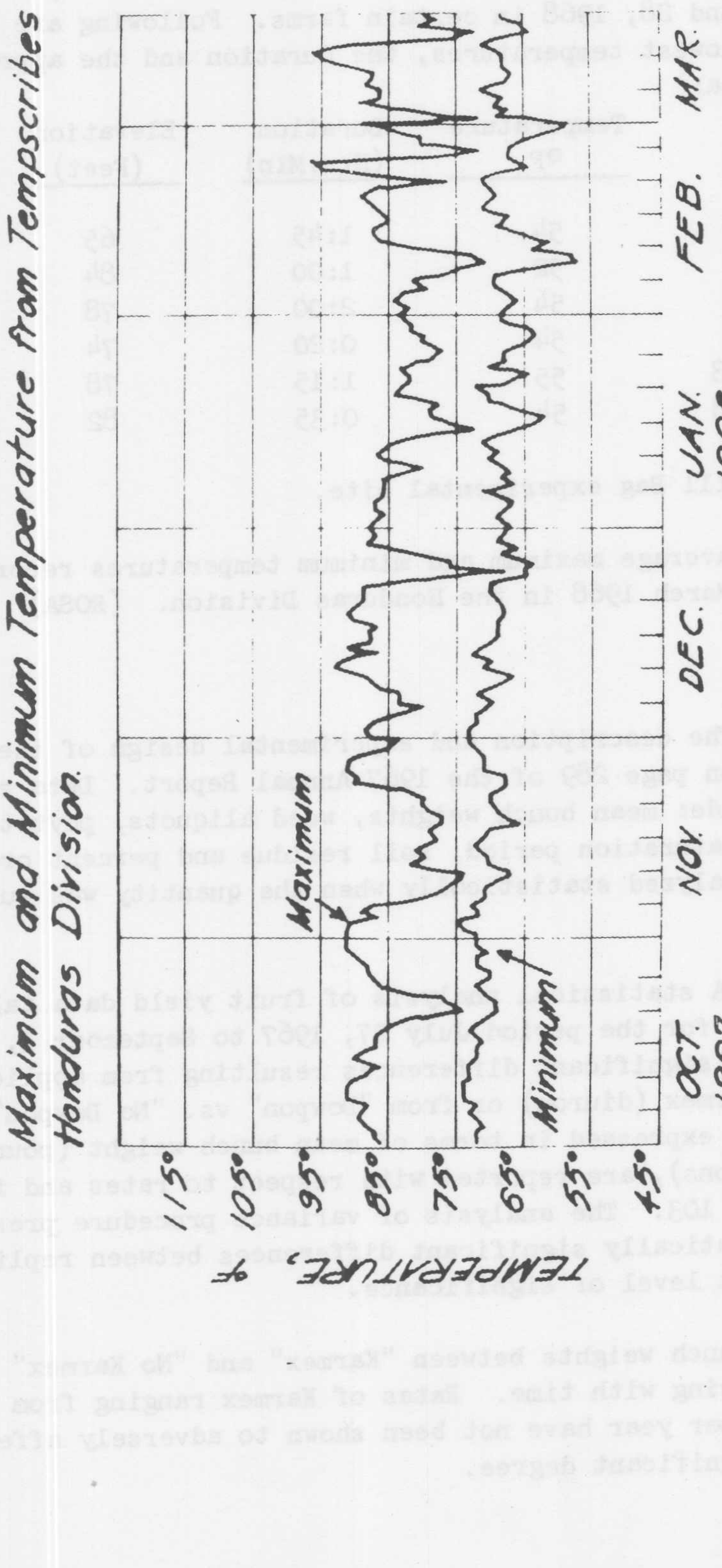
Maximum and Minimum Temperature from Tempscribes
Honduras Division
TEMPERATURE, °F
115°
105°
95°
85°
75°
65°
55°
45°
Maximum
Minimum
OCT. 1967
NOV.
DEC.
JAN. 1968
FEB.
MAR.

Figure 63

Table 102

Summary of Effects of Application Rates of Karmex (Diuron) and Dowpon (Dalapon), Irrespective of Application Frequencies, on Mean Bunch Weight and Production Per Acre

Herbicide 1/ Treatment	Mean 2/ Bunch Weight (Lbs.)	3/ Production Per Acre (Tons)
No Karmex (Control)	87.63	33.06
Karmex 4#/Acre	86.67	32.70
Karmex 8#/Acre	84.72	31.96
Karmex 12#/Acre	84.46	31.86
Dowpon Only	87.44	32.99

1/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year. Dowpon applied at 5 lbs. active/acre on April and July 17, 1967; January and July 17, 1968.

2/ Represents means of data compiled from four replications for period July 26, 1967 to September 1, 1968.

3/ Based on 1.5 crops/mat/year from 503 population density.

Table 103

Summary of Effects of Frequency of Application of Karmex (Diuron), Irrespective of Application Rate, on Mean Bunch Weight and Production Per Acre

Herbicide[1/] Treatment	Mean[2/] Bunch Weight (Lbs.)	[3/] Production Per Acre (Tons)
No Karmex (Control)	85.99	32.44
3 Month	86.85	32.76
6 Month	85.52	32.26
9 Month	87.00	32.82
12 Month	87.44	32.99

1/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year.

2/ Represents means of data sampled from four replications for period July 26, 1967 to September 1, 1968.

3/ Based on 1.5 crops/mat/year from 503 population density.

Table 104

Analysis of Variance of Treatment Effects on Bunch Weight Taken from the Karmex Experiment for the Period of July 26, 1967 to September 1, 1968

Source	d.f.	S.S.	M.S.	F (Cal.)	F* (Tab.)	F** (Tab.)
Total	56	417784.095				
Mean	1	416502.979				
Reps	3	253.537	84.51	4.32**	2.84	4.31
Treatment	11	225.235	20.48	1.05	2.04	2.73
A (Rate)	2	81.880	40.94	2.09	3.23	5.18
B (Frequency)	3	45.320	15.11	.77	2.84	4.31
A x B	6	98.035	16.34	.83	2.34	3.29
Dowpon vs. No Dowpon	1	19.720	19.72	1.01	4.08	7.31
Error	40	782.624	19.57			

Symbols * and ** indicate significant differences at 5% and 1% levels, respectively.

Weed Aliquots: Degrees of weed control achieved for a six-month sampling period are reported in Tables 105, 106 and 107. Data compiled with respect to rates (Table 105) illustrate the effectiveness of control with Karmex as low as 4 pounds actual per acre per year. Data compiled with respect to frequency of application (Table 106) favor Karmex cycled at three-month intervals.

Beginning in March 1968, the broadleaf species Conde (Syngonium podophyllum) was sampled separately from other broadleaves. This low-growing, vine species proved very resistant to Karmex treatments and was confounding previous broadleaf control data.

Karmex has proven to be very effective in controlling a broad spectrum of grass and broadleaf weed species both pre- and post-emergence. Its application with surfactant at rates of one pound per acre every three months is providing excellent weed control in treated plots in Guaruma II.

Phytotoxicity Ratings: No phytotoxic symptoms have been observed within the sampling areas of any plot in this experiment.

Rate of Growth: Vertical height and diameter measurements previously taken bi-weekly are now recorded only at time of shooting (Table 108). Differences in both measurements did not warrant the continued frequent measurements. Plant height and diameter differences resulting from applied rates and frequencies are negligible.

Maturation Period: The effect of herbicide treatments on days required for fruit maturity remains negligible (Table 108).

Soil Residue (Diuron): Soil samples taken from four replications of each treatment (0"-3" depth) indicate a correlation between rate of Karmex applied and parts per million of diuron residue (Tables 109 and 110). Approximate build-up of 1, 2 and 3 ppm were recorded for rates of 4, 8 and 12 lbs. of Karmex applied during a 15-month period (Table 109). Differences with respect to frequency of Karmex application are not illustrated as variations of diuron residue (ppm) are negligible.

Percent Organic Matter: Comparisons of soil organic matter content indicate a slight reduction 15 months following original determinations (Table 110). Since the percent organic matter level is lower also for the control, factors other than herbicide treatments must be involved.

Gramoxone Experiment. Gramoxone herbicide [1:1'-dimethyl-4,4'-bipyridylium dimethylsulphate] is under evaluation in Guaruma II for phytotoxic determinations and degree of weed control effectiveness in bananas. Gramoxone is being applied at 1.5 pint per acre, plus surfactant at 1/2 percent by volume. Four replications of each treatment are arranged in a completely randomized design.

Table 105

Summary of Effects of Application of Karmex (Diuron) and Dowpon (Dalapon) Treatments, Irrespective of Application Frequencies, in Controlling Broadleaf, Grass and Conde Weed Species

Herbicide[1/] Treatment	Lbs. Dry Weight/Acre[2/]		
	Broadleaves	Grasses	Conde[3/]
No Karmex (Control)	62.53	32.97	37.35
Karmex 4#/Acre	33.24	8.48	39.11
Karmex 8#/Acre	22.20	6.05	33.40
Karmex 12#/Acre	17.29	2.24	35.19
Dowpon Only	54.95	5.98	41.72

1/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year. Dowpon cycled only as required to apply 5 pounds active/acre/treatment (April and July 17, 1967; January and July 17, 1968).

2/ Represents means of data compiled from four replications for period March 1968 to September 1968.

3/ Listed scientifically as Syngonium podophyllum.

Table 106

Summary of Effects of Application Frequencies of Karmex (Diuron), Irrespective of Application Rate, in Controlling Broadleaf, Grass and Conde Weed Species

Herbicide[1/] Treatment	Lbs. Dry Weight/Acre[2/] Broadleaves	Grasses	Conde[3/]
No Karmex (Control)	62.53	32.97	37.35
3 Month	18.50	.67	34.50
6 Month	25.32	6.93	35.89
9 Month	28.95	10.74	50.19
12 Month	24.18	4.02	23.01

1/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year.

2/ Represents means of data compiled from four replications for period March 1968 to September 1968.

3/ Listed scientifically as Syngonium podophyllum.

Table 107

Effects[1] of Applications of Karmex (Diuron) and Dowpon (Dalapon) Herbicides on Broadleaf, Grass and Conde Weed Species Measured Monthly from March to September 1968 - Guaruma II Farm, Honduras

Treatment Description	Pounds/Acre Karmex	Pounds/Acre Dowpon	Number of Cycles[2] Karmex	Number of Cycles[2] Dowpon	Weed Species (Lbs./Acre) Broadleaves	Weed Species (Lbs./Acre) Grasses	Weed Species (Lbs./Acre) Conde[3]
No herbicide (Control)	0	0	0	0	62.53	32.97	37.35
Dowpon Only	0	20	0	4	54.95	5.98	41.75
Karmex-Dowpon	5	10	5	2	23.26	.85	24.97
" "	10	10	5	2	13.34	.21	38.84
" "	15	10	5	2	18.89	.96	39.69
Karmex-Dowpon	4	10	2	2	52.71	15.47	47.91
" "	8	10	2	2	14.30	4.48	26.46
" "	12	10	2	2	8.96	.85	33.29
Karmex-Dowpon	4	10	1	2	31.16	12.16	62.10
" "	8	10	1	2	34.36	15.15	42.47
" "	12	10	1	2	21.34	4.91	45.99
Karmex-Dowpon	4	10	1	2	25.82	5.44	21.45
" "	8	10	1	2	26.78	4.37	25.82
" "	12	10	1	2	19.95	2.24	21.77

1/ All figures represent means of data sampled from four replications of each treatment.

2/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year. Dowpon applied at 5 pounds active/acre on April and July 17, 1967; January and July 17, 1968.

3/ Listed scientifically as Syngonium podophyllum.

Table 108

Effects[1/] of Applications of Karmex (Diuron) and Dowpon (Dalapon) Herbicides on Bunch Weight, Bunches Harvested, Maturation Period and Plant Growth Characteristics Measured from July 26 to September 1, 1968 - Guaruma II Farm, Honduras

Treatment	Pounds/Acre		Number of Cycles[2/]		Bunch Weight (Pounds)	Bunches Harvested	Maturation Period (Days)	Plant Height (Feet)	Plant Diameter (Inches)
	Karmex	Dowpon	Karmex	Dowpon					
No herbicide (Control)	0	0	0	0	87.44	145	108	13.5	10.2
Dowpon Only	0	20	0	4	84.46	147	107	13.4	9.9
Karmex-Dowpon	5	10	5	2	87.22	151	108	13.5	10.0
" "	10	10	5	2	85.50	146	104	13.4	9.9
" "	15	10	5	2	85.18	142	110	13.4	10.1
Karmex-Dowpon	4	10	2	2	88.42	149	108	13.4	10.0
" "	8	10	2	2	87.15	156	107	13.4	10.0
" "	12	10	2	2	84.92	146	106	13.3	9.9
Karmex-Dowpon	4	10	1	2	87.99	144	111	13.6	10.2
" "	8	10	1	2	84.25	138	110	13.4	10.1
" "	12	10	1	2	84.25	143	109	13.3	9.9
Karmex-Dowpon	4	10	1	2	86.90	145	109	13.5	10.2
" "	8	10	1	2	89.50	153	107	13.5	10.2
" "	12	10	1	2	84.54	149	109	13.3	10.0

1/ All figures represent means of data sampled from four replications of each treatment.

2/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year. Dowpon applied at 5 pounds active/acre on April and July 17, 1967; January and July 17, 1968.

Table 109

Summary of Effects of Application Rates of Karmex (Diuron), Irrespective of Application Frequencies, on Build-up of Diuron Soil Residue

Herbicide[1/] Treatment	Parts Per Million Apparent Diuron[2/] April 13, 1967	July 12, 1968
No Karmex (Control)	1.92	1.42
Karmex 4#/Acre	1.19	2.94
Karmex 8#/Acre	1.73	3.99
Karmex 12#/Acre	1.86	4.96
Dowpon Only	1.68	1.44

1/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year. Dowpon applied at 5 lbs. active/acre on April and July 17, 1967; January and July 17, 1968.

2/ Represents means of data compiled from four replications.

Table 110

Effects[1/] of Applications of Karmex (Diuron) and Dowpon (Dalapon) Herbicides on Soil Residue (Diuron) and Percent Organic Matter
Guaruma II Farm, Honduras

Treatment	Pounds/Acre		Number of Cycles[2/]		Diuron (P.P.M.)		% Organic Matter	
	Karmex	Dowpon	Karmex	Dowpon	Apr. 13, 1967	July 12, 1968	Apr. 13, 1967	July 12, 1968
No herbicide (Control)	0	0	0	0	1.92	1.42	7.06	4.74
Dowpon Only	0	20	0	4	1.68	1.44	6.58	5.86
Karmex-Dowpon	5	10	5	2	1.78	2.54	6.69	4.15
" "	10	10	5	2	1.57	3.43	6.41	5.37
" "	15	10	5	2	1.62	4.21	6.76	5.14
Karmex-Dowpon	4	10	2	2	2.20	3.30	6.29	5.51
" "	8	10	2	2	1.55	4.33	6.61	5.44
" "	12	10	2	2	1.97	5.05	6.61	5.51
Karmex-Dowpon	4	10	1	2	1.59	2.52	6.80	5.91
" "	8	10	1	2	2.04	3.04	6.16	5.64
" "	12	10	1	2	1.81	5.38	6.31	5.69
Karmex-Dowpon	4	10	1	2	2.06	3.40	6.95	5.76
" "	8	10	1	2	1.75	5.16	6.81	5.67
" "	12	10	1	2	2.05	5.20	6.57	5.81

1/ All figures represent means of data sampled from four replications of each treatment.

2/ Karmex treatments cycled every 3, 6, 9 and 12 months to apply 0, 4, 8 and 12 pounds actual/acre/year. Dowpon applied at 5 pounds active/acre on April and July 17, 1967; January and July 17, 1968.

The plant population density in the experimental area consists of 503 mats per acre. Individual plots are 72' x 79' in size. Sampling areas consist of the center twenty-five mats within each plot. A report on data taken since the project was initiated in January 4, 1968 follows:

Mean Bunch Weight: Differences in fruit yield resulting from Gramoxone applications are negligible (Table 111). Data from four months' production indicate a slightly higher yield resulting from Gramoxone treatments.

Weed Aliquots: Gramoxone treatments, when applied as required for an optimum degree of weed control, were needed approximately every two months. Effectiveness of weed control for broadleaf, grass and Conde (resistant broadleaf) weed species is reported in Table 112. Gramoxone appears more effective under conditions of heavier shade which may result from increased translocation of the herbicide, or a weaker plant system succumbing more easily to treatment.

Phytotoxicity Ratings: Bi-weekly observations indicate no phytotoxic symptoms resulting from Gramoxone application.

Rate of Growth: Difference in vertical height and diameter, measured at time of shooting, indicate only slight variations from the control (Table 113).

Maturation Period: Maturation period for Gramoxone-treated plots averages four days shorter than for the controls. Gramoxone plots averaged 96 days compared to 100 days for the control for the four-month sampling period (Table 113).

<u>Karmex Versus Gramoxone in Established Banana Plantations.</u> Karmex (diuron) and Gramoxone (paraquat) are being compared for weed control effectiveness at one pound and one pint per acre, respectively. Frequency of application is based on three-month cycles for both herbicides.

This experiment is located in Section 37 of Guaruma II. Three replications of each treatment are being sampled prior to initial and subsequent herbicide applications for grass and broadleaf weed densities. Sampling areas consist of the center twenty-five mats within each plot. Treatments are arranged in a completely randomized design. Individual plots measure 70 x 90 feet. All plots, excluding checks, were initially treated with Dalapon at five pounds per acre. Dowpon treatments were applied on June 5, 1968. Gramoxone-Karmex treatments have been applied on June 19 and September 11, 1968. Sufficient data have not been collected to make valid comparisons on degree of weed control achieved.

Table 111

Summary of Effects of Gramoxone (Paraquat) Applications on Mean Bunch Weight and Production Per Acre

Herbicide[1/] Treatment	Mean[2/] Bunch Weight	Production[3/] Per Acre (Tons)
Control	87.03	10.94
Gramoxone	87.86	11.05

1/ Gramoxone treatments applied at 1.5 pt./acre on January 4, February 22, May 9 and August 27, 1968.

2/ Represents means of data compiled from four replications for period May 3 to September 1, 1968.

3/ Based on 1.5 crops/mat/year from 503 population density and adjusted for four months production (251.5 stems/acre).

Table 112

Summary of Effects of Gramoxone (Paraquat) Applications in Controlling Broadleaf, Grass and Conde Weed Species - Guaruma II

Herbicide1/ Treatment	Lbs. Dry Weight/Acre2/ Broadleaves	Grasses	Conde3/
Control	80.24	23.47	10.67
Gramoxone	45.88	14.08	10.67

1/ Gramoxone treatments applied at 1/5 pt./acre on January 4, February 22, May 9 and August 27, 1968.

2/ Represents means of data compiled from four replications for aliquots harvested prior to all treatments (excluding January 4 treatment).

3/ Listed scientifically as _Syngonium podophyllum_.

Table 113

Effects[1/] of Gramoxone Applications on Mean Bunch Weight, Bunches Harvested, Maturation Period and Plant Growth Characteristics, Measured from May 3 to September 1, 1968 - Guaruma II Farm, Honduras

Treatment	Rate/A	No. of[2/] Cycles	Mean Bunch Weight (Lbs.)	Bunches Harvested	Maturation Period (Days)	Plant Height (Feet)	Plant Diameter (Inches)
Control	0	0	87.03	36	100	13.4	10.1
Gramoxone	1.5 pt.	4	87.86	35	96	13.4	10.2

1/ All figures represent means of data sampled from four replications of each treatment.

2/ Gramoxone treatments applied as required for optimum weed control. Treatments applied on January 4, February 22, May 9 and August 27, 1968.

Maleic Hydrazide (MH-30) for Irrigation-Drainage Ditch Weed Control

Maleic Hydrazide (MH-30) was evaluated in Guaruma II for effectiveness as a growth retardant in irrigation drainage channels. The experiment was laid out as a randomized complete block design incorporating four replications of four treatments. The experimental area was surface-chopped on January 10, 1968, and treatments applied on February 15, 1968. Treatments involved 0, 1, 2 and 3 gallons of MH-30 per acre. Treatments were applied with five quarts of water plus surfactant (.05 percent by volume) in plots measuring 15 x 20 sq. ft.

Three months (12 weeks) following treatment each plot was sampled for weed density. Four samples of one square foot each were randomly selected from each plot. All aliquots were subsequently oven-dried for 48 hours and dry weights determined. Grams dry weight per square foot have been converted to pounds dry weight per acre, and are shown in Table 114.

A statistical analysis of data reveals statistically significant differences resulting from both the two- and three-gallon per acre treatments (Table 115). These treatments resulted in significant reduction in vegetative growth at both the 5 percent and 1 percent levels of significance. All maleic hydrazide treatments were effective in retarding vertical growth of Leche grass (Ixophorus unisetus), Guinea grass (Panicum maximum) and Camalote grass (Paspalum fasciculatum). Significant growth retardation was also noted for the broadleaf quiscamote (Xathosoma roseum).

Erosion or wash-out of graded banks and fills could be maintained at a minimum with maleic hydrazide as grass density is generally unaffected. Cell division of treated plants is greatly curtailed, thereby limiting vertical growth. The effectiveness of maleic hydrazide at 2-3 gallons per acre could be expected to provide a minimum of 3- to 4-month vegetation control. The quoted price of $8 per gallon (for a one-gallon lot), however, appears to favor hand weed control practices, particularly at present labor costs.

Herbicide Screening for Leche Grass Control. Procedures for primary screening of candidate herbicides for control of Leche grass (Ixophorus unisetus) in bananas is outlined on page 299 of the 1967 Annual Report. Additional herbicides screened since this report are presented in Table 116. With the completion of screening of pre-emergence herbicides, a post-emergence phase has been undertaken to evaluate effectiveness of post-emergence properties on Leche grass. This work is currently in progress and compounds being evaluated are listed in Table 117. Phytotoxic evaluations of herbicides selected from the primary screening phase are scheduled during October 1968 in Guaruma II. Herbicides to be evaluated are given in Table 118.

Banana Eradication for Moko Control. The bananacide formulation consisting of Banvel-D and Herbicide 273, when mixed in a ratio of 2-3 and injected

Table 114

Mean Dry Weights, Expressed As Pounds/ Acre, of Vegetation Produced from Four Treatments of Maleic Hydrazide Applied to a Main Irrigation Channel in Guaruma II

Treatment (Gal./A)	Lbs. Dry[1/] Weight/A
0	1330
1	1096
2	889**
3	706**

1/ Means of four aliquots of one sq. ft. each taken randomly from each plot three months after treatment.

** Denotes 1% (.99) level of significance.

Table 115

Analysis of Variance of Effects on Vegetation
Produced (Lbs./A) by Four Treatments of Maleic Hydrazide
Applied to a Main Irrigation Channel in Guaruma II

Source	d.f.	S.S.	M.S.	F (Cal.)	F* (5%)	F** (1%)
Total	16	154781.238				
Mean	1	142189.326				
Reps	3	2046.726	682.242	2.10	3.86	6.99
Treatment	3	7615.341	2538.447	7.80**	3.86	6.99
Error	9	2929.845	325.538			

Symbols * and ** indicate 1% (.99) level of significance.

Table 116

Effects of Pre-Emergence Herbicides in Greenhouse Screening Trials on Growth and Yield of Leche Grass (Ixophorus unisetus) After Six-Week Evaluation Periods

Manufacturer	Herbicide	Application Rate (Lbs./A)	Mean Plant Count	Percent Control	Mean Dry Wt. (Grams)
Geigy	Gesatop	0 active	45.60	-----	.88
		2	4.40	90.35	.0
		4	5.40	88.16	.0
		6	4.20	90.79	.0
		8	.80	98.25	.0
Hoechst	Aresin	0 actual	22.80	-----	.03
		1	.80	96.49	.00
		2	.00	100.00	.00
		3	.00	100.00	.00
		4	.00	100.00	.00
Monsanto	CP-24074	0 actual	28.20	-----	.97
		2	5.00	82.27	.00
		4	6.40	77.30	.00
		6	3.80	86.52	.00
		8	4.40	84.40	.00
	CP-522	0 active	27.00	-----	1.61
		2	1.80	93.33	.00
		4	3.40	87.41	.00
		6	2.20	91.85	.00
		8	2.00	92.60	.00
Rohm & Haas	FW 925	0 actual	17.60	-----	.57
		2	.00	100.00	.00
		4	.00	100.00	.00
		6	.00	100.00	.00
		8	.00	100.00	.00
Thompson-Hayward	Casoron	0 active	28.88	-----	1.56
		2	15.80	45.14	.00
		4	5.80	79.86	.00
		6	2.80	90.28	.00
		8	7.00	75.69	.00

Cont...

Manufacturer	Herbicide	Application Rate (Lbs./A)	Mean Plant Count	Percent Control	Mean Dry Wt. (Grams)
Upjohn	Enide	0 actual	19.60	-----	1.97
		3	1.60	91.84	.00
		6	1.60	91.84	.00
		9	.60	96.94	.00
		12	.40	97.96	.00
US Rubber	Alanap 3	0 actual	31.80	-----	1.74
		2	9.60	69.81	.28
		4	11.60	63.52	.27
		6	17.40	45.28	.89
		8	21.20	33.33	.75

Table 117

Herbicides Selected for Post-Emergence Evaluations
in Greenhouse Screening Trials for Leche Grass
(*Ixophorus unisetus*) Control

Manufacturer	Herbicide	Formulation	Manufacturer's Recommended Rates
CIBA	C-6313	50 WP	2 lbs/A (Active)
CIBA	Cotoran	80 WP	2 lbs/A (Active)
CIBA	Tenoran	50 WP	3 lbs/A (Active)
Dow	Daxtron	1.5 lbs/gal	1.5 lbs/A
Dow	Dowpon	85 WP	5 lbs/A (Active)
DuPont	Karmex	80 WP	4 lbs/A
DuPont	Lorox	50 WP	6 lbs/A (Active)
DuPont	Sinbar	80 WP	3 lbs/A
Geigy	Ametryne (Gesapax)	80 WP	8 lbs/A
Geigy	Atrazine	80 WP	4 lbs/A
Hoechst	Afalon	50 WP	4 lbs/A
Hoechst	Aresin	50 WP	2 lbs/A
Hoechst	Nata	95 WP	10 lbs/A
Monsanto	Ramrod	65 WP	6 lbs/A
Pennsalt	Herbicide 273	3 lbs/gal	6 lbs/A
Rohm & Haas	FW-925	4 lbs/gal	4 lbs/A
Rohm & Haas	TOK E-25	2 lbs/gal	4 lbs/A
Shell	S-7961	50 WP	2 lbs/A
Thompson-Hayward	Casoron	50 WP	4 lbs/A (Active)
Union Carbide	UC-22463	4 lbs/gal	6 lbs/A
Upjohn	U-14611	50 WP	2 lbs/A (Active)
Velsicol	Banvel-D	4 lbs/gal	2 lbs/A
Velsicol	OCS-21799	80 WP	2 lbs/A

Table 118

Pre-Emergence Herbicides Screened for Leche Grass (Ixophorus unisetus) Control and Selected for Phytotoxic Evaluations in Bananas in Guaruma II

Manufacturer	Chemical Name	% A.I.	Rates
Amchem	Amiben	2 lbs/gal	3 lbs/Active/A 6 lbs/Active/A
CIBA	Cotoran	80 WP	4 lbs/Active/A 8 lbs/Active/A
Diamond	Dacthal	75 WP	4 lbs/Active/A 8 lbs/Active/A
DuPont	Lorox	50 WP	3 lbs/Active/A 6 lbs/Active/A
Elanco	Trifluralin	4 lbs/gal	1 lb/active/A 2 lbs/Active/A
Geigy	Atrazine	80 WP	6 lbs/A 8 lbs/A
Hoechst	Aresin	50 WP	2 lbs/A 4 lbs/A
Monsanto	CP-31675	4 lbs/gal	3 lbs/Active/A 6 lbs/Active/A
Monsanto	CP-50144	4 lbs/gal	1 lb/Active/A 2 lbs/Active/A
Rohm & Haas	FW 925	4 lbs/gal	2 lbs/A 4 lbs/A
Shell	SD-11831	75%	1 lb/A 2 lbs/A
Union Carbide	UC-22463	4 lbs/gal	9 lbs/Active/A 12 lbs/Active/A

at rate of 50 ml. per mat, has been observed to produce buffer mat deformation. This deformation is characterized by moderate to severe malformation of the center leaves and occasionally malformation of the fruit stem only during the early developmental stages.

Subsequent to the appearance of this malformation (June 15, 1968), a Bananacide Dilution Experiment was conducted in Guaruma II in an attempt to reduce herbicide volume injected, thereby reducing apparent malformation. The proportion of Banvel-D to Herbicide 273 was unvaried. Amount of each herbicide injected was reduced only by dilution with water (Table 119). Observations at ten weeks indicated buffer deformation resulting from all treatments exclusive of treatment A. Center leaves of affected buffer plants were most deformed at treatment level E and less affected at treatment level B. No buffer deformation occurred at treatment level A. Deformation of buffer plants appeared to result from translocation or absorption of Banvel-D via adjacent root system. Deformation in nearly all instances was noted 6-8 weeks following injection. The transport of Banvel-D may have contributed to the death and subsequent decomposition of roots of injected mats. This herbicide, which is root translocated, is then possibly absorbed by adjacent roots of buffer mats following its release into the surrounding soil.

Kill of above ground plant parts was acceptable at dilutions to and including the 50 percent water dilution (treatment C). Kill of suckers and root systems after ten weeks appeared acceptable at treatment level A; however, retreatment of several mats was required.

On August 28, 1968 a further experiment was initiated to find a proportion of both compounds which would give acceptable top and root kill, yet not adversely affect buffer mats. Since treatment A (Table 119) gave acceptable root kill at 3 ml. Banvel-D per mat, rates were ranged from 1, 2, 3 to 4 ml. per mat. Amount of Herbicide 273 was maintained at 30 ml. per mat. Water was added to each solution to bring total volume to 50 ml. per mat. Readings made four weeks following injection indicated excellent top kill resulting from all treatments. Sucker and root kill was observed to be better at the 3- and 4-ml. (Banvel-D) levels.

By reduction in amount of Banvel-D injected per mat, more acceptable kill appears possible. Buffer distortion can be eliminated or kept to a minimum, while amount of retreatment required will be increased only to a moderate level.

<u>Survey of Dowpon Effect on Sword Sucker Emergence</u>. The number of emerging sword suckers and their points of origin have been determined for both "no herbicide" and "Dowpon only" treatments from Project 41 in Guaruma II. The center twenty-five mats of each treatment were sampled from each of four replications. Sword sucker emergence from each pseudostem base was rated as either below surface, 0"-1", 1"-2", or 2"-3" above the soil surface. Actual sucker counts are reported in Table 120.

Table 119

Effects of Bananacide Concentrations[1] Diluted with Various Percentages of Water in an Attempt to Reduce Buffer Mat Deformation

Treatment Number	% Water Dilution	(Ml) Banvel-D	(Ml) Herbicide 273	Results (10 Weeks) Mat Kill	Buffer Damage
A	90	2	3	Light	None
B	75	5	7.5	Moderate	Slight
C	50	10	15	Moderate-Complete	Moderate
D	25	15	22.5	Complete	Severe
E	0	20	30	Complete	Severe

1/ Herbicide components mixed in a ratio of 2 parts Banvel-D to 3 parts Herbicide 273. Fifty ml. of each dilution injected into ten mats using hypodermic assembly.

box-stem ratio between 2 and 3 years after planting and then the box-stem ratio declined to 60 to 75% of the peak value. Representative curves are shown in Figures 64-65. An analyses of all factors that might be involved in the decline in box-stem ratio resulted in drainage being implicated as one contributing factor. During 1967 rainfall was abnormally heavy and resulted in high water tables for prolonged periods. A study of root growth was made to determine the influence of drainage on root distribution and abundance.

A trench 6 feet long by 4 feet deep was made 4 feet from the base of the mat and the location of all roots exposed on the trench face was mapped. Distribution of roots was compared in areas of higher contour considered better drained than areas of lower contour with the water table between 4 and 5 feet in the dry season (Table 121). Root distribution in depth was correlated with water tables and root growth was common between 3 and 4 feet only where a water table was not present above 4 feet. Root distribution maps representative of the better and more poorly-drained areas are shown in Figures 66-67. Yields in the former areas were about 20% greater than in the latter. There was no correlation between root distribution in depth and clay content (Figures 68-69). One of the highest clay areas was the levee in Farm 61, where roots were abundant down to the 4-foot level. An adjacent poorly-drained area had only 5% of the roots below 2 feet. Yields were higher where root distribution down to 4 feet was greatest.

Where there are few or no roots between 36 and 48 inches below the soil surface and where there are fewer than 25% of the roots below 2 feet, drainage is not sufficient for optimum yields. It remains to be determined how long VALERY can tolerate a water table in the major 36-inch root zone. Any rise in the water table above 4 feet must be for the shortest time possible, probably 48 hours or less, for maximum yields.

An analyses of root distribution was made at 3 sites in Ceibita Farm, Honduras - 2 in loam and 2 in clay (Table 122). Four excavations were made at each site. Fruit from the loam area averages 14 lbs. more per stem than from the clay. One of the clay areas had a water table at or above 3 feet and had fewer than 25 percent of the roots below 2 feet and none below 3 feet and thus is classified as poorly-drained. This area had the highest elevation of the 4 areas sampled, indicating that water was not moving out via drains. The loam area with 27% of the roots below 2 feet and a water table at 40-50 inches was just barely adequately drained. The largest outbreak of yellow mat disease in Honduras occurred in Ceibita Farm in January 1965.

As a result of the root studies in Bocas, an extensive revision of the drainage systems began in May 1968. Drains were cleaned and repassed, many new primary drains were opened, and pumping capacity was increased.

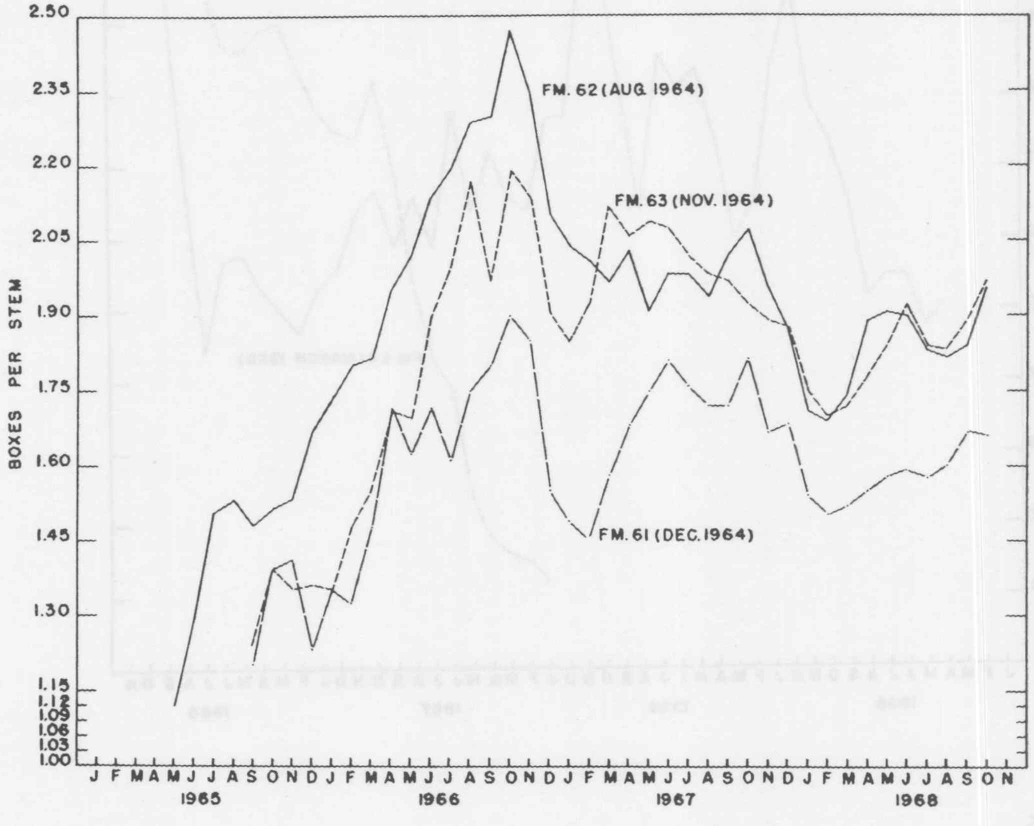

Figure 64

Trends in boxes per stem from 3 farms in Bocas from time of planting.

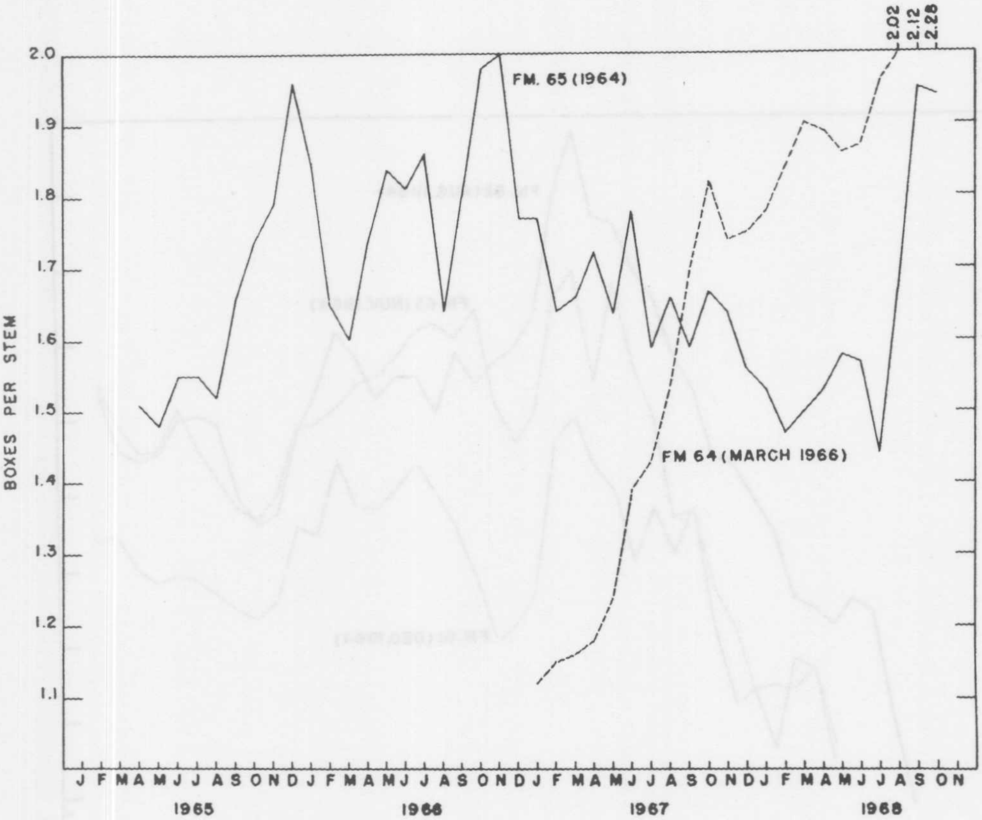

Figure 65
Trends in boxes per stem from 2 farms in Bocas from time of planting. In general, a peak is reached 2-3 years after planting followed by a decline. In 1968 some recovery from the decline occurred.

Table 121

Root Distribution in Different Areas in Relation to Water Table in Bocas

	Percentage of Roots*			
	Above 2 Feet	Below 2 Feet	Below 3 Feet	Water Table Observed
Locations with Better Drainage				
Farm 24, Plot 1	66	34	14	No
Farm 62	57	43	17	No
Farm 61, Bordo	57	43	21	No
Locations with Poorer Drainage				
Farm 24, Plot 8	88	12	1	Yes, $4\frac{1}{2}$ - 5 feet
Cotes	75	25**	0	Yes, $4\frac{1}{2}$ feet
Farm 32	100	0	0	Yes, $3\frac{1}{2}$ feet
Farm 61	95	5	0	Yes, 4 feet

* In an area 6 feet long by 4 feet deep, 4 feet from base of mat.

** New roots recently formed; many remnants of dead roots at 24 to 36 inches.

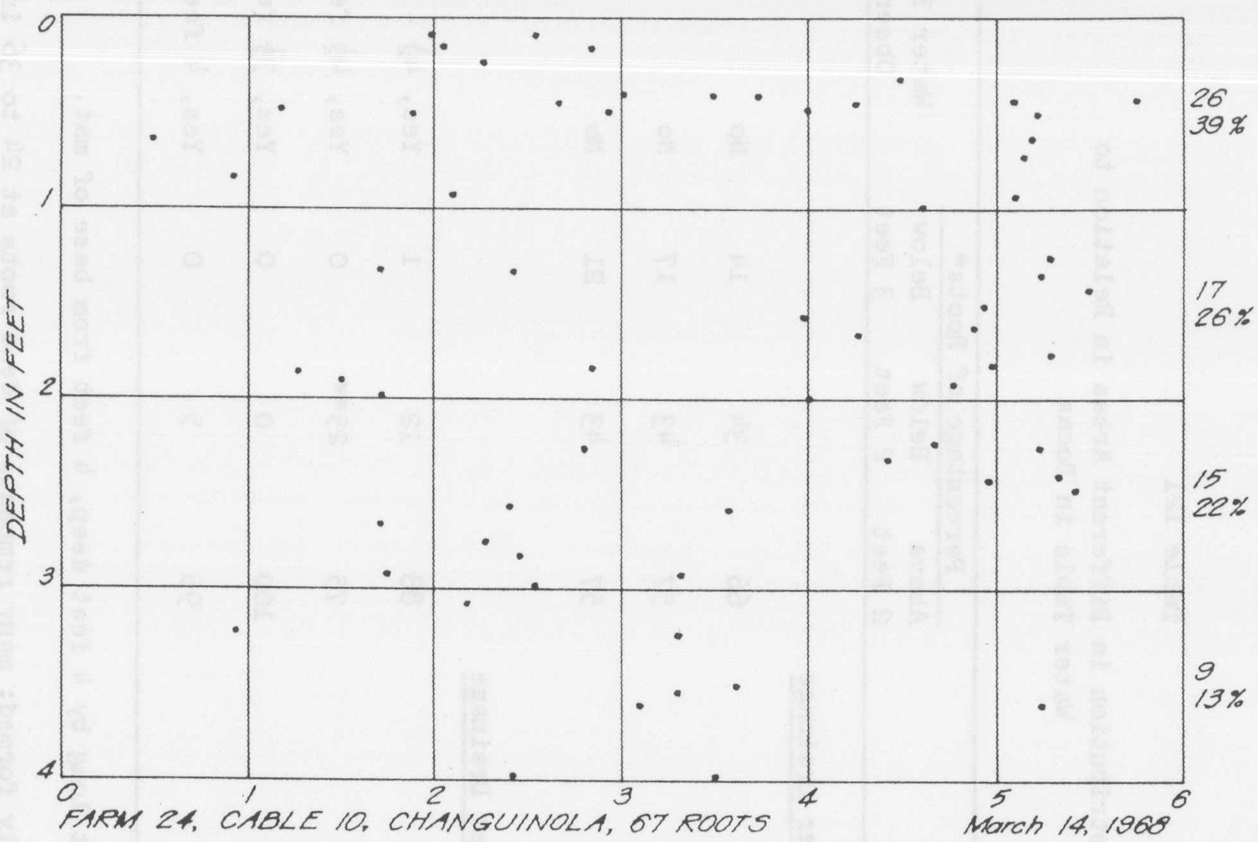

Figure 66

Distribution of roots in a better drained area of Farm 24. Note distribution down to 4 feet.

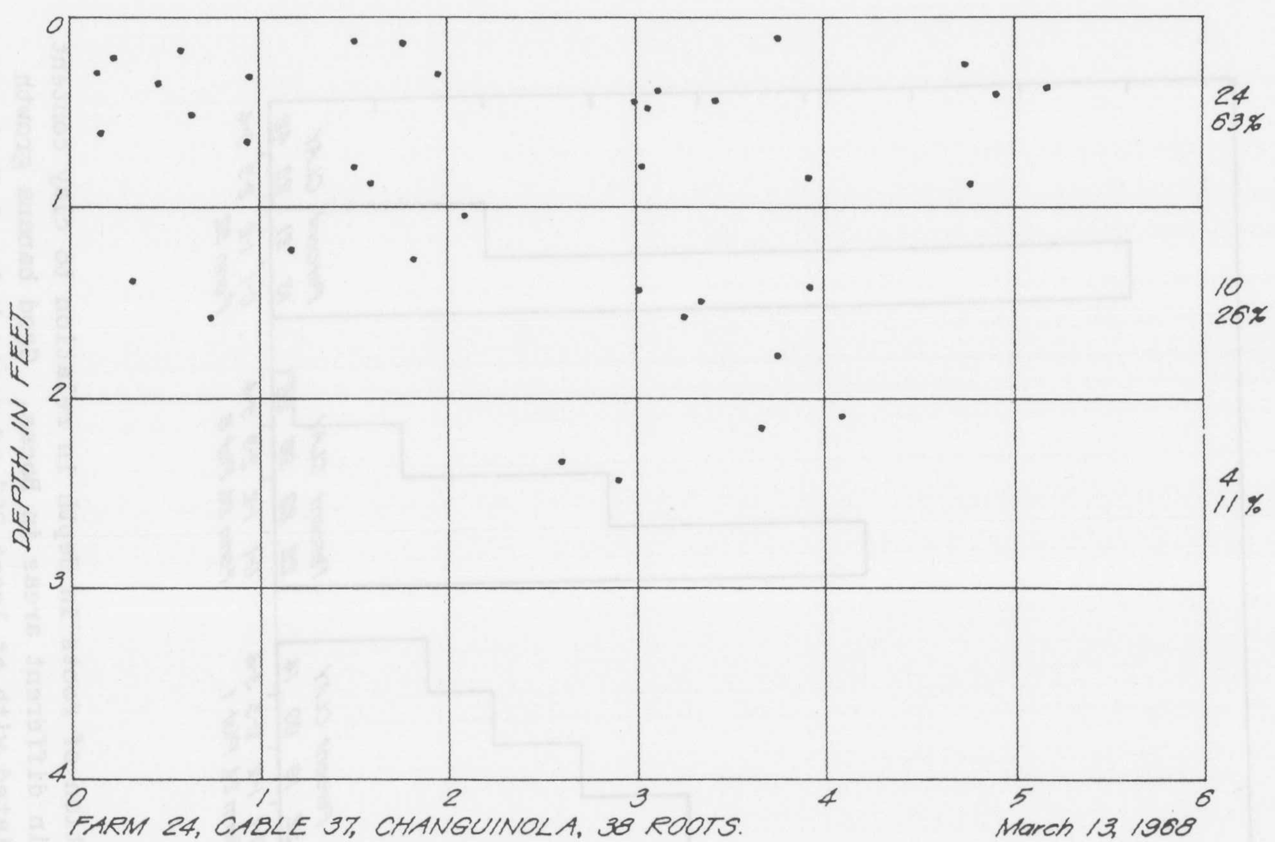

Figure 67
Distribution of roots in a poorer drained area of Farm 24. Note few roots are present below 2 feet.

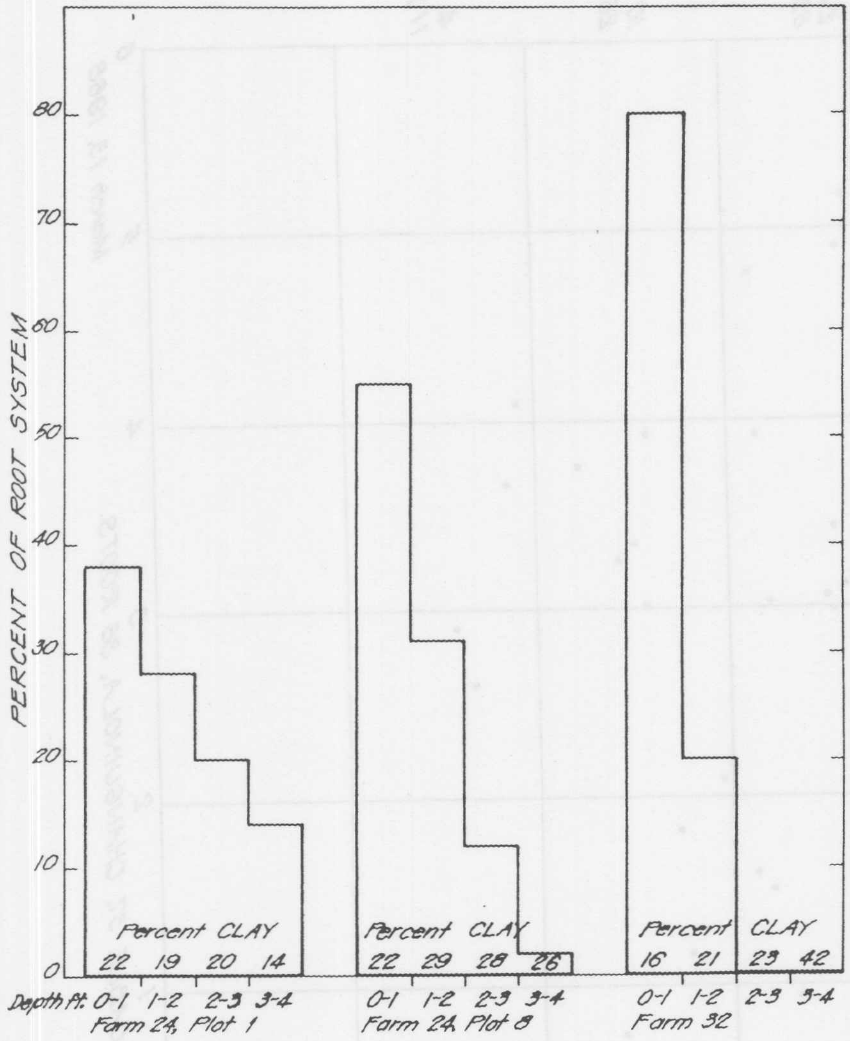

Figure 68

Distribution of roots in depth in relation to clay content of soil in different areas in Bocas. Good banana growth is associated with at least 25% of roots below 2 feet and some roots present between 3 and 4 feet.

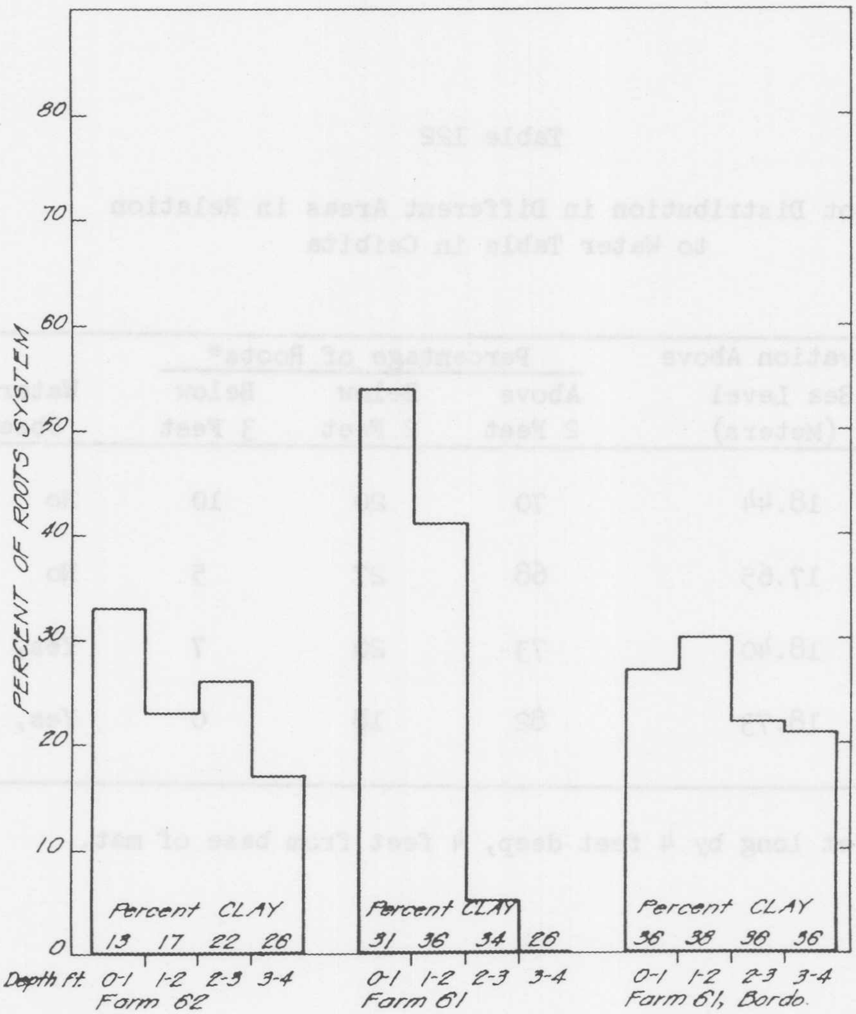

Figure 69
Distribution of roots in depth in relation to clay content of soil in different areas in Bocas. Good banana growth is associated with at least 25% of roots below 2 feet and some roots present between 3 and 4 feet.

Table 122

Root Distribution in Different Areas in Relation to Water Table in Ceibita

Location & Soil Type	Elevation Above Sea Level (Meters)	Percentage of Roots* Above 2 Feet	Below 2 Feet	Below 3 Feet	Water Table Observed
2B - Loam	18.44	70	20	10	No
2A - Clay	17.65	68	27	5	No
2D - Loam	18.40	73	20	7	Yes, 40-50"
2D - Clay	18.73	82	18	0	Yes, 30-36"

* In an area 6 feet long by 4 feet deep, 4 feet from base of mat.

A second series of root observations were made in mid-July, 4 months after the first series. A summary of the data on total roots found at various depths is shown in Table 123. Root numbers increased in all locations since the March survey. There was a great improvement in Plot 8, Farm 24. In March, only 13% of the roots were below 2 feet, whereas 26% were below 2 feet in July. This compares with 35% in Plot 1 at the upper contour level of Farm 24. There has been some improvement but not enough at Farm 61, Cable 34. Only 12% of the roots are below 2 feet compared with 5% in March. Roots of plants growing on the adjacent levee are well distributed down to 4 feet. There has been an increase in root growth in Farm 62 but distribution remains about the same and is adequate down to 4 feet. Root growth has increased in Farm 32 and Finca San Martin (Cotes) but there is very poor distribution below 2 feet (4% in Farm 32 and 16% in San Martin). These areas will require a considerable improvement in soil drainage and aeration if maximum yields are to be obtained.

These studies show that maps of root distribution can be used to indicate drainage efficiency. Maximum yields can only be obtained where considerable root growth occurs in the 2- to 4-foot zone. This amounts to an average of 25% or more of the root system or the presence of some roots between 3 and 4 feet. When this percentage is "pruned off" by a prolonged rise in the water table, future crops will undoubtedly suffer in growth and yield. (STOVER)

Irrigation

To determine the water requirements of VALERY, the following irrigation experiment to be conducted in Sections 44 and 45 of Mopala Farm has been designed:

A. Study of four levels of irrigation applied in two frequencies. Evapotranspiration will dictate how much water should be applied per irrigation but never above the desired levels of the following gross applications:

a,b. 1.0 inch once a week and 0.50 inches twice a week
c,d. 1.75 inches once a week and 0.87 inches twice a week
e,f. 2.50 inches once a week and 1.25 inches twice a week
g,h. 3.25 inches once a week and 1.62 inches twice a week.

B. Study of four levels of irrigation applied when rainfall has permitted evapotranspiration to accumulate and reach those desired levels. These levels are: 1.0, 1.75, 2.50 and 3.25 inches of water (gross applications).

The experiment covers a total area of 23.5 acres of bananas (plantilla) divided in 96 plots (90 x 90 feet). While study "A" has a split plot experimental design, study "B" has a randomized complete block arrangement. Both include eight replications of each treatment. Production and growth (height and diameter) will be evaluated on basis of 50 mats per plot using those mats located at the center of each plot, according to standard procedures used by the Department.

Table 123

Total Roots in Cross Section of Trenches 4' x 3' x 6' at Various Locations - Changuinola

	Farm 24 Cable 10 Plot 1		Farm 24 Cable 37 Plot 8		Farm 61 Cable 34		Farm 61 Bordo		Farm 62 Cable 10		Farm 32 Lake 3		Finca San Martin Cable 11	
No. Holes	4	4	4	4	4	4	1	1	4	4	2	2	2	2
1'	126	(147)	128	(142)	129	(156)	26	(38)	84	(139)	93	(107)	33	(68)
2'	97	(131)	57	(57)	99	(101)	28	(25)	62	(92)	22	(49)	24	(48)
3'	57	(83)	27	(41)	16	(34)	21	(16)	65	(89)	--	(6)	20	(15)
4'	53	(76)	5	(29)	--	(3)	20	(13)	49	(57)	--	(--)	--	(6)
Total	333	(437)	217	(269)	244	(294)	95	(92)	260	(377)	115	(162)	77	(137)

March Survey: Plain.

July Survey: In parentheses.

Farm 32 - Water table at 30-40 inches.

San Martin - Water table at 46 inches.

Farm 61 - Water table at 46 inches.

All cultural practices will be conducted as it is normally done in the Division, with soil fertility assumed to be optimum and soil homogeneity accepted to be present in the area.

Because the enormous quantities of water which growing banana plants transpire are taken from the soil, there is a continuous soil water loss. It is lowest at night and highest sometime after midday, but is not replenished on a daily basis by rain or irrigation; hence, the soil acts as a moisture reservoir for the plants. The capacity of the soil as a moisture reservoir is limited by field capacity (upper limit) and permanent wilting point (lower limit) of the soil in the effective root zone of the banana crop. Since the agronomists need a practical way to measure day-to-day changes of soil water in order to know when this moisture reservoir should be filled up again by irrigation, out of several methods that have been developed the following will be used in Mopala:

A. Methods that depend on the measurement of equilibrium tension between water in a porous ceramic cup and the soil water.

B. Methods that depend on the electrical properties of soils in moisture equilibrium with soil water (conductance or resistance).

C. Methods that depend on neutron scattering.

NOTE: Soil moisture content will be determined by above methods at 6, 12, 24 and 36 inches of depth. Any amount of water reaching over 36 inches of depth will be considered as deep percolation.

To match these methods with the use of a Class A pan or empirical formulas to predict irrigation, a weather station has been located in the center of the experimental site, at canopy level, where daily climatic data, such as temperature, relative humidity, solar radiation, wind speed and rain, will be recorded. The technical information of the irrigation system in use can be summarized as follows: undertree sprinkler system, small revolving head 29B low angle type; at a working pressure of 35 p.s.i. a nozzle of 1/8 diameter discharges 2.62 gallons per minute or 0.20 inches per hour (rate of application); the spacing is 45 x 30 feet having little over 100 percent overlap.

<u>Evaluation of Irrigation Systems</u>. To determine the adequacy of design and operation (essential to successful sprinkler operation), a preliminary comparison was made of Mopala and Copen irrigation systems. The former was designed as small undertree system for conducting an irrigation experiment, while the latter is a converted large overhead to small undertree system now working on a commercial basis.

This preliminary evaluation followed the common practices recommended by the USDA Agriculture Handbook No. 82. Results showed that:

a. For any single irrigation application in Mopala there is at least an 80 percent of uniformity of water application (CU) but it is increased to 85 percent for the irrigation season (these tests were conducted in an open field where banana trees had just been chopped down). On the other hand, Copen showed a 70 percent of CU. This lower value may be the result of intercepting trees found close to sprinkler heads.

b. The test conducted under a moderate wind speed in an open field showed a lower CU value in Mopala but there was no wind under the tree canopy of the banana plantation at Copen. If this remains true, during the year undertree irrigation performance will not be affected by wind.

c. The irrigation system in Mopala has uniformity of intra and inter lines discharge. Differences in the various lines studied are due to individual sprinkler heads rather than to pressure in the pipe system (the Mopala system has DOLE VALVES which control pressure and hence flow). In the Copen system there is no uniformity of inter or intra lines discharge. Close to the pump the sprinkler heads are delivering more water than far away from it where the pressure is lower (5.21, 3.92, 3.55 gallons per minute actual discharge vs. 3.50 gallons per minute catalog discharge). Therefore, the system is not applying the 2.7 inches of irrigation water as it was designed.

d. Because Mopala is a new system there is no leaking as of date, while leaking at the base of the risers and broken springs of the revolving head is common throughout the farm in Copen, where the system is at least five years old.

e. Nozzle pressure test results are uniform in Mopala, while they vary with sprinkler position (seven possible positions) in the sub-lateral line in Copen, the reason being that pressure along the pipe system is decreased with distance because of friction, and Copen does not have DOLE VALVES to control pressure and flow in the sub-lateral lines.

f. Crop damage caused by sprinkling (drop impact, unfavorable jet trajectory or inadequate riser height) is not expected in Mopala where low angle nozzles are in use. In Copen the jet trajectory is unfavorable since it is impinging on fruit or fruit bags (after the stem is protected).

In the final analysis, field tests indicate that there is a difference in water application throughout Copen Farm, while this is not true of Mopala. How this fact is affecting production is not known yet but it must be remembered that uniformity of growth, and hence production, is directly proportional to the uniformity of distribution of the applied water.

Flowmeter Evaluation. A unit set in Mopala was tested to evaluate its performance as a device to measure water flow. Readings were compared to those obtained by field measurements (volumetric in nature).

Results showed that the flowmeter is working as desired, giving accurate readings of water flow.

Santa Rosa Farm. The large overhead irrigation system of this farm was tested to evaluate its design and performance.

1. In Mopala Farm, where it is possible to do so, 30 orifice plates of different sizes and shapes and 38 Rippy LB model old giant sprinklers were calibrated to know their discharge when pressure changed from 80 to 120 p.s.i., in increments of 10 p.s.i., as measured at the base of the riser.

2. At the designed pressure of 105 p.s.i., the average discharge was well over the 500 gpm expected (it was about 540 gpm).

3. At the designed pressure of 105 p.s.i., the radius of throw was less than 200 feet (average of about 180 feet). Wind up to 10-15 miles per hour affected the reach greatly.

4. Higher pressures than 105 p.s.i. do not increase the radius of throw but increase the discharge about 15-20 percent. Hence, this is not the way to solve the problem of the dry triangles.

5. Pressure, as controlled by orifice plates, is well-distributed throughout Santa Rosa Farm. When the sprinklers were placed at the nearest points to the pump, the pressure at the base of the riser varied from 104 to 123 p.s.i. (average discharge of 540 gpm), and when placed at the most distant points to the pump, it was 100 to 112 p.s.i. (average discharge of 560 gpm).

6. The water distribution pattern or uniformity of application of the system and the Rippy LB sprinklers have not been tested yet.

7. The pumping plant at Santa Rosa Farm performed as presumably designed, i.e. 550 gpm with 20 risers irrigating at the same time, or to provide 500 gpm per riser plus 10 percent excess flow. Its efficiency was estimated at about 80 percent which is considered a very good one.

8. Excess of suspended sand and debris was detected in the irrigation water, especially after each flood of River Ulua.

(GUNDERSEN)

POST HARVEST RESEARCH

Polypack

In 1967 various tests indicated that packing VALERY fruit in 0.5 mil polyethylene bags would provide some advantages to the Company as a substitute for both the BANAVAC and slip-sheet packs. These advantages were reviewed in the 1967 Annual Report.

Further testing of various aspects of this pack have continued to improve the quality of our bananas. Commercial shipments of Polypack VALERY have largely replaced the BANAVAC pack to Northern Europe, resulting in a substantial material savings to the Company. Increased amounts of crown rot with Polypack as compared to BANAVAC have been consistently reported, but this can now be controlled with Thiabendazole.

Polypack vs. Slip-Sheet - Two or Three Days at Ambient Temperature. Studies were made to determine whether Polypack would provide advantages in fruit quality above the slip-sheet pack in view of a 2-day holding period at ambient temperature. The Honduras Division was cutting fruit on Saturdays for Monday loading of ships for Tampa and Galveston discharge. Forty boxes each of slip-sheet and Polypack were packed and held at Copen Farm for 3 days. Twenty of each pack were shipped to New York and twenty held in La Lima to simulate New York shipment. Two shipments were made.

In the local tests, 12 of the 40 slip-sheet boxes had R & T fruit after the 9-day period, while 3 of the 40 boxes of Polypack fruit were R & T. The corresponding fruit shipped to New York arrived all green. After ripening, the fruit was rated for crown rot severity and appearance. The results of the rot inspection are shown in Table 124. The after-ripening appearance of Polypack fruit was much better than the slip-sheet fruit and crown rot was significantly less in the Polypack.

Ten-box samples each of slip-sheet and Polypack from two-trial shipments to New Orleans were held at La Lima for evaluation. The fruit was packed and held at ambient temperature for 2 days and then placed in a room at 56° F for 4 days to simulate shipment. The fruit was then ripened for evaluation 12 days after harvest. The evaluation for crown rot is shown in Table 125. Crown rot in either pack was not objectionable but crown condition was significantly improved in the Polypack lot. The Polypack fruit had a fresher appearance than the slip-sheet pack.

Project 83 - Commercial Shipments Comparing Polypack and Slip-Sheet Packs of VALERY Bananas. Three shipments of 1000 boxes each of VALERY fruit in Polypack compared with slip-sheet pack were sent from Golfito to Seattle.

Table 124

Severity of Crown Rot in Polypack and Slip-Sheet Packed VALERY Fruit Held 3 Days at Ambient Temperature Before Shipment

	# of	Severity of Crown Rot (% of Clusters)				
Treatment	Clusters	None	Trace	Light	Medium	Severe
			Shipment #1			
Slip-sheet	249	2.0	36.9	50.6	8.0	2.5
Polypack	254	16.9	60.6	22.1	-	0.4
			Shipment #2			
Polypack	110	38.2	55.4	6.4	0.0	0.0
Slip-sheet	107	18.7	58.9	21.5	0.9	0.0

Table 125

Severity of Crown Rot in VALERY Fruit in Polypack and Slip-Sheet Packs Held 2 Days at Ambient Temperature Prior to Shipment

Treatment	# of Clusters	Severity of Crown Rot (% of Clusters) None	Trace	Light	M + S
		Shipment #1			
Polypack	115	29.6	67.8	2.6	0
Slip-sheet	104	19.2	64.4	16.4	0
		Shipment #2			
Polypack	53	37.7	60.3	2.0	0
Slip-sheet	55	14.5	63.6	21.9	0

A summary of the results of these shipments was as follows:

<u>At discharge</u>:

1) Pulp temperatures were higher in the Polypack. This was unavoidable with the small amount of Polypack fruit shipped and mixed with the slip-sheet pack. Temperature controls were set for carrying slip-sheet, whereas Polypack should be carried like BANAVAC.

2) The percentage of ripes and turnings was higher in the Polypack than the slip-sheet pack (2.3% vs. 1.3%). This was probably a reflection of the higher pulp temperatures during shipping.

<u>After ripening</u>:

1) The average weight loss per box from time of packing in Polypack was 1/3 that of the slip-sheet pack.

2) After ripening the color index was higher in Polypack than slip-sheet. This was the result of ripening the two packs together in the same room, where proper ripening requires lower temperatures with Polypack.

3) Split peel was reported to be higher in Polypack but again this result was likely due to too high a ripening temperature.

4) There were no differences in the two packs reported for crown rot, scarring, latex stain or quality score, despite the unfavorable shipping and ripening conditions for Polypack.

<u>Project 83 - Amendment 1 - Comparison of Polypack and Slip-Sheet Packed VALERY and Gros Michel (Cocos) Bananas from Golfito to New York</u>. The purpose of this project was to determine the response of Gros Michel (Cocos) to shipment in Polypack compared with VALERY.

The results of four shipments of 100 boxes each were summarized as follows:

1) At discharge the incidence of ripes and turnings was no different in the two packs.

2) Pulp temperatures at discharge were the same between the two packs, but pulp temperatures were higher in Polypack during ripening.

3) Weight loss during ripening was 2 times greater in the slip-sheet pack than in Polypack.

4) Latex stain, crown rot, neck rot and pitting disease were the same between packs.

5) Fruit scarring was less in Polypack than slip-sheet pack.

6) The quality score was higher in Polypack than the slip-sheet pack.

The conclusions of this project were that Gros Michel/Cocos and VALERY fruit could be shipped successfully to the U. S. in Polypack and that the fruit quality and quality score after ripening would be higher in Polypack.

Project 83 - Amendment 2 - Effect of Alum on Latex Stain in Polypack and Slip-Sheet Packs. Four shipments were made of this project from Golfito to the East Coast with both Gros Michel/Cocos and VALERY fruit. A summary of the differences in latex stain found on the fruit with and without the 1% alum treatment packed with slip-sheets and Polypack is shown in Table 126.

The conclusions from these shipments were that alum treatment significantly reduced latex stain of both VALERY and Gros Michel/Cocos in both packs. Latex staining was 4-5 times greater on non-treated Gros Michel/ Cocos than non-treated VALERY fruit. The alum treatment was more effective in reducing latex staining in Polypack than the slip-sheet pack. When no alum was used, clusters of fruit on the bottom layer of the box contained significantly more latex stain than those in the top layer, but the difference disappeared with the use of alum.

On the basis of these tests, alum treatment was recommended for all boxed bananas to reduce latex stain.

Project 83 - Amendment 3 - Effect of 1% Alum Treatment on Latex Stain in Polypack vs. No Treatment in the Slip-Sheet Pack. Seven commercial shipments of VALERY in Polypack were made to New Orleans and Baltimore from Honduras to compare alum-treated Polypack with untreated slip-sheet fruit. Quality control discharge and ripe inspections were made to compare the severity of latex stain as well as other quality factors between the two lots.

The data obtained from these shipments showed that latex stain was less frequent and less severe on alum-treated fruit in Polypack than on untreated fruit in the slip-sheet pack. As reported in other shipments, weight loss, crown rot and scarring were less in Polypack than in the slip-sheet pack. General appearance of alum-treated fruit in Polypack was superior to fruit in the slip-sheet pack and the Polypack fruit was fresher than slip-sheet fruit.

Project 85 - Polypack vs. Slip-Sheet for Turbo Boxed Gros Michel to Europe. Results of shipments of Gros Michel bananas in Polypack from Golfito to the East and West coasts indicated that fruit should carry to

Table 126

Effect of Alum Treatment on Latex Staining of Gros Michel/Cocos and VALERY Fruit in Polypack and Slip-Sheet Packs (Sq. In. of Latex Stain/100 Clusters)

	Gros Michel/Cocos		VALERY	
	Slip-Sheet	Polypack	Slip-Sheet	Polypack
No Alum	190	256	49	46
1% Alum	15	6	13	4
	Top Layer	Bottom Layer	Top Layer	Bottom Laye
No Alum	98	329	32	63
1% Alum	10	11	9	8

Europe in good condition with reduced weight loss and improved quality. Three shipments of 800 boxes each of Polypack and slip-sheet were made from Turbo to Rotterdam, Holland for evaluation.

The results of these shipments were summarized as follows:

1) Polypack provided a reduction in fruit scarring over slip-sheets.

2) Less latex staining is present in Polypack than the slip-sheet pack.

3) Weight loss during shipping and ripening was significantly less in Polypack.

4) The quality score for the fruit was higher with Polypack than the slip-sheet pack.

5) There was no difference in the incidence of crown rot, neck rot or pitting disease between the two packs.

As a result of these shipments, it was concluded that Gros Michel from Turbo could be successfully shipped to Europe and that all Turbo boxes should be converted to Polypack with 1% alum treatment.

Project #78 - Polypack vs. BANAVAC Shipments of VALERY Bananas to Europe. Experimental results with fruit packed in Polypack and held in Honduras under conditions simulating shipment and experimental shipments made from Honduras to Weehawken indicated that VALERY fruit could be shipped satisfactorily to Europe in this pack. The pack would eliminate the abnormally soft green fruit which occurs in the BANAVAC pack and would still provide similar reduction in weight loss and scarring. The Polypack pack would reduce the cost per box by approximately four cents.

The significant findings of 5 shipments of 500 boxes each of Polypack and BANAVAC to Europe were as follows: At discharge, 1) ripes and turnings were the same in both packs, 2) there was no abnormally soft green fruit in Polypack, 3) crown rot and neck rot were more frequent in Polypack. After ripening, 1) crown rot, neck rot and latex stain were higher in Polypack, 2) finger rot was more prevalent in BANAVAC, 3) the quality score of BANAVAC and Polypack was the same. (WOODRUFF, MILLENSTED)

Latex Stain Control

Effects of Buffers and Organic Acids on the Control of Latex Discoloration. The exudation of latex from green bananas and its subsequent discoloration has been the subject of much investigation. It was found that Carbowax would coagulate latex, and the coagulated latex remained as a white precipitate. However, Carbowax was not very effective in commercial trial. Acids such as acetic and hydrochloric controlled latex discoloration but acetic acid turned the peel black, and hydrochloric acid burned the bananas. A method was needed so that the pH could be kept constant, even if concentration of the chemical occurred due to evaporation of water from the solution A buffered product should be effective. Some preliminary work with buffers indicated that a concentration of 0.2 M was not toxic. Also, a pH around 3 did not burn the bananas.

To determine the effects of buffers, organic acids and other compounds on latex discoloration and their toxicity to bananas, the following trial was made. Green fingers were cut shallowly on one side so that latex would exude. The fingers were then placed in water and delatexed for 20 minutes. They were dipped in one of the test solutions listed below and placed on a plastic-covered table with the cut surface in contact with the plastic. The fingers were left in contact with the plastic 2 days and then turned over so the cut surface and latex were exposed to the air. After 2 more days, the fingers were evaluated for latex stain. The results are presented in Table 127.

In the buffer group, treatments at a pH range of 2.5 to 3.5 worked very well. When a combination of buffer and Carbowax treatment was used, there were no differences observed in control of latex discoloration when this group was compared to the buffer treatment alone. In the organic acid group citric acid gave good results with regard to prevention of latex discoloration. However, there was some burning of the fingers with citric acid. The other organic acids had some effect on the prevention of discoloration, but this group was definitely less effective in preventing discoloration than the buffers.

The other miscellaneous compounds were not effective in reducing latex discoloration. Sodium EDTA was used to chelate any iron which was in the solution so that the discoloration would not be due to an iron-latex reactio however, this treatment was very discolored.

<u>Effect of Alum on Latex Discoloration</u>. It was postulated that alum cou control latex discoloration since alum solutions also have a low pH. To tes whether alum could be effective in control of latex discoloration, bananas were treated with 2% alum, water or 2% Carbowax 6000 after delatexing. The bananas were packed in clysar shrink film and brought to La Lima for ripenin The bananas were then evaluated for latex discoloration (Table 128).

The pH of the alum solution was 3.5. Alum was much more effective than the other two treatments in controlling latex discoloration. The results obtained were not quite as good as those obtained previously using phosphate buffer; however, alum would be much easier to use. Supervision of the use of alum would be easier than for phosphate buffer and the safety precautions would be less involved.

Table 127

Effects of Various Chemicals on Control of Latex Discoloration

eatment Solution	Concentration	pH	Results
O_4-KH_2PO_4 buffer	0.2 M	1.7	Complete control of latex discoloration; fingers burned.
O_4-KH_2PO_4 buffer	0.2 M	2.1	Complete control of latex discoloration. Small amounts of burn on fingers.
O_4-KH_2PO_4 buffer	0.2 M	2.5	Complete control of latex discoloration. No burning on fingers.
O_4-KH_2PO_4 buffer	0.2 M	3.1	Complete control of latex discoloration. No burning on fingers.
O_4-KH_2PO_4 buffer	0.2 M	3.5	Complete control of latex discoloration. Very slight burning on fingers.
-KH_2PO_4 buffer	0.2 M	2.5	Complete control of discoloration. No burning on fingers.
ric acid	1.0 M	1.6	Complete control of discoloration. Small amount of burning on fingers.
ric acid	0.2 M	2.2	Complete control of discoloration. Small amount of burning on fingers.
ric acid	Sufficient for desired pH	3.0	Complete control of discoloration; severe burning on fingers.
orbic acid	"	2.5	Slight control of discoloration; no burning.
orbic acid	"	3.2	Slight control of discoloration; slight burning on fingers.
aric acid	"	2.5	Slight effect on discoloration. No burning on fingers.
loacetic acid	"	2.5	Slight effect on discoloration. No burning on fingers.
toglutaric acid	"	2.5	Slight effect on discoloration. No burning on fingers.
taric acid	"	2.5	No effect.

Continued on next page...

Table 127 Cont.

Treatment Solution	Concentration	pH	Results
H_3PO_4-KH_2PO_4 + 1% Carbowax	0.2 M	2.5	Complete control of discoloration. No burning.
H_3PO_4-KH_2PO_4 + 1% Carbowax	0.2 M	3.1	Complete control of discoloration. No burns.
Citric Acid + 1% Carbowax	0.2 M	2.2	Complete control of discoloration. No burns.
Carbowax	2%	7.0	Good control of discoloration. No burning.
Sodium EDTA	1%	6.4	No control.
Nabam	1%	5.5	No control; severe burns.
$NaHSO_3$	1%	3.5	Slight reduction of discoloration. Small burning on fingers.
Tris buffer	0.1 M	10.5	No control.
Control		7.0	Very dark discoloration.

Table 128

Comparison of Ammonium Alum, Water and Carbowax on the Control of Latex Discoloration

	Percentage Clusters Affected by Latex Stain					
Treatment	None	Trace	Light	Medium	Severe	M + S
Alum	61.9	26.1	8.3	1.1	2.3	3.4
Water	28.7	21.2	21.2	15.1	13.6	18.7
Carbowax	37.5	31.2	21.8	3.1	6.2	9.3

Evaluation of Sodium Phosphate and Alum for Chemical Control of Late Discoloration. Potassium phosphate was used initially as one component o the buffer solution. It was found that potassium phosphate is available as technical grade material which is quite expensive. The purpose of thi evaluation was to determine if other cheaper materials would work to prev latex discoloration. Alum is relatively cheap. Sodium phosphate is avai able as food grade material and is also rather cheap.

Monobasic sodium phosphate and dibasic sodium phosphate at a pH of 2 were compared with 2% alum and water only for the control of latex stain (Table 129). The solutions were sprayed on the bananas with a knapsack sprayer just prior to packaging. The bananas were packed in Polypack and ripened.

Alum at a concentration of 2% did not work as well as the buffer tre ments. Both monosodium and disodium phosphate were effective in controll latex discoloration. The material cost of the buffer treatments would be from $0.05 to $0.07 per 100 boxes.

Latex Stain Control with Buffers at Different Hydrogen Ion Concentra tions. Five boxes of bananas were sprayed with each of the following sol tions. The bananas were packaged in Polypack and brought to La Lima for ripening. The treatments were monobasic sodium phosphate-phosphoric acid at a concentration of 0.1 molar and a pH range of 3.5 to 4.75 in incremen of 0.25 pH units and monobasic sodium phosphate-dibasic sodium phosphate a concentration of 0.1 molar and a pH range of 5.0 to 5.5 in increments o 0.25 pH units. After ripening, the bananas were scored for severity of latex stain.

The optimum pH was 3.5 or below (Table 130). Previous evaluations h shown that a pH of 2.5 was very satisfactory and generally, a pH above 4. seemed to be less effective in preventing discoloration of latex. The da indicated that there was a difference in latex discoloration control betw a pH of 4.25 and 4.5. The percentages of none and trace ratings dropped several points, while the percentages of medium and severe ratings increa slightly. There was a definite improvement between every treatment and t control. (JONES)

Latex Stain Control - Carbowax 6000 - In Automatic Spray System. Fo the purpose of testing latex stain control procedures on a more practical basis, a spraying device was installed on one line at Copen station. Fiv spray nozzles were installed above the roller conveyor such that all the fruit in the tray received treatment. The fruit was sprayed in the trays after weighing and just before packing so that the fruit was packed very wet. The excess solution drained to a reservoir for recirculation. Each tray of fruit was left under the spray until the weigher completed weighi

Table 129

Comparison of Monobasic and Dibasic Sodium Phosphate Buffer with Alum on Control of Latex Discoloration

Treatment	Percentage Clusters Affected by Latex Stain					
	None	Trace	Light	Medium	Severe	M + S
A. NaH_2PO_4-H_3PO_4	71.6	22.2	6.2	0	0	0
B. Na_2HPO_4-H_3PO_4	72.0	22.2	6.2	0	0	0
C. Alum	59.5	31.6	3.8	3.8	1.3	5.1
D. Water	33.3	37.5	11.5	8.3	9.4	17.7

Table 130

The Effect of Varied pH Ranges on the Control of Latex Discoloration

	Percentage of Clusters						
Treatment	None	Trace	Light	Medium	Severe	N + T	M +
Monosodium phosphate-phosphoric acid							
pH 3.5	25	75				100	0
3.75	29	60	8	1.5	1.5	89	3
4.0	17	64	10	5	4	81	9
4.25	26	55	9	5	5	81	10
4.5	8	63	18	6	5	71	11
4.75	24	52	15	2	7	76	9
Monosodium phosphate-disodium phosphate							
5.0	2	68	17	11	2	70	13
5.25	8	67	13	3	9	75	12
5.5	5	54	25	11	5	59	16
Control	4	29	24	12	31	33	43

another tray of fruit. It was then pushed out and replaced with the newly-weighed tray of fruit. Each tray of fruit received the spray for ½-1 minute.

Carbowax 6000 at 2.0% was tested initially with the system. Thirty gallons of solution was used for 4½ hours with approximately 500 boxes being treated. The concentration of Carbowax in the solution was 1.6% after 4½ hours. The results of the evaluation of latex staining from sample boxes of fruit taken during the treatment period are shown in Table 131. The effectiveness of the Carbowax treatment was enhanced by the spray system above that which was observed with dip treatments. (WOODRUFF)

<u>Latex Stain Control - Buffer - In Automatic Spray System</u>. In order to evaluate the control of latex discoloration with a buffered solution in the automatic recirculating spray system, all bananas were treated just after weighing and just prior to packing. The bananas were packed in Polypack and brought to La Lima for ripening. After ripening, the bananas were scored for latex stain (Table 132). The buffer-treated bananas exhibited extremely low latex discoloration. The bananas which were treated with water just prior to packing exhibited a higher degree of latex stain than the control group.

<u>Latex Stain Control - Phosphate Buffer</u>. A 0.1 M phosphoric acid-dipotassium phosphate buffer was tested under semi-commercial conditions at Copen Farm with a recirculating in-line spray system to determine how much fruit could be treated effectively with a given amount of material. Twenty gallons of material was used to treat about 250 boxes of fruit and the pH of the solution was followed at 30-minute intervals. Sample boxes of fruit were also taken at the 30-minute time intervals, and held in La Lima for evaluation. The same system was used to treat boxes of fruit with 2.0% Carbowax 6000 for comparison. All the fruit were packed in Polypack.

Shown below are the pH changes of the buffer solution which occurred during fruit treatment:

Time (Hrs.):	0	½	1	1½	2	2½
pH:	2.6	2.9	3.1	3.2	3.4	3.6

The fruit was held in storage 5 days at 56° F and then ripened. The evaluation of latex staining after fruit ripening is shown in Table 133. The buffer treatment in this test gave excellent control of latex staining. Latex, when present, was nearly transparent and, therefore, not objectionable. Carbowax reduced latex staining but to a lesser degree than the buffer solution.

<u>Manebs and Phosphate Buffer</u>. With the outstanding results obtained in reducing latex stain with 0.1 M phosphate-phosphoric acid buffers, a test was conducted using buffer together with UF-63, since this material is used

Table 131

Severity of Latex Stain in Slip-Sheet Packed VALERY Bananas
Sprayed with 2.0% Carbowax 6000

Treatment	Severity of Latex Staining (% of Clusters)			# of
	None + Trace	Light	Medium + Severe	Cluste
2.0% Carbowax 6000 Spray	95.2	1.0	3.8	104
Control (Untreated)	76.7	12.1	11.2	116

Table 132

Comparison of Phosphate Buffer and Water Spray on Reduction of Latex Discoloration

	Severity of Latex Discoloration (% of Clusters)						
Treatment	None	Trace	Light	Medium	Severe	N + T	M + S
Buffer	86.3	10.7	1.5	0.8	0.7	97.0	1.5
Water	46.1	24.4	7.8	7.8	13.9	70.5	21.7
Control	44.8	28.6	15.2	2.8	8.6	73.4	11.4

Table 133

Severity of Latex Stain in Polypack VALERY Bananas
Treated with Carbowax and Phosphate Buffer

	Severity of Latex Stain (% of Clusters)			# of
Treatment	None + Trace	Light	Medium + Severe	Cluster
Control	57.0	23.4	19.6	107
2.0% Carbowax 6000	86.9	7.9	5.2	117
0.1 M Phosphate Buffer	97.4	2.6	0.0	145