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PARASITIC AND OTHER FUSARIA COUNTED IN TROPICAL SOILS

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With 2 figures in the text.

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Contents.

I. Introduction.

A detailed study and identification of various parasitic and saprophytic fusaria found in soil and on plants in the tropical Caribbean region has been made (2) (4). No investigation on the relative number and distribution of these fusaria as they occurred in tropical soil types had been made up to the time of the present study. An understanding of this relationship is important in the study of soil or supposed soil fusaria that are the cause of wilts and rots or decays. The parasitic nature of some of the types discussed in the present paper has been established by investigations in various parts of the world. —

As pointed out by WAKSMAN (7), it is important in a study of the various soil fusaria, from a standpoint of disease production, to know what fungi are true soil organisms and what fungi are merely occasional invaders. It is also important to know whether they are limited to certain areas or are wide spread and whether the types present in one soil are also common in other soils or are of local character. Certain bacteria have been found to be more abundant in alkaline soils than in acid soils. This and other relationships have been determined for bacteria and some fungi (10). It is to be presumed that soil fungi may also be influenced by the type of soil, composition of soil, climate, presence of host for known pathogens and possibly other factors that might have a bearing on their abundance and distribution.

WAKSMAN (8) (9) (10), and WAKSMAN and STARKEY (11) have summarized data on the relation of soil environment to plant infection and fungus growth. The factors that they cite as most important from an infection standpoint are temperature, moisture, reaction, and composition. WAKSMAN (10) states that "These soil environmental factors may determine not only the geographical distribution of the disease, but also its seasonal severity". WAKSMAN and STARKEY (11) further point out that the soil is very complex where chemical, physical, and biological factors are active. Any influence which tends to disturb this adjustment in the soil condition alters these processes. A change in soil reaction, addition of inorganic fertilizers, introduction of organic substances, change of temperature, moisture, pressure, and air movements may affect the numbers and activities of microorganisms in the soil. The composition of the soil microbial population is, therefore, a resultant of numerous factors. RUSSELL (5) indicated that the type of soil and its treatment exercised a great influence over the number of fungi present. — A discussion of the literature on the occurrence and activities of the soil fungi in the temperate zone has been fully covered by other investigators (6) (7) (10) (11). In so far as the writers have been able to ascertain no detailed investigations have been made on the number and distribution of fusaria in different tropical soil types.

The object of the present investigation was to determine the relative number and distribution of parasitic and saprophytic fusaria in various soil types in Honduras and Guatemala in order to ascertain whether these fusaria varied according to the different soil types and climatic conditions; and to determine which of the fusaria were true soil organisms and which were merely soil invaders. — The studies were conducted, along with related investigations, from December, 1930 to November, 1932 in the Tela, Honduras, and in the San Jose (Los Angeles) and Tiquisate West Coast of Guatemala regions of Central America.

II. Materials and Methods.

1. Description and Classification of Areas Sampled[1].

General descriptions and locations of the fifteen areas comprising this report are as follows:

1. *Guaymas Peat.* This is a soil of marsh formation occurring near Progreso, Honduras, with successive layers of peat and clay, the top layer of peat being from 0 to 3″[2] in depth. A heavy clay occurs from

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[1] The writers are indebted to W. W. PATE, G. W. VOLK, and M. H. GALLATIN, soil chemists of the United Fruit Company at Tela, Honduras, for the descriptions and analyses of soils herein reported.

[2] ″ = inches.

3″ to 7″, the mechanical analysis showing it to be composed of 10% sand, 5% silt, and 85% clay. From 7″ to 8″ the peat again occurs, and from 8″ to 18″ is another layer of clay analyzing 37% sand, 25% silt, and 38% clay. From 18″ to 21″ occurs a very fine sand containing 82% sand, 7% silt, and 11% clay, while from 21″ to 40″ is a sandy clay composed of 51% sand, 17% silt, and 32% clay. The average for the p_H was 4.2, the range being from 3.8 to 4.5. Two areas were sampled on this soil type. Drainage here is poor, the water table on one area being at 18″, but none being found on the other down to 36″.

2. *Guaymas Very Fine Sandy Loam.* This is a soil from Lancetilla valley near Tela, Honduras, and is typical of valley formations which are derived from outwash and alluvial material. The soil from 0 to 9″ is a very fine sandy loam averaging about p_H 5.8 and containing 68% sand, 14% silt, and 18% clay. From 9″ to 15″ the soil is a very fine sand composed of 88% sand, 6% silt, and 6% clay. The soil at the time of sampling was moist, but no water table was noticeable within 48″.

3. *Guaymas Clay*—34%. This is a soil taken from San Alejo Valley near Tela, Honduras, and is composed of a mixture of outwash material from the nearby hills and alluvial material deposited by short, small creeks. It is a very young soil, as shown by the presence of mica and other non-decomposed rock material. From 0 to 14″ the soil is composed on an average of 46% sand, 20% silt, and 34% clay, while from 14″ to 27″ it is a fine sandy loam averaging 79%, 8%, and 13% respectively of sand, silt, and clay. The p_H of this soil ranges from 5.0 to 5.5. At the time of sampling, the surface was quite wet due to recent rains, and the subsoil was moist, the water table being at 50″.

4. *Guaymas Clay*—41%. Two areas were sampled on this soil type, these two being about 600 feet from the Guaymas light clay and of the same derivation, but of heavier texture. From 0 to 16″ the soil is a clay composed on an average of 30% sand, 29% silt, and 41% clay. From 16″ to 40″ the soil is heavier, the average analysis being 38% sand, 20% silt, and 42% clay. The soil at the surface averages p_H 5.2. At the time of sampling, the water table in the first area sampled was at about 22″ due to recent heavy rains, the soil samples, even on the surface, being quite moist. At the time the second area was sampled, however, no water table was noticeable down to 30″, but the soil samples were moist.

5. *Quebrada Seca Clay*—37%. This soil is found near Progreso, Honduras, and is a mixture of outwash material from the Mico Quemado Mountains and alluvial deposit from the Ulua River. From 0 to 7″ the soil, on an average, is composed of 43% sand, 20% silt, and 37% clay, while from 7″ to 15″ the soil is a sandy clay composed on an average of 50%, 11%, and 39% respectively of sand, silt, and clay. Again at 15″

to 21″ clay occurs, composed of 46% sand, 12% silt, and 42% clay, while from 21″ to 40″ a sandy clay is found which is made of 60% sand, 8% silt, and 32% clay. The p_H of the surface soil averages about p_H 7.2. At the time of sampling, the surface soil was friable and dry, but the subsoil was dry and hard.

6. *Quebrada Seca Fine Sand.* This area was taken about 250 feet from the Quebrada Seca clay and is of the same origin and received the

Fig. 1. Area measured prior to taking twenty-five surface samples.

same cultural treatment as that area. From 0 to 15″ the soil is a fine sand made up of 85% sand, 5% silt, and 10% clay, while from 15″ to 40″ the soil is composed of 65% sand, 10% silt, and 25% clay. The p_H for the surface soil averaged p_H 6.9. At the time of sampling, the soil was dry and compact with a water table at 36″.

7. *Progreso Sandy Clay Loam.* This area is near Rancheria, Honduras, and is a soil of alluvial deposit of the Ulua River which has been brought down from the semi-arid interior. There were three areas sampled here, two of them being adjacent to each other, and the third

about one mile away. The average texture is 54% sand, 23% silt, and 23% clay for the soil from 0 to 8″, with an average texture of 45% sand, 22% silt, and 33% clay for the soil between 8″ and 16″, while the soil between 16″ and 40″ is composed of 39% sand, 28% silt, and 38% clay. The average p_H for these soils was 7.8. At the time of sampling, the soils were moist, but there was no water table down to 40″.

8. *Progreso Clay*—33%. This is also an alluvial soil found near

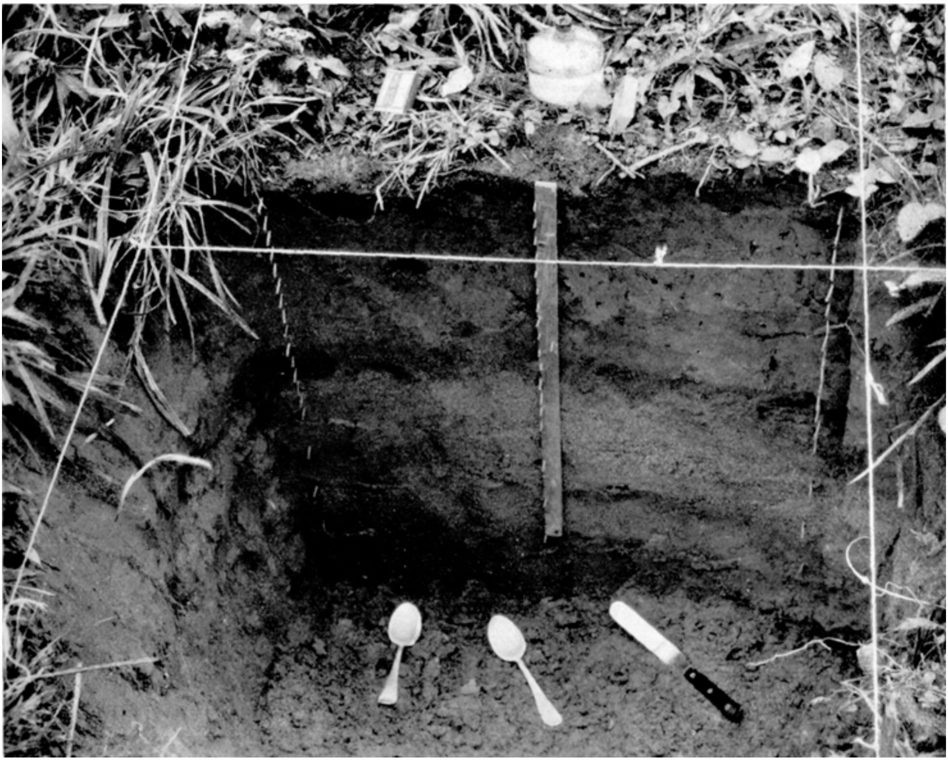

Fig. 2. Technique used in taking depth samples down to twenty-four inches.

Rancheria, Honduras, and deposited by the Ulua River. From 0 to 10″ the soil is composed of 40% sand, 27% silt, and 33% clay. From 10″ to 24″ the soil contained 34% sand, 29% silt, and 37% clay. The p_H for the surface soil was 7.7. At the time of sampling, the soil was moist, but no water table was noticeable down to 40″.

9. *Progreso Clay*—46%. This soil, of which three sampled areas comprise a group, is found near Rancheria, Honduras, and was deposited by the Ulua River. From 0 to 17″ the soil averaged 22% sand, 32% silt, and 46% clay, while the texture is 23% sand, 30% silt, and 47% clay

for the layer of soil between 17″ and 42″. The average p_H for these areas is p_H 7.7. At the time of sampling one area (Progreso Clay—46%, b), only the surface samples were taken due to the high water table; at the time the depth samples of this area and Progreso Clay—46%, c, were taken, the soil was in a moist condition with a water table at 36″.

10. *Los Angeles Clay*—39%. *Fallowed Area.* This soil is of alluvial deposit from the Rio Guacalate, the sample being taken near San Jose (Los Angeles), Guatemala. From 0 to 12″ the soil is composed of 47% sand, 14% silt, and 39% clay, while from 12″ to 15″ it is composed of 60% sand, 14% silt, and 26% clay. The soil between 15″ and 23″ is composed of 69% sand, 13% silt, and 18% clay. It will be noted here that the surface soil, although classed as a clay, has a very high per cent of sand. The p_H for this soil is 6.4. In 1929 the area was cleared of all vegetation and had been kept in a fallowed condition up to the date of sampling, at which time the soil was moist and in good condition.

11. *Los Angeles Clay*—39%. This area was taken about 200 feet from the above sample. From 0 to 14″ the soil is composed of 48% sand, 13% silt, and 39% clay, while from 14″ to 20″ the soil is composed of 70% sand, 11% silt, and 19% clay; between 20″ and 32″ it is composed of 82% sand, 8% silt, and 10% clay. The p_H for the surface soil was 6.6. At the time of sampling, the surface soil was dry and hard, while the subsoil was dry, but loose. The area was in direct contrast to the fallowed area as regards moisture, in that it was dry while the other was moist.

12. *Los Angeles Clay*—41%. This soil is also an alluvial deposit of the Rio Guacalate and is about one-half of a mile from the above two areas. The surface soil analyzed around 41% clay The p_H of the soil surface was 6.7. No water table was noticed down to 30″.

13. *Tiquisate Sandy Clay.* This soil is a black, light type of volcanic origin and was taken near La Maquina, Guatemala. From 0 to 12″ the soil is composed of 53% sand, 15% silt, and 32% clay, while from 12″ to 24″ the analysis showed 59% sand, 6% silt, and 35% clay to be present. The p_H was approximately 7.2. At the time of sampling, the soil was moist, but no water table was found down to 36″.

14. *Tiquisate Sandy Clay Loam.* This is a black, loose, light soil of volcanic origin. The sample was taken at Tiquisate, Guatemala. From 0 to 16″ the soil is composed of 63% sand, 12% silt, and 25% clay; from 16″ to 26″ the soil is composed of 79% sand, 8% silt, and 13% clay. The p_H of this soil was 7.3. The soil was moist, but no water table could be determined down to 40″.

15. *Nagualate Very Fine Sandy Loam.* This is an alluvial soil occurring three kilometers from the beach at Concepcion del Mar, Guatemala, being deposited mostly by the Nagualate River and by the Madre

Viejo River. The surface soil of this area is a very fine sandy loam. Two areas were sampled in the soil type, the average p_H of the two being 7.8. At the time of sampling, the soil of both areas was dry and powdery. These two areas, as well as the other areas sampled in Guatemala, represent a semi-arid type of land with a long dry season.

All soil types sampled were in areas with wilt diseased bananas exept the following: Los Angeles Clay—39%, Fallowed Area; Tiquisate Sandy Clay Loam; areas "a" and "b" in Nagualate Very Fine Sandy Loam; and area "c" in Progreso Clay—46%. The Los Angeles Clay—39%, Fallowed Area, had been in diseased bananas approximately one year before sampling. The Tiquisate Sandy Clay Loam area, area "a" in Nagualate Very Fine Sandy Loam and area "c" in Progreso Clay—46% were in healthy banana plantings. Area "b" in Nagualate Very Fine Sandy Loam was in a location virgin to banana culture.

2. Chemical Analyses of Soils.

Table 1 gives a general chemical analysis of the various soils used in the investigation.

Table 1. Chemical Analyses of Soils.

Soil Type	p_H Value Guinhydrone	Organic Matter Per cent	Loss on Ignition Per cent	Total Salts p. p. m.
Honduras Samples				
Guaymas Peat	4.2	53.70	57.00	380
Guaymas Very Fine Sandy Loam	5.8	2.22	5.06	120
Guaymas Clay—34%	5.3	2.99	8.42	74
Guaymas Clay—41%	5.2	1.62	8.06	74
Quebrada Seca Clay—37%	7.2	4.24	8.71	575
Quebrada Seca Fine Sand	6.9	.60	3.59	197
Progreso Clay—33%	7.7	1.84	6.33	535
Progreso Clay—46%	7.5—7.8	3.08	9.87	576
Progreso Sandy Clay Loam	7.7—7.9	2.01	6.90	522
Guatemala West Coast Samples				
Los Angeles Clay—39% Fallowed Area	6.4	3.42	8.09	1062
Los Angeles Clay—39%	6.6	3.73	9.07	480
Los Angeles Clay—41%	6.7	—	—	—
Tiquisate Sandy Clay	7.2	12.80	18.18	620
Tiquisate Sandy Clay Loam	7.3	8.57	11.07	232
Nagualate Very Fine Sandy Loam	7.5—8.0	—	—	—

3. Meteorological Data.

The meteorological data for the Progreso, Guaymas, Los Angeles, and Tiquisate soil type regions are given in Tables 2, 3, and 4. The same meteorological condition exists for the Nagualate soil type area as that given for the Los Angeles soil type area.

Table 2. Rainfall — San Alejo Valley, Honduras.

1931	Inches
January	22.25
February	5.78
March	7.70
April	14.40
May	6.90
June	2.55
July	10.98
August	12.91
September	6.85
October	26.29
November	11.67
December	4.01
Total	132.29

Table 3. Meteorological Record — Progreso, Honduras.

Month	Maximum Temperature	Minimum Temperature	Mean Rel. Humidity	Total Rainfall
1931				Inches
January	88	54	68	5.50
February	92	53	64	1.63
March	101	56	68	4.31
April	94	60	73	2.24
May	96	68	70	2.22
June	95	70	71	5.29
July	94	72	71	11.29
August	98	70	74	5.73
September	94	68	72	3.34
October	90	69	69	14.42
November	90	65	69	3.56
December	94	64	73	2.27
			Total	62.30

4. Method of Sampling.

All of the Honduras samples collected for fungous isolations were put in sterile paper envelopes. These were made by folding sheets from obsolete forms into envelopes, or by using No. 1 paper sacks, and sterilizing them. The samples collected on the Guatemala West Coast were taken in sterilized test tubes. Surface samples were collected by carefully removing all large portions of dead plant material from the area selected. This included dead banana cepas, banana leaves, sticks, and if grass or weeds were present they were pulled off close to the ground, the roots being left intact. Then a square containing one hundred square feet was laid out and subdivided into twenty-five squares, each containing four square feet, as represented in Plate I. Each one of these blocks was sampled in the following manner: From nine to twelve spots within each square- or wherever possible scrapings of the entire surface-

Table 4. Meteorological Record — Guatemala West Coast.

Month	Maximum Temperature	Minimum Temperature	Mean Temperature	Mean Rel. Humidity	Total Rainfall
1931	*San Jose (Los Angeles), Guatemala*				Inches
January	88	61	75.5	75.9	—
February . . .	105	52	80.0	73.0	—
March	95	58	76.0	75.0	—
April	100	59	79.0	82.0	—
May	97	70	82.5	73.3	4.93
June.	93	71	78.1	78.1	14.17
July.	89	70	78.0	78.0	12.69
August.	87	67	77.0	79.0	5.53
September . . .	85	70	75.9	80.4	25.00
October	93	68	81.0	80.5	6.69
November . . .	91	57	74.0	84.0	.52
December . . .	76	59	67.0	83.0	2.12
				Total	71.65
	Tiquisate, Guatemala				
January	90	56	—	69.0	—
February. . . .	101	49	79.0	49.0	—
March	100	59	80.0	64.0	—
April	101	63	84.0	69.0	2.07
May	100	66	83.0	76.0	20.30
June.	98	68	61.0	80.0	20.07
July.	95	69	80.0	83.0	20.13
August.	96	67	81.0	80.6	13.28
September . . .	94	66	80.0	81.0	25.77
October	92	67	80.0	83.0	18.40
November . . .	—	—	—	—	1.13
December . . .	92	59	76.0	73.0	2.79
				Total	123.94

were sampled with a sterilized spoon. a small but representative sample being taken to one pile. This pile was then mixed and the paper envelope filled. The surface samples were taken to include the first one-half to one inch.

The vertical or depth samples were taken by first digging a hole approximately two and one-half feet long, two feet wide, and two and one-half feet deep. The hole was dug so that its length was at right angles to the direction in which the sampling was desired. A non-contaminated face of dirt was obtained by starting at the top and cutting the dirt away in short sections, allowing it to fall to the bottom. A sterilized spatula, with the handle bent about twenty-five degrees, and with the edges sharpened, was used to cut away the sections of dirt which were about two inches deep and one inch thick. The spatula was re-sterilized and the operation continued until the bottom of the trench had been reached. At about two-thirds of the way down the cut, the dirt that had collected at the base of the cut was pulled to the back so as to facilitate the work at the bottom of the trench. No attempt was made to sterilize the surface, the method being to remove the face from the top down in short sections and then to sample from the bottom upwards. A measuring stick was next placed in the hole (Plate II.) and small safety matches were pushed in the dirt opposite the inches from which a sample was desired. Three lines of matches, one on each side and one in the middle, were used. A sample was taken up to about an inch from the match so that there was no chance of contamination. All sampling was done by starting at the lowest depth from which a sample was desired and moving toward the top. In this way falling dirt caused no trouble. There was a slight overlap where samples were taken at consecutive inches, this condition mostly occurring from the inch above the one being sampled. No samples were taken below twenty-four inches. Three or four vertical samples were taken in each one hundred square feet. One of these was sampled at every inch to twenty-four and the other three were sampled at every inch to fifteen and then at the eighteenth, twenty-first, and twenty-fourth inch depths.

5. Method of Plating.

Throughout the work the dilution method was used on the basis of .02, .004, and .002 grams of soil per cubic centimeter, giving a dilution of 1/50, 1/250, and 1/500. The method used was to weigh a two gram sample on a sterile aluminum balance pan and then transfer it to a one hundred cubic centimeter sterile water blank containing about a teaspoonful of glass beads. Sterilization of the pans was effected by dipping them in denatured alcohol and then igniting. Two balance pans were used so that one cooled while the other one was in use, the one cooling being kept in a sterile beaker which was lying on its side.

In making the dilutions, the bottle containing the 1/50 dilution was quickly agitated by hand after being shaken for fifteen minutes in a mechanical shaker, and then twenty cubic centimeters of the solution were drawn off into eighty cubic centimeters of sterile water to give a dilution of 1/250. To obtain the dilution of 1/500, ten cubic centimeters of the 1/50 solution were drawn off into ninety cubic centimeters of sterile water. Dilutions of samples from the Guaymas Very Fine Sandy Loam and Progreso Clay—46%, areas a and b, were run in duplicate, one cubic centimeter of the dilution being transferred to each plate. Subsequent areas were plated in the following manner: One cubic centimeter of suspension at the dilution used was plated in four plates, approximately .25 of a cubic centimeter being placed in each dish. By pouring four plates the fungi were actually grown at a greater dilution than stated, but the count was not changed. A total of the fusaria in the four plates times the dilution gave the count per gram. These series were not run in duplicate. Plates were kept at room temperature for three to four days and then examined and all fusaria were isolated and purified for identification. The numbers of fungi determined in all soil types were calculated on the basis of the moist soils with a moisture content ranging from 10% to 30%.

6. Media Used.

The media used in the investigation was ordinary acidified potato dextrose agar made according to the following formula: Peeled, sliced potatoes (old) 200 gms., Dextrose 15 gms., Agar Agar 25 gms., Tap water 1000 cc.

The potatoes were peeled, sliced fairly thin, and then brought to a boil in the full amount of water required. Boiling was continued until the slices of potatoes were soft. The liquid was then strained through cotton cloth and placed in Erlenmeyer flasks in liter lots and sterilized. To inhibit bacteria a 25 % solution of lactic acid was used, one drop being placed in each dilution plate and in the agar plates at the time the fusaria were being freed from contaminations.

III. Investigations and Results.

1. Fusaria isolated.

In conducting the soil isolations, according to the method described above, all fusaria that grew in the plates were transferred to tubes in order to obtain counts and final determinations. Table 5 gives the systematic arrangements of the twenty-four different fusaria that were isolated from the areas sampled.

The identifications of the organisms were made in Tela, Honduras. Type cultures, however, were verified by the senior author by comparison and study with cultures in the mycological laboratories of the Biologischen Reichsanstalt, Berlin-Dahlem, Germany. The writers are indebted to Dr. O. Appel, Director of the Station, and to Dr. H. W. Wollenweber for providing facilities and for valuable assistance in these studies. The systematic arrangement and nomenclature of the *Fusarium* types listed is according to the revised classification by Wollenweber (14). Earlier investigations were found helpful in these classification studies (1) (4) (12) (13). —No description of the various organisms are given in the present report, as the majority of these have been fully described from the Tropics in former papers (2) (4).

Table 6 gives the areas, according to the fifteen different soil conditions, from which the various fusaria were isolated. Of the fifteen soil conditions, fourteen were representative of different soil types. Looking over Table 6 it is evident that certain fusaria are commonly found in

Table 5. Systematic arrangement of Fusaria isolated.

Fusarium.

I. Eupionnotes
  Chlamydospora
    Fusarium dimerum
III. Spicarioides
    Fusarium decemcellulare
VII. Sporotrichiella
    Fusarium chlamydosporum
IX. Arthrosporiella
    Fusarium semitectum
    Fusarium camptoceras
    Fusarium diversisporum
X. Gibbosum
    Fusarium equiseti var. *bullatum*
    Fusarium scirpi
    Fusarium scirpi var. *caudatum*
XIII. Liseola
    Fusarium moniliforme
    Fusarium moniliforme var. *maius*
XIV. Elegans
  Orthocera
    Fusarium orthoceras
    Fusarium orthoceras var. *triseptatum*
  Constrictum
    Fusarium bulbigenum
  Oxysporum
    Fusarium oxysporum
    Fusarium oxysporum f. 3.
    Fusarium oxysporum f. 5.
    Fusarium oxysporum v. *aurantiacum.*
    Fusarium vasinfectum v. *lutulatum.*
XV. Martiella
    Fusarium solani var. *minus*
    Fusarium solani var. *martii* f. 1.
    Fusarium solani var. *eumartii*
    Fusarium javanicum var. *theobromae*
      (*Hypomyces ipomoeae*)
    Fusarium javanicum var. *ensiforme*

all soils tested, while others are found only in certain soils. One would infer from this that there are distinct soil fusaria while others are merely soil invaders of scattered occurrance under the local conditions in the areas from which isolations have been made. The organisms that were generally found to be present in all or practically all surface soils studied were the following: *F. dimerum*, *F. equiseti* var. *bullatum*, *F. moniliforme*, *F. bulbigenum*, *F. oxysporum* f. 3, *F. oxysporum* f. 5, *F. solani* var. *martii* f. 1, and *F. javanicum* var. *theobromae* (*Hypomyces ipomoeae*). *F. oxysporum* f. 3 was found only in the soil about diseased bananas. The following organisms were found to be more commonly

Table 6. Fusaria isolated from different soil types.

Name of Organism	Guaymas Peat	Guaymas VFSL	Guaymas C—34%	Guaymas C—41%	Quebrada Seca C—37%	Quebrada Seca FS	Progreso C—33%	Progreso C—46%	Progreso SCL	*Los Angeles C—39%	Los Angeles C—39%	Los Angeles C—41%	Tiquisate SC	Tiquisate SCL	Naguabate VFSL
F. dimerum	x	x	—	x	x	—	x	x	x	x	x	x	x	x	x
F. decemcellulare	—	—	—	—	—	—	—	—	—	—	—	—	x	—	d
F. chlamydosporum	—	x	—	x	—	—	—	—	x	—	d	—	x	—	—
F. semitectum	x	x	—	—	—	—	x	x	—	x	—	—	—	—	—
F. camptoceras	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x
F. diversisporum	—	—	—	—	—	—	—	—	d	—	—	—	—	—	—
F. equiseti v. *bullatum*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
F. scirpi	—	—	—	—	—	—	—	x	—	—	x	—	—	—	—
F. scirpi v. *caudatum*	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—
F. moniliforme	x	x	x	x	x	x	x	x	x	—	x	d	x	x	x
F. moniliforme v. *maius*	x	—	—	—	—	—	—	x	—	—	x	—	—	—	x
F. orthoceras	—	x	—	—	—	—	—	x	x	—	—	—	—	x	—
F. orthoceras v. *triseptatum*	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—
F. bulbigenum	x	x	x	x	x	x	—	x	x	x	x	x	x	x	x
F. oxysporum	—	x	—	x	x	—	—	x	d	—	d	—	—	x	—
F. oxysporum f. 3	x	x	x	x	x	x	x	x	x	—	x	d	x	—	—
F. oxysporum f. 5	x	x	x	x	x	x	x	x	x	—	x	x	x	x	—
F. oxysporum v. *aurantiacum*	—	x	x	x	—	x	x	x	—	—	—	—	x	x	—
F. vasinfectum v. *lutulatum*	—	—	—	—	—	—	—	—	—	—	—	—	—	d	—
F. solani v. *minus*	—	x	x	—	—	x	—	x	—	—	x	—	x	d	—
F. solani v. *martii* f. 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
F. solani v. *eumartii*	—	d	—	—	—	d	—	x	—	—	—	x	—	d	x
F. javanicum v. *theobromae* (*Hypomyces ipomoeae*)	x	x	x	x	—	x	x	x	x	—	x	—	—	d	x
F. javanicum v. *ensiforme*	—	—	x	—	x	—	—	—	—	—	—	—	—	—	—

x Surface soil and possibly depth. d Depth soil only. — No isolations. * Fallowed area.

present in the depth soil isolations as compared to the surface: *F. solani* var. *minus* and *F. solani* var. *eumartii*. These organisms are more fully discussed under the number of fusaria in the soil.

2. Relative Number and Distribution of Fusaria in Type Soils Investigated.

a) Surface Soil Isolations.

Table 7 gives the number of the different fusaria per gram of soil isolated from the surface soil of fourteen different soil types. A study of Table 7 shows that the number per gram of soil of the different organisms varies. Certain of the fungi are present in practically every soil from which isolations were made, while other fusaria were found to be present only in some soil types. The following fusaria, grouped according to their respective sections, were isolated:

I. *Eupionnotes*. *Fusarium dimerum* in the *Eupionnotes* group was rather common in almost all of the soils. The counts ranged, in the various soil types, from 10 to 890 organisms per gram of soil. It also was found to be present down to a depth of 15″ in certain of the soil types. Due to the wide distribution of this fungus we have regarded it, for the present and until a definite host is established, as a distinct soil organism. Former isolations made of the organism were from soil and decaying banana pseudostem (4).

II. *Spicarioides*. The one fungus from this section, *Fusarium decemcellulare,* was isolated only in the surface of one soil type, and in the subsoil of another type. The fact that this organism was isolated in only two soil types and then in small numbers of 10 to the gram of soil would indicate that it was not a true soil organism, but merely an occasional invader. Former isolations in the Caribbean region were from cacao twigs (4).

VII. *Sporotrichiella*. The one organism in this section that was isolated, *Fusarium chlamydosporum,* was present in only four of the soil type areas and then varied in numbers, according to soil type, from 10 to 80 to the gram of soil. This organism, while not extremely scarce, cannot be regarded as a distinct soil *Fusarium* due to its absence in most of the soil types. It may be a saprophyte or a facultative saprophyte growing on the decaying organic matter, or occasionally on living parts of some host plant, and is merely a soil invader. Former isolations (4) from the Caribbean regions were from banana pseudostem, the air and soil.

IX. *Arthrosporiella*. Three organisms in this section were isolated from a few of the soil types. *Fusarium semitectum* was more commonly isolated, but it was found only in five out of the fourteen soil types. *Fusarium camptoceras* and *Fusarium diversisporum* were isolated from only one soil type each, and the latter fungus only from depth isolations.

Because of the scarcity of these organisms in the surface and depth soil types we have placed them in the class of soil invaders. Former studies (4) indicated that *F. semitectum* was primarily present on dead parts of banana and other fruits, while *F. camptoceras* was present on rotted fruit of banana and cacao and also in the soil. *F. diversisporum* was only isolated from various parts of the cacao plant.

X. *Gibbosum.* Of the three fungi in this section that were isolated from the soil, *F. equiseti* var. *bullatum* was the most common one found. This fungus was present in all of the soil types, ranging in numbers, according to soil type, from 20 to 470 per gram of soil. It was found in the depth soil isolations reaching to a depth of 24″ in certain soil types. *F. scirpi* and *F. scirpi* var. *caudatum* were isolated from two and one soil types respectively. In prior studies (4) *F. equiseti* var. *bullatum* was isolated from dead floral parts of the banana and from the soil. Due to the wide distribution of *F. equiseti* var. *bullatum* in the surface and depth soil, we have regarded it as a true soil *Fusarium.* The low counts in the surface might indicate that the organism lives best on decaying parts of plants and is only a soil invader arising from these plant hosts. From the results obtained in our studies we have placed *F. scirpi* and *F. scirpi* var. *caudatum* in the soil invader class. The latter organism was previously isolated from the soil in the Caribbean region (2)(4).

XIII. *Liseola.* Two fusaria from section *Liseola* were isolated from the soil. *Fusarium moniliforme* was isolated from all fourteen soil types, twelve isolations being from the surface soil and two from the depth soil isolations. The fungus ranged, according to soil type, from 10 to 400 per gram of surface soil. *F. moniliforme* was found fairly commonly in the depth soil isolations, having been present down to a depth of twelve inches. In prior isolations (4) it was found on dead plant parts and in the soil. *F. moniliforme* var. *maius* was isolated from four soil types. In former studies (4) it was isolated from dead parts of the banana. The isolation investigations from surface and depth soils indicate that *F. moniliforme* is a real soil organism. Due to the variety of host plants this fungus has been isolated from (4), it might be determined later that it is only a so ilinvader. The other *Fusarium* in section *Liseola* has been classed merely as a soil invader.

XIV. *Elegans.* The following eight fusaria included in section *Elegans* were isolated from various soil types: *F. orthoceras, F. orthoceras* var. *triseptatum, F. bulbigenum, F. oxysporum, F. oxysporum* f. 3, *F. oxysporum* f. 5, *F. oxysporum* var. *aurantiacum,* and *F. vasinfectum* var. *lutulatum. F. orthoceras* and *F. orthoceras* var. *triseptatum* were isolated from four and one different soil types respectively out of fourteen. *F. bulbigenum* was isolated from thirteen out of fourteen soil types. *F.*

Table 7. Average number of fusaria

Name of Organism	Guaymas Peat		Guay-mas VFSL	Guay-mas C—34%	Guaymas C—41%		Que-brada Seca C—37%	Que-brada Seca FS	Pro-greso C—33%
	a[1]	b	a	a	a	b[2]	a	a	a
F. dimerum	20	300	340	—	60	—	210	—	530
F. decemcellulare	—	—	—	—	—	—	—	—	—
F. chlamydosporum	—	—	80	—	20	—	—	—	—
F. semitectum	20	—	40	—	—	—	—	—	30
F. camptoceras	—	—	—	—	—	—	—	—	—
F. diversisporum	—	—	—	—	—	—	—	—	—
F. equiseti v. *bullatum*	20	60	20	40	80	—	310	130	80
F. scirpi	—	—	—	—	—	—	—	—	—
F. scirpi v. *caudatum*	—	—	—	40	—	—	—	—	—
F. moniliforme	60	400	60	100	100	—	30	220	10
F. moniliforme v. *maius*	20	—	—	—	—	—	—	—	—
F. orthoceras	—	—	200	—	—	—	—	—	—
F. orthoceras v. *triseptatum*	—	—	20	—	—	—	—	—	—
F. bulbigenum	—	20	1120	140	120	110	60	20	—
F. oxysporum	—	—	94	—	20	—	30	—	—
F. oxysporum f. 3	580	1180	840	640	80	48	280	750	280
F. oxysporum f. 5	20	40	1320	260	420	490	550	620	80
F. oxysporum v. *aurantiacum*	—	—	20	40	20	—	—	63	20
F. vasinfectum v. *lutulatum*	—	—	—	—	—	—	—	—	—
F. solani v. *minus*	—	—	20	20	—	—	—	10	—
F. solani v. *martii* f. 1	620	1020	1374	1840	1160	—	6770	7190	7310
F. solani v. *eumartii*	—	—	—	—	—	—	—	—	—
F. javanicum v. *theobromae* (*Hypomyces ipomoeae*)	100	260	180	320	40	—	—	180	10
F. javanicum v. *ensiforme*	—	—	—	40	—	—	10	—	—
Date Sampled	9/29/31	10/21/31	2/6/31	10/12/31	10/16/31	12/9/31	12/28/31	12/28/31	9/2/31
Date Plated	10/1/31	10/22/31	2/9/31	10/13/31	10/17/31	12/10/31	12/30/31	12/31/31	9/5/31
Dilution	1/500	1/500	1/50 1/500 1/5000	1/500	1/500	1/250	1/250	1/250	1/250

oxysporum was isolated from seven out of fourteen soil types. *F. oxysporum* f. 3 was isolated from twelve out of fourteen soil types, but only in those soils about diseased banana plants. *F. oxysporum* f. 5 was isolated from thirteen out of fourteen soil types. *F. oxysporum* var. *aurantiacum* was isolated from eight out of fourteen soil types. *F. vasinfectum* var. *lutulatum* was isolated from one out of fourteen soil types and this isolation was from the soil depth. In former isolations (4) *F. oxysporum* and *F. oxysporum* f. 5 were isolated from the soil only, while all of the other types except *F. vasinfectum* var. *lutulatum* were isolated

[1] Wet and soggy. [2] Only fusaria of Section Elegans isolated. [3] Fallo-

per gram of soil in surface samples.

Progreso C—46%			Progreso SCL			Los Angeles[3] C—39%		Los Angelos C—39%	Los Angelos C—41%	Tiquisate SC	Tiquisate[4] SCL		Nagualate VFSL	
a	b	c[4]	a	b	c[2]	a	b	a	a	a	a	b[2]	a[4]	b[5]
190	120	830	890	300	—	40	—	10	220	40	20	—	10	50
—	—	—	—	—	—	—	—	—	—	10	—	—	—	—
—	—	—	—	10	—	—	—	—	—	10	—	—	—	—
—	10	—	—	—	—	20	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	20
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
90	218	300	60	380	—	90	—	150	90	50	40	—	200	470
—	—	20	—	—	—	—	—	20	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	40	—	—	—
80	10	10	160	—	—	—	—	20	—	70	20	—	10	400
10	—	10	—	—	—	—	—	10	—	—	—	—	—	10
—	12	10	—	60	20	—	—	—	—	—	20	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
42	38	10	20	30	20	—	2	20	10	40	—	16	30	1040
20	68	40	—	—	—	—	—	—	—	—	20	—	—	—
94	26	—	160	50	30	—	—	40	—	270	—	—	—	—
22	234	50	10	90	90	—	—	20	10	220	40	12	—	—
—	34	—	—	—	—	—	—	—	—	20	40	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
220	—	—	—	—	—	—	—	90	—	10	—	—	—	—
6260	2624	5640	17260	12710	—	120	—	2060	1610	1780	14170	—	8750	240
—	10	—	—	—	—	—	—	—	10	—	—	—	—	20
—	10	40	200	—	—	—	—	10	—	—	—	—	10	10
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3/9/31 3/13/31	9/13/31 9/19/31	9/7/31 9/16/31	9/2/31 9/6/31	9/18/31 9/24/31	12/2/31 12/6/31	5/31/31 6/14/31	4/21/32 4/29/32	5/3/31 6/28/31	4/21/32 5/4/32	6/1/31 7/7/31	6/3/31 7/5/31	4/17/32 4/29/32	4/18/32 5/2/32	4/18/32 5/3/32
1/250	1/50	1/250	1/250	1/250	1/250	1/250	1/50	1/250	1/250	1/250	1/500	1/50	1/250	1/250

from the soil and also from decaying banana parts or decaying parts of some other plant. Judging by our isolations from the surface and soil depth, the following fungi have been regarded, for the present, as soil invaders: *F. orthoceras*, *F. orthoceras* var. *triseptatum*, *F. oxysporum*, *F. oxysporum* f. 3, and *F. vasinfectum* var. *lutulatum*. *F. oxysporum* f. 3 was placed in this class as it could be isolated only from the soil about wilt diseased banana plants.

F. bulbigenum, having been isolated readily from the surface soil of thirteen out of fourteen soil types in numbers ranging, in different soils,

wed area. [4] Healthy banana area. [5] Area virgin to banana culture.

from 10 to 1120 per gram of soil, has been regarded, for the present and until a distinct host is found, as a real soil organism. The organism was also frequently found in the soil depth studies, being present in certain soil types down to thirteen inches.

F. oxysporum f. 3 was isolated from the soil of all soil types in which wilt diseased bananas were found. It was not isolated from the soil about healthy bananas in areas free from disease, or in soils virgin to banana culture. Judging from the figures in Table 7, without knowing the conditions as to culture in these soils, one would infer that the organism was a distinct soil fungus due to its presence in twelve out of fourteen soil types. The fact, however, that this organism could only be isolated from the soil about diseased banana plants, and could not be isolated from the soil about healthy bananas, or in soils virgin to bananas would indicate that it is merely a soil invader, being present in the soil about its diseased host plant and not found elsewhere in various soil types. In former isolations (2) (4) the organism was obtained from wilt diseased banana plants and from the soil about diseased banana plants.

F. oxysporum f. 5, having been isolated from almost all of the different surface soil types and having been found in the soil depth down to twelve inches, in some of the soil types, has been regarded, for the present and until a distinct host is found, as a typical soil organism.

F. oxysporum var. *aurantiacum* having been isolated from eight out of the fourteen soil types is classed as a soil organism. Due to the low count of the organism in the various soils, it may be that it is only a soil invader.

XV. *Martiella.* The following five fusaria in section *Martiella* were isolated from the soil during the investigation: *F. solani* var. *minus*, *F. solani* var. *martii* f. 1, *F. solani* var. *eumartii*, *F. javanicum* var. *theobromae* (*Hypomyces ipomoeae*) and *F. javanicum* var. *ensiforme*. *F. solani* var. *minus* was isolated from seven out of fourteen of the soil types investigated, *F. solani* var. *martii* f. 1 from all fourteen, *F. solani* var. *eumartii* from seven out of fourteen, *F. javanicum* var. *theobromae* (*Hypomyces ipomoeae*) from eleven out of fourteen and *F. javanicum* var. *ensiforme* from two out of fourteen. In former isolations (4) *F. javanicum* var. *ensiforme* was isolated from decaying fruit of wild fig (*Ficus* sp.). The other of the *Martiellas* cited above were isolated from plant parts of various hosts and also in every case from the soil.

F. javanicum var. *ensiforme* is regarded as a soil invader because of the infrequent isolations.

Because the following organisms were found to be present in the depth soil isolations down to a depth of from nine to twenty-three inches, they have been classed as soil fungi: *F. solani* var. *minus* and *F. solani* var. *eumartii*. These fungi were not present in the majority of the various soil types, but because of their ability to grow in the soil depth down to from nine to twenty-three inches, we feel justified in classing them as soil fungi.

F. solani var. *martii* f. 1 is considered as a distinct soil organism, even though it has been found on various decaying host tissues (4). It was found to be present in all types of surface soils from which isolations were made. Generally large numbers of from 120 to 17,260 per gram of soil were present in the various soil types. Depth soil isolations made from the fourteen soil types showed the organism to be present in each soil, ranging from a depth of one to twenty-four inches. In most of the soils it was abundant down to a depth of ten to fourteen inches with an average count of 13 to 8,750 per gram, depending on the soil type. At twenty-four inches it was found to be present in certain soils at an average count ranging from 63 to 813 per gram of soil, depending on the soil type. This *Fusarium* is the most common soil *Fusarium*, being present in practically every soil sample analyzed from various localities of the Caribbean and Pacific Coast of Guatemala regions.

Fusarium javanicum var. *theobromae* (*Hypomyces ipomoeae*) was isolated from eleven out of the fourteen soil types. It was present, according to soil type ,at a rate of from 10 to 320 per gram of surface soil and was isolated down to a depth of fifteen inches in certain of the soil types. In the depth soil isolations it was found at the rate of 13 to 1688 per gram of soil. Isolations made of this organism during a prior investigation (4) showed it to be present on decaying plant material and in the soil. Because of its common occurrence in most of the soil types investigated, it has been regarded, for the present, as a distinct soil fungus. Further isolations from various hosts might show that this organism is generally associated with certain host tissues and then may have to be classed as a soil invader, or as an organism that passes part of its life history in the soil. The depth soil isolations would indicate that this is not the case.

b) Number and Distribution of Some of the Common Soil Fusaria.

Table 8 includes representatives of the more common fusaria that we have regarded as distinct soil organisms. *Fusarium solani* var. *martii* f. 1 was commonly found in all soil types investigated. Generally large numbers, varying according to the soil type, of from 120 to 17,260 per gram of surface soil were present, and large numbers were found down to twenty-four inches. *Fusarium equiseti* var. *bullatum* is the next most common *Fusarium* found in the soils investigated. It was present in the surface soil in numbers, depending on soil type, of from 10 to 470 per gram of soil, and was also rather commonly found in the subsoil down to twenty-four inches, which would further lead one to believe

Table 8. Average number of some of the more common

Name of Organism	Guaymas Peat		Guay-mas VFSL	Guay-mas C—34%	Guaymas C—41%		Que-brada Seca C—37%	Que-brada Seca FS	Pro-greso C—33%
	a	b	a	a	a	b	a	a	a
F. dimerum	20	300	340	—	60	—	210	—	530
F. equiseti v. *bullatum*	20	60	20	40	80	—	310	130	80
F. moniliforme . . .	60	400	60	100	100	—	30	220	10
F. bulbigenum . . .	—	20	1120	140	120	110	60	20	—
F. oxysporum f. 5 . .	20	40	1320	260	420	490	550	620	80
F. solani v. *martii* f. 1	620	1020	1374	1840	1160	—	6770	7190	7310
F. javanicum v. *theobromae*	100	260	180	320	40	—	—	180	10

Table 9. Number of Fusaria per gram of surface soil from individual *Fusarium equiseti*

Square Number	Guaymas Peat		Guay-mas VFSL	Guay-mas C—34%	Guay-mas C—41%	Que-brada Seca C—37%	Que-brada Seca FS	Pro-greso C—33%	Progreso C—46%		
	a	b	a	a	a	a	a	a	a	b	c
1	—	500	—	500	—	500	250	—	500	250	1000
2	—	—	—	500	—	—	—	—	250	250	250
3	—	—	—	—	1000	500	—	250	—	500	250
4	—	500	—	—	—	—	—	—	—	—	250
5	—	—	—	—	—	500	—	—	—	—	250
6	—	—	—	—	—	—	250	—	250	750	—
7	—	—	—	—	500	—	250	250	—	250	500
8	—	—	—	—	—	—	—	500	—	200	250
9	—	500	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	750	—	—	—	—
11	—	—	—	—	—	—	—	—	—	500	750
12	—	—	—	—	500	250	—	—	—	250	500
13	—	—	—	—	—	—	250	—	—	250	—
14	—	—	—	—	—	—	—	—	—	—	250
15	—	—	—	—	—	250	—	—	—	250	250
16	—	—	—	—	—	250	—	—	250	—	500
17	—	—	—	—	—	250	250	—	—	250	250
18	—	—	500	—	—	1000	250	1000	—	750	500
19	—	—	—	—	—	500	500	—	—	250	—
20	—	—	—	—	—	—	—	—	250	—	—
21	—	—	—	—	—	1500	—	—	—	—	500
22	—	—	—	—	—	750	—	—	250	—	—
23	500	—	—	—	—	750	250	—	250	250	500
24	—	—	—	—	—	—	250	—	—	500	250
25	—	—	—	—	—	750	—	—	250	—	500

[1] Only fusaria of section Elegans isolated. [2] Fallowed area.

soil fusaria per gram of soil in surface samples.

Progreso C—46%			Progreso SCL			Los[2] Angeles C—39%		Los Angeles C-39%	Los Angeles C-41%	Tiquisate SCL		Tiquisate SC	Nagualate VFSL	
a	b	c	a	b	c[1]	a	b[1]	a	a	a	b[1]	a	a	b
190	120	630	890	300	—	40	—	10	220	20	—	40	10	50
90	218	300	60	380	—	90	—	150	90	40	—	50	200	470
80	10	10	160	—	—	—	—	20	—	20	—	70	10	400
42	38	10	20	30	20	—	2	20	10	—	16	40	30	1040
22	234	50	10	90	90	—	—	20	10	40	12	220	—	—
6260	2624	5640	17260	12710	—	120	—	2060	1610	14170	—	1780	8750	240
—	10	40	200	—	—	—	—	10	—	—	—	—	10	10

squares of the twenty-five sampled for each soil type
var. *bullatum*.

Progreso SCL		Los[2] Angeles C—39%	Los Angeles C—39%	Los Angeles C—41%	Tiquisate SC	Tiquisate SCL	Nagualate VFSL	
a	b	a	a	a	a	a	a	b
—	500	250	250	—	—	—	—	2000
—	250	—	—	250	500	—	—	250
—	—	500	—	—	—	—	—	250
—	—	—	1000	250	—	—	—	—
250	2000	250	—	250	—	500	250	1500
—	250	—	—	—	—	500	500	500
500	250	—	250	250	250	—	1000	—
—	250	—	250	250	—	—	250	—
—	250	—	—	—	—	—	—	250
—	250	—	—	—	—	—	—	—
500	—	—	—	—	—	—	—	4500
—	—	750	250	250	—	—	500	—
—	1000	—	—	—	—	—	250	1000
—	—	500	750	250	—	—	—	—
—	1250	—	—	—	250	—	—	250
—	—	—	—	—	250	—	—	—
—	—	—	—	—	—	—	500	—
—	—	—	—	—	—	—	250	—
—	2500	—	—	—	—	—	250	—
—	250	—	250	—	—	—	—	—
—	250	—	—	—	—	—	—	—
—	250	—	500	—	—	—	250	250
250	—	—	—	—	—	—	750	500
—	—	—	—	—	—	—	250	250
—	—	—	250	500	—	—	—	250

Table 10. Number of Fusaria per gram of surface soil from *Fusarium*

Square Number	Guaymas Peat		Guay-mas VFSL	Guay-mas C—34%	Guaymas C—41%		Que-brada Seca C—37%	Que-brada Seca FS	Pro-greso C—33%	Progreso C—46%		
	a	b	a	a	a	b	a	a	a	a	b	c
1	—	—	500	—	1000	250	750	500	—	—	—	—
2	—	500	2000	—	—	—	500	500	250	—	250	—
3	—	—	1000	—	—	—	750	1200	250	—	100	—
4	—	—	1500	—	500	—	500	500	—	—	750	—
5	—	—	3000	500	500	250	250	—	—	—	—	—
6	—	—	1500	500	—	—	250	500	—	—	—	—
7	—	—	2500	—	2000	—	1250	750	250	50	—	—
8	—	—	2000	500	—	—	—	—	—	—	250	—
9	—	—	1000	500	2000	—	250	500	—	—	500	—
10	—	—	2500	1000	—	1250	2750	500	—	—	—	—
11	—	—	1500	500	—	500	—	1250	500	—	500	—
12	—	—	1500	1000	—	—	1250	1500	—	—	50	—
13	—	—	500	—	—	9000	750	1750	—	—	250	—
14	—	—	500	—	2500	500	250	250	500	—	200	500
15	—	—	500	—	500	—	—	750	—	—	200	—
16	—	—	500	500	—	—	500	1000	250	—	50	250
17	500	—	500	500	—	—	500	1000	—	—	—	—
18	—	—	1500	—	1000	—	500	500	—	—	100	—
19	—	500	2000	—	—	500	—	—	—	—	—	—
20	—	—	2500	—	—	—	—	500	—	—	100	—
21	—	—	1500	500	—	—	1050	500	—	—	50	250
22	—	—	500	500	—	—	—	750	—	—	—	—
23	—	—	500	—	—	—	750	—	—	—	—	250
24	—	—	500	—	—	—	750	250	—	—	—	—
25	—	—	1000	—	500	—	250	500	—	500	—	—

that it is a distinct soil fungus. The other organisms listed in the table were found generally in all of the soil types investigated and have been regarded, for the time being, as true soil organisms. Further study may show that some of these have distinct, or a number of host plants, as is the case with *F. oxysporum* f. 3. If this is established we may have to regard them as soil invaders instead of true soil types. In the case of the *F. oxysporum* f. 3 isolations, the known diseased host or absence of same was definitely established as the areas tested were investigated from this standpoint. The possibility of one host or a variety of hosts being present in all soil types sampled, for those fusaria classed as true soil organisms, would appear to be highly improbable. The seven fusaria

[1] Fallowed area.

individual squares of the twenty-five sampled for each soil type *oxysporum* f. 5.

Progreso SCL			Los[1] Angeles C—39%		Los Angeles C—39%	Los Angeles C—41%	Tiqui-sate SC	Tiquisate SCL		Nagualate VFSL	
a	b	c	a	b	a	a	a	a	b	a	b
—	—	750	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	500	—	—	—	—	500	—	—	—	—
—	250	—	—	—	250	—	250	—	50	—	—
—	—	—	—	—	—	250	—	500	—	—	—
—	—	—	—	—	—	—	—	—	50	—	—
—	—	250	—	—	—	—	250	—	50	—	—
—	—	—	—	—	—	—	250	500	100	—	—
—	—	—	—	—	—	—	500	—	—	—	—
—	—	250	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	250	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	250	—	—	—	—	—	—	—	—	—	—
—	250	—	—	—	—	—	1000	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	500	—	—	—	—	500	—	—	—	—
—	—	—	—	—	—	—	750	—	—	—	—
—	1250	—	—	—	—	—	250	—	—	—	—
—	—	—	—	—	250	—	500	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	250	—	—	—	—	—	250	—	50	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	250	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—

listed in Table 8, because of their common occurrence in the soil, have been used for the correlations discussed in the latter part of the paper.

Tables 9, 10, and 11 give the number of fusaria isolated per gram of surface soil from individual squares of the twenty-five sampled from each soil type for the three following fungi: *Fusarium equiseti* var. *bullatum*, *Fusarium oxysporum* f. 5, and *Fusarium solani* var. *martii* f. 1. Similar isolations of all organisms listed were made for each soil type analyzed in the present investigations. Check samplings were made of the following soil types; Guaymas Peat, Guaymas Clay—41%, Progreso Clay—46%, Progreso Sandy Clay Loam, Los Angeles Clay—39% (Fallowed area), Tiquisate Sandy Clay Loam, and Nagualate Very Fine Sandy Loam.

Table 11. Number of Fusaria per gram of surface soil from *Fusarium solani*

Square Number	Guaymas Peat		Guaymas VFSL	Guaymas C—34%	Guaymas C—41%	Quebrada Seca C—37%	Quebrada Seca FS	Progreso C—33%
	a	b	a	a	a	a	a	a
1	—	—	1000	2500	500	1250	9250	6250
2	—	2500	1000	2000	500	1000	8500	5250
3	—	3000	4000	2000	3000	1000	10000	1500
4	500	3000	1500	Not	3500	3750	6000	6500
5	500	1500	500	sampled	500	2250	8250	3000
6	—	500	500	500	1000	3750	11750	7750
7	—	2000	2000	500	4000	8750	7750	5250
8	—	3000	2000	500	4000	6500	4000	1250
9	2000	500	500	2000	1000	9500	3000	4750
10	—	—	4000	500	1500	18250	9500	8500
11	1000	2500	1500	1000	500	5750	3000	9250
12	—	2500	—	—	2500	3000	10500	16750
13	500	1500	2000	500	1500	8250	4750	5250
14	—	1500	1800	3000	500	13500	2250	31750
15	—	—	1500	5500	1000	11250	8500	8500
16	500	—	1000	2500	—	6000	13750	13500
17	500	—	50	3500	—	12000	5750	7250
18	—	—	500	4500	1000	9500	5000	1750
19	4500	—	—	5000	500	9250	3500	5250
20	500	1000	500	1500	500	7250	11000	6500
21	3000	—	1000	1500	500	8250	3500	9250
22	—	—	—	2000	500	7000	9500	7750
23	1000	—	5000	2000	—	6250	7000	4250
24	—	—	500	2000	500	2250	7000	1500
25	1000	500	2000	1000	—	3750	6750	4250

The typical surface isolations, as represented in Tables 9, 10, and 11, give a better idea of the methods employed in the investigations and the distribution of the particular fungi as they occurred in each square of the one hundred square feet analyzed. An analysis of these tables shows that *F. solani* var. *martii* f. 1 was generally present in all squares of soil in most of the soil types. In some of the soil types the fungus was not so uniformly distributed. The distribution of *Fusarium equiseti* var. *bullatum* and *Fusarium oxysporum* f. 5 was not so uniform. The results, as given, may not show the total actual distribution, as the following various dilutions were used: 1/50, 1/250, and 1/500. For example, where a dilution of 1/250 was used, all fungi that were in the soil below a number of 250 to the gram theoretically would not be

[1] Fallowed area. NS Not sampled.

individual squares of the twenty-five sampled for each soil type var. *martii* f. 1.

Progreso C—46%			Progreso SCL		Los[1] Angeles C—39%	Los Angeles C—39%	Los Angeles C—41%	Tiquisate	Tiquisate SCL	Nagualate VFSL	
a	b	c	a	b	a	a	a	a	a	a	b
6500	3000	4000	29000	28000	—	2250	1000	1000	7250	250	—
6250	1750	9250	14500	6000	—	250	2500	2000	9500	—	250
1000	1250	9750	8750	9000	—	500	3000	1750	5500	750	750
4750	500	4250	12250	18750	—	6000	1250	3000	6000	250	—
10500	5000	2500	5250	14000	—	5500	2000	500	5500	500	—
14500	6000	20000	26750	11250	—	750	750	500	8500	250	—
2000	3750	8250	11500	16000	—	3500	3000	6000	8000	—	—
12750	3500	13250	7750	4000	—	750	3750	2750	78500	—	1000
4250	7250	6500	6500	6000	250	2000	1750	3750	5000	750	—
3000	750	2250	15500	14750	—	1000	1250	1000	143500	250	1750
16250	1750	3250	15750	15000	—	1000	250	500	6500	250	250
1250	850	5250	17250	12000	—	250	250	750	3000	1250	250
NS	1000	2500	17250	6750	—	3250	4500	750	7000	—	—
17000	4500	3500	34250	12500	500	750	4500	1000	3000	—	250
20250	1750	5000	37250	10750	—	1000	1000	2250	2000	—	—
3250	1500	2000	12000	33750	—	3750	1250	750	1000	—	—
1250	2250	2750	7250	10000	—	2500	1250	1250	2000	—	—
2500	1750	2250	11250	9500	500	2500	1250	2250	17000	250	500
9750	1500	5000	38750	6000	500	1000	1000	1750	1000	3250	—
3000	1500	2000	9750	26750	—	1750	1000	2750	3000	—	250
1000	2000	2000	15500	5250	—	1000	250	1250	1500	—	—
1000	2000	6500	14500	12250	—	500	1000	1000	2000	250	500
2500	4000	4000	29500	4250	250	1500	250	2000	2000	—	250
4000	1500	8250	18750	15750	750	750	250	2250	2500	500	—
1750	5000	6750	14750	9500	250	7500	2000	1750	23500	—	—

isolated. Each square of soil, therefore, not showing the presence of a particular organism may actually contain this organism, but in numbers less than 250 to the gram of soil. A relative rough quantitative measurement, we believe, however, was definitely obtained. — In Tables 9 and 11 no counts are given for the following isolations, as only fusaria of section Elegans were isolated: Guaymas Clay—41%, b sample; Progreso Sandy Clay Loam, c sample; Los Angeles Clay—39%, fallowed area, b sample; and Tiquisate Sandy Clay Loam, b sample. Table 10 with *Fusarium oxysporum* f. 5, that is an Elegans, includes counts for all samples.

c) *Correlation between the Average Number of Fusaria per gram of Surface Soil and Texture.*

Table 12 gives the correlation between the average number of fusaria per gram of surface soil and texture for the eight common fusaria listed.

Table 12. Correlation between number of

Name of Organism	Progreso C—46%			Los Angeles C—41%	Guaymas C—41%		Los Angeles C—39%	Quebrada Seca C—37%
	a	b	c	a	a	b[1]	a	a
F. dimerum	190	120	830	220	60	—	10	210
F. equiseti v. *bullatum*	90	218	300	90	80	—	150	310
F. moniliforme	80	10	10	—	100	—	20	30
F. bulbigenum	42	38	10	10	120	110	20	60
F. oxysporum f. 3	94	26	—	—	80	48	40	280
F. oxysporum f. 5	22	234	50	10	420	490	20	550
F. solani v. *martii* f. 1	6260	2624	5640	1610	1160	—	2060	6770
F. javanicum v. *theobromae*	—	10	40	—	40	—	10	—

By taking the total average number of fusaria in the different clay types, those containing 33 to 46 per cent clay, as compared with the total average number of fusaria containing less than 33 per cent clay, we obtain the results as presented in Table 13:

Table 13. Average number of fusaria per gram of clay soils as compared to lighter textured soils.

Name of Fungus	Average No. Fusaria Clay 33—46%	Average No. Fusaria Lighter textured soil
F. dimerum	241	206
F. equiseti v. *bullatum*	151	169
F. moniliforme	40	118
F. bulbigenum	55	234
F. oxysporum f. 3	165	350
F. oxysporum f. 5	214	240
F. solani v. *martii* f. 1	3919	7934
F. javanicum v. *theobromae*	48	73

According to the results given in Table 13, larger average numbers of *F. dimerum* were isolated from the heavier soils than from the lighter soils. In all other instances more fusaria were isolated from the lighter textured soils than from the heavier textured soils.

If we analyze the lighter clay soils further, as presented under descriptions and classification of areas sampled, we find that the Guaymas Clay with 34% clay had 46% sand, that the Progreso Clay with 33% clay had 40% sand, that the Los Angeles Clay with 39% clay had 48% sand and that the Quebrada Seca Clay with 37% clay had 43% sand. These clays, therefore, approach sandy clays and would be expected to have a different reaction on fungous growth than the clays with a low percentage of sand. If we compare the total average number of fusaria in the

[1] Only fusaria of Section Elegans isolated.

fusaria per gram of surface soil and texture.

Guaymas C–34%	Progreso C—33%	Tiquisate SC	Tiquisate SCL		Progreso SCL			Guaymas VFSL	Nagualate VFSL		Quebrada Seca FS
a	a	a	a	b[1]	a	b	c[1]	a	a	b	a
—	530	40	20	—	890	300	—	340	10	50	—
40	80	50	40	—	60	380	—	20	200	470	130
100	10	70	20	—	160	—	—	60	10	400	220
140	—	40	—	16	20	30	20	1120	30	1040	20
640	280	270	—	—	160	50	30	840	—	—	750
260	80	220	40	12	10	90	90	1320	—	—	620
1840	7310	1780	14170	—	17260	12710	—	1374	8750	240	7190
320	10	—	—	—	200	—	—	180	10	10	180

different clay types with 41 to 46% clay as a class, with the total average number of fusaria in the lighter textured soils as a class, we obtain the results as presented in Table 14:

Table 14. Average number of fusaria per gram of clay soils as compared with lighter textured soils.

Name of Fungus	Average No. Fusaria Clay 41–46%	Average No. Fusaria Lighter textured soils
F. dimerum	284	200
F. equiseti v. *bullatum*	156	161
F. moniliforme.	40	92
F. bulbigenum	55	183
F. oxysporum f. 3	50	350
F. oxysporum f. 5	204	237
F. solani v. *martii* f. 1.	4011	6789
F. javanicum v. *theobromae*	18	77

According to the results given in Table 14, larger average numbers of *F. dimerum* were isolated from the heavier soils than from the lighter soils. In all other cases larger average numbers were isolated from the lighter textured soils. Practically the same number of *F. equiseti* var. *bullatum* and of *F. oxysporum* f. 5 were isolated from each soil class.

In these calculations the number of fusaria found in the fallowed area, Los Angeles Clay—39%, and the Guaymas Peat area were not included. The fallowed area was not considered as a normal condition. The peat area is representative of a less common soil type that is totally different from the other types. If the peat areas were included in the lighter textured soils the average counts, in most instances, for this group of soils would have been increased. The averages given for *F. oxysporum* f. 3 were calculated only from isolations made about wilt diseased banana plants.

The results of these isolations show that one *Fusarium* grew better in heavier textured soils, and that the others listed grew better in the lighter textured soil. This difference in ability to grow better in lighter textured soils than in heavier textured soils may be due to a physical factor or oxygen relationship, but from studies made elsewhere (10) it would seem that it is due to a combination of these factors along with differences in the chemical constituents of the soils.

Table 15. Correlation between number of

Name of Organism	Progreso SCL			Nagualate VFSL		Progreso C—46%			Progreso C—33%	Tiquisate SCL	
	a	b	c[1]	a	b	a	b	c	a	a	b[1]
(p_H value) . . .	7.7	7.9	7.9	7.5	8.0	7.8	7.5	7.8	7.7	7.3	7.3
F. dimerum . .	890	300	—	10	50	190	120	830	530	20	—
F. equiseti v. *bullatum* . . .	60	380	—	200	470	90	218	300	80	40	—
F. moniliforme .	160	—	—	10	400	80	10	10	10	20	—
F. bulbigenum .	20	30	20	30	1040	42	38	10	280	—	16
F. oxysporum f. 3	160	50	30	—	—	94	26	—	—	—	—
F. oxysporum f. 5	10	90	90	—	—	22	234	50	80	40	12
F. solani v. *martii* f. 1 . .	17260	12710	—	8750	240	6260	2624	5640	7310	14170	—
F. javanicum v. *theobromae* .	200	—	—	10	10	—	10	40	10	—	—

d) Correlation between the Average Number of Fusaria per gram Surface Soil and the p_H.

Table 15 gives the correlation between the average number of fusaria per gram of surface soil and the p_H value of that soil for the eight common fusaria listed. If we compare the total average number of fusaria in the alkaline soils with the acid soils, the results as presented in Table 16 are obtained:

Table 16. Correlation between number of fusaria per gram of surface soil and p_H.

Name of Fungus	Alkaline soils 7.2—8.0	Acid soils 3.8—6.9
F. *dimerum*	290	106
F. equiseti v. *bullatum*	200	74
F. moniliforme	73	107
F. bulbigenum	104	173
F. oxysporum f. 3	149	458
F. oxysporum f. 5	108	356
F. solani v. *martii* f. 1.	7592	2109
F. javanicum v. *theobromae*	25	121

[1] Only fusaria of section Elegans isolated.

According to results obtained in Table 16 the following fungi grew better in alkaline soils than acid soils. *F. dimerum*, *F. equiseti* var. *bullatum*, and *F. solani* var. *martii* f. 1. The following fungi grew better in acid soils than alkaline soils: *F. moniliforme*, *F. bulbigenum*, *F. oxysporum* f. 3, *F. oxysporum* f. 5, and *F. javanicum* var. *theobromae*. Judging from these results some of the fusaria prefer alkaline soils and others prefer acid soils. All of the fungi in section Elegans, according to these

fusaria per gram of surface soil and p_H.

Tiquisate SC	Quebrada Seca C—37%	Quebrada Seca FS	Los Angeles C—41%	Los Angeles C—39%	Guaymas VFSL	Guaymas C—34%	Guaymas C—41%		Guaymas Peat	
a	a	a	a	a	a	a	a	b[1]	a	b
7.2	7.2	6.9	6.7	6.6	5.8	5.3	5.2	5.2	4.5	3-8
40	210	—	220	10	340	—	60	—	20	300
50	310	130	90	150	20	40	80	—	20	60
70	30	220	—	20	60	100	100	—	60	400
40	60	20	10	20	1120	140	120	110	—	20
270	280	750	—	40	840	640	80	48	540	1180
220	550	620	10	20	1320	260	420	490	20	40
1780	6770	7190	1610	2060	1374	1840	1160	—	620	1020
—	—	180	—	10	180	320	40	—	100	260

results, preferred the acid soils. Undoubtedly the p_H value of these soils is not the only factor that influenced the development of the fungi. In these calculations the number of fungi found in the fallowed area, Los Angeles Clay—39%, were not included. The averages given for *F. oxysporum* f. 3 were calculated only from isolations made about wilt diseased banana plants.

e) Variations in Counts due to Local Soil and Meteorological Conditions.

According to Table 7, various duplicate isolations to demonstrate possible variations in counts were made from certain of the soil types. Apparently, in these few cases, significant results have been obtained where extreme variations existed. In the Guaymas Peat area, isolations in area "a" were made in a locality that had a water table at 18" and a wet and soggy top and depth soil. Fewer counts of the same organisms were obtained in this wet and soggy area as compared with area "b", the surface soil of which was in a good cultural condition.

The Los Angeles Clay—39% soil type, where two areas, "a" and "b", were sampled, was a fallowed area situated in a region with a distinct hot and dry season (Table 4). All weeds were kept from the area by cultivation that was carried on at intervals during a year previous to the date of sampling. The Los Angeles Clay—39% soil type, where only one area "a was sampled, adjoined and was similar to Los Angeles Clay—39%, areas "a" and "b", except that no fallowing was done. The records show that apparently a distinct reduction in the numbers of fusaria took place in the surface soil of the fallowed area. *F. solani* var. *martii* f. 1 was present at the rate of 2060 in the unfallowed Los Angeles Clay—39%, and at the rate of 120 to the gram of soil in the fallowed area. It is interesting to note, according to figures in Table 17, that in the fallowed area, Los Angeles Clay—39%, *Fusarium solani* var. *martii* f. 1 was found in greater numbers from one inch downward than in the surface one-half inch. Undoubtedly fallowing with occasional cultivation to keep down the weeds, and exposure to the sun, in the semi-arid regions of the Guatemala West Coast has a material effect on reduction in numbers of surface soil fusaria. *F. oxysporum* f. 3 was not isolated in great numbers from the surface soil of the unfallowed Los Angeles Clay—39% type, but was isolated in greater numbers at the one inch depth and down to eight inches. This correlation is also evident with some of the other fungi. One would infer that under these conditions the fusaria present are greatly reduced in numbers in the surface one-half inch, but are not so materially affected below three inches. A comparison of the fallowed area of Los Angeles Clay—39% with the non-fallowed area of Los Angeles Clay—39% brings out this difference, even though the surface soil in the unfallowed plot was dry and partially exposed to the sun due to very little shade.

The Tiquisate Sandy Clay and the Tiquisate Sandy Clay Loam areas were located in irrigated sections, while the Los Angeles and the Nagualate areas were situated in regions not irrigated. The largest number of different fusaria per gram of soil were, in the majority of cases, isolated from the irrigated areas, although this correlation did not hold true in all instances. In our results no significant correlation existed between these factors.

While it was not possible to determine definite correlations between the meteorological conditions and the number and distribution of the soil fusaria, it can be readily seen from the data in the various tables, regardless of irrigation, that the common and real soil fungi were present under the dry conditions of the Progreso and Los Angeles regions, as well as under the more uniform rainfall conditions of the Guaymas and the Tiquisate areas. The Los Angeles and Tiquisate regions had a much more distinct dry period than the Progreso and Guaymas regions. Apparently, while there may be some difference in total numbers, some of the same soil fusaria were found to grow almost equally as well in the soils of the semi-arid region, when isolated at the end of the dry season, as in areas with a uniform distribution of rainfall. *F. solani* var. *martii* f. 1 was isolated at the rate of 1840 and 1160 in the two Guaymas Clays as compared with 2060 and 1610 per gram of soil in the two Los Angeles Clays.

f) Depth Soil Isolations.

Table 17 gives the average number of fusaria per gram of soil isolated at different depths. These isolations were conducted as described under the method of sampling. Depth isolations were made in four squares to a depth of 24″ from each soil type except in the following soils, in which cases only three squares were sampled: Guaymas Peat, area b; Guaymas Clay—34%; Guaymas Clay—41%; and Nagualate Very Fine Sandy Loam, area a. Depth samples in soil type, Guaymas Clay—41%, area b, were taken in four representative squares, but only down to six inches, and in this case only fusaria of section Elegans were isolated. — Isolations were conducted for every inch down to 24″ in one square and in the other two or three squares for every inch down to 15″, and then at the 18, 21, and 24 inch depths, except in the one instance given above.

An analysis of Table 17 shows that all fusaria isolated in these soil investigations were found to occur in the soil depth varying from 1 to 24 inches, except the following: *Fusarium semitectum, Fusarium camptoceras, Fusarium scirpi, Fusarium scirpi* var. *caudatum, Fusarium moniliforme* var. *maius*, and *Fusarium javanicum* var. *ensiforme*. All of these were isolated only from the surface soil, generally in small numbers and have been classified as soil invaders.

The following organisms were found to occur commonly in the soil depth: *Fusarium dimerum, F. equiseti* var. *bullatum, Fusarium moniliforme, Fusarium bulbigenum, Fusarium oxysporum* f. 3, *Fusarium oxysporum* f. 5, *F. solani* var. *minus, Fusarium solani* var. *martii* f. 1, *Fusarium solani* var. *eumartii*, and *Fusarium javanicum* var. *theobromae*. All of these fungi have been classed as true soil fungi except *Fusarium oxysporum* f. 3 that was found associated in the soil only about its diseased host. *F. decemcellulare, F. chlamydosporum, F. diversisporum, F. orthoceras, F. orthoceras* var. *triseptum, F. oxysporum* and *F. vasinfectum* var. *lutulatum* were all found in the depth soil isolations, but in numbers not sufficient to classify them as true soil organisms.

Fusarium solani var. *martii* f. 1 was found in greater numbers, down to a depth of 24″, than any other *Fusarium* in the soil. In certain soil types it was widely distributed down to this depth and undoubtedly penetrates further.

Fusarium equiseti var. *bullatum* was found scattered rather abundantly through various soil types down to 24″.

IV. Discussion of Results.

Fifteen different soil areas were used in the investigation of the relative number and distribution of fusaria in various tropical soils. Of these soil areas fourteen were distinct soil types. These soil types ranged from fine sand to clays with a 46% clay content. They also included acid and alkaline soils with reactions ranging from a p_H of 3.8 to 8.0. A wide range in organic content is present between the various soils.

Nine of the fourteen soil types are present in a region near Tela, Honduras. The Guaymas soil types are in a locality with a fairly equal distribution of rainfall averaging about 132″ during the year. The Progreso and Quebrada Seca soil types are in a region with a rainfall of around 60″ during the year.

Table 17. Average number of fusaria

Depth in Inches	Guaymas Peat		Guaymas VFSL	Guaymas C—34%	Guaymas C—41%		Quebrada Seca C—37%	Quebrada Seca FS	Progreso C—33%
	a	b	a	a	a	b [1]	a	a	a
									Fusarium
1	—	—	—	—	—	—	63	—	—
2	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—
4	—	167	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—
6	—	—	125	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	63
8	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	63
									Fusarium
6	—		—	—	—	—	—	—	—
									Fusarium
1	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—
									Fusarium
9	—	—	—	—	—	—	—	—	—

[1] Only fusaria of section Elegans isolated. [2] Fallowed area.

Five of the fourteen different soil types are situated on the West Coast of Guatemala. The various areas are in a region that have a distinct dry season during which time little or no rain falls. The amount of rain that falls during the rainy season varies according to proximity to the Pacific Ocean, less rain falling near the ocean. The Los Angeles and Nagualate soil types are in an area which receives about 70″ of rainfall during the year. The Tiquisate soil types are in a region of higher rainfall where about 123 inches falls during the year.

A variety of soil and meteorological conditions are represented in this investigation. These conditions appear to be variable enough to aid in determining what fusaria are true soil organisms and to determine whether the number and distribution of these soil fusaria varied according to the different soil types and climatic conditions as found in parts of Honduras and Guatemala.

per gram of soil isolated at different depths.

	Progreso C—46%			Progreso SCL			Los[2] Angeles C—39%		Los Angeles C—39%	Los Angeles C—41%	Tiquisate SC	Tiquisate SCL		Nagualate VFSL	
	a	b	c	a	b	c[1]	a	b	a	a	a	a	b[1]	a	b
dimerum															
	—	—	—	—	63	—	—	—	—	—	—	125	—	83	—
	13	—	—	—	—	—	—	—	—	188	—	—	—	—	—
	13	—	63	—	—	—	—	—	—	125	—	—	—	83	—
	—	—	63	—	63	—	—	—	—	—	—	—	—	83	—
	—	—	—	—	63	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	63	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	63	—	—	—	—	—	—	—	63	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	63	—	—	—	—	—	—	—	—	—	—	—	—
	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
decemcellulare															
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10
chlamydosporum															
	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—
diversisporum															
	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—

Table 17. (continued) Average number of fusaria

Depth in Inches	Guaymas Peat		Guaymas VFSL	Guaymas C—34%	Guaymas C—41%		Quebrada Seca C—37%	Quebrada Seca FS	Progreso C—33%
	a	b	a	a	a	b[1]	a	a	a
									Fusarium equiseti
1	—	—	13	—	—	—	—	—	—
2	—	—	25	—	—	—	—	—	—
3	—	—	—	—	—	—	—	63	—
4	—	—	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	63	63
7	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—
10	—	—	125	—	—	—	—	63	—
11	—	—	—	—	—	—	—	—	63
12	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—	—
17	—	—	—	—	—	—	—	—	—
18	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—
21	—	—	—	—	—	—	—	—	—
22	—	—	—	—	—	—	—	—	—
23	—	—	—	—	—	—	—	—	63
24	—	—	—	—	—	—	—	—	—
									Fusarium
1	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	63	63
3	—	—	13	—	—	—	—	—	—
4	—	—	13	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—
7	—	167	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—
10	—	—	125	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—

[1] Only fusaria of section Elegans isolated. [2] Fallowed area.

per gram of soil isolated at different depths.

Progreso C—46%			Progreso SCL			Los[2] Angeles C—39%		Los Angeles C—39%	Los Angeles C-41%	Tiquisate SC	Tiquisate SCL		Nagualate VFSL	
a	b	c	a	b	c[1]	a	b[1]	a	a	a	a	b[1]	a	b
var. *bullatum*.															
—	125	—	—	—	—	63	—	125	938	—	125	—	—	—
25	13	63	—	—	—	—	—	—	—	—	—	—	—	—
—	13	63	—	—	—	—	—	—	—	—	—	—	—	—
—	13	—	—	63	—	—	—	1500	125	—	—	—	—	—
—	250	—	—	—	—	—	—	—	—	—	—	—	—	125
—	—	125	—	—	—	—	—	63	—	63	—	—	83	125
125	—	—	—	63	—	—	—	63	63	—	250	—	—	125
—	—	63	63	—	—	—	—	—	—	—	63	—	—	—
13	—	63	—	—	—	63	—	125	—	—	63	—	—	63
—	63	—	125	—	—	—	—	—	—	—	63	—	—	—
—	13	—	—	63	—	—	—	—	—	—	—	—	250	63
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	125	—	63	—	—	—	63	63	—	—	—
13	—	63	—	—	—	63	—	—	—	—	—	—	—	—
—	—	—	—	63	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	125	—	—	—	—	—	—	—	—	—	—	—	—	—
125	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	63	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	188	—	—	—	—	—	63	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	63	63	—	—	—	—	—	—	—	—	—	—
moniliforme.															
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	63	—	63	—	—	—
—	—	—	63	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	63	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	63	—	—	125
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	63	—	—	—	—	—	—	—	—	—	—
13	—	—	—	63	—	—	—	—	63	—	—	—	—	—

Table 17 (continued). Average number of fusaria per

Depth in Inches	Guaymas Peat a	Guaymas Peat b	Guaymas VFSL a	Guaymas C—34% a	Guaymas C—41% a	Guaymas C—41% b[1]	Quebrada Seca C—37% a	Quebrada Seca FS a	Progreso C—33% a
									Fusarium
1	—	—	—	—	—	—	—	—	—
2	—	—	38	—	—	—	—	—	—
3	—	—	25	—	—	—	—	—	—
4	—	—	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—
6	—	—	125	—	—	—	—	—	—
									Fusarium orthoceras
5	—	—	38	—	—	—	—	—	—
									Fusarium
1	—	—	400	—	—	—	—	—	—
2	—	—	88	—	—	—	—	—	—
3	—	—	38	—	167	—	—	—	—
4	—	—	50	—	—	—	—	—	—
5	—	—	75	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
9	—	—	13	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
11	—	—	25	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—
									Fusarium
1	—	—	125	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—
3	—	—	25	—	—	—	—	—	—
4	—	—	—	—	—	—	—	—	—
5	—	—	38	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—
10	—	—	63	—	—	—	—	—	—

The plate method was used for the isolation of all fusaria. It is recognized that the use of the plate method for determining the number of fungi in the soil has its limitations. Fungi occur in the soil in the

[1] Only fusaria of Section Elegans isolated. [2] Fallowed area.

gram of soil isolated at different depths.

Progreso C—46%			Progreso SCL			Los[2] Angeles C—39%		Los Angeles C—39%	Los Angeles C—41%	Tiqui-sate SC	Tiquisate SCL		Nagualate VFSL	
a	b	c	a	b	c[1]	a	b[1]	a	a	a	a	b[1]	a	b
orthoceras														
—	13	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	125	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
var. *triseptatum.*														
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
bulbigenum.														
—	—	—	—	—	—	—	—	—	63	63	—	—	—	63
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	63	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	63	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
oxysporum.														
—	63	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	63	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	63	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	63	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

form of both vegetative mycelium and reproductive spores. Because a particular organism may be present in a soil primarily in the form of the vegetative mycelium, in the process of shaking the soil suspension, the mycelium may be broken up in varying degrees so that a difference

Table 17. (continued). Average number of fusaria

Depth in Inches	Guaymas Peat		Guaymas VFSL	Guaymas C—34%	Guaymas C—41%		Quebrada Seca C—37%	Quebrada Seca FS	Progreso C—33%
	a	b	a	a	a	b[1]	a	a	a
									Fusarium
1	—	167	63	167	—	—	63	125	—
2	—	333	100	—	—	—	63	—	—
3	125	—	100	—	—	—	—	—	—
4	—	—	100	—	—	—	—	63	—
5	—	833	38	—	—	—	—	—	—
6	—	—	75	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—
8	—	—	13	—	—	—	—	—	—
9	—	—	13	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—
									Fusarium
1	—	125	125	333	167	63	—	—	—
2	—	—	38	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—
4	—	—	50	—	—	—	—	—	—
5	—	—	25	—	—	—	—	—	—
6	—	—	38	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
9	—	—	13	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—
12	—	—	13	—	—	—	—	—	—
									Fusarium oxysporum
1	—	—	13	—	—	—	—	—	—
									Fusarium vasinfectum
1	—	—	—	—	—	—	—	—	—

in the count would result from the growth of each portion of mycelium. A high count in a sample also may arise because the fungus, just before sampling, had sporulated heavily due to some recent meteorological condition or to some peculiar localized soil condition. Periodic samplings throughout the year would rectify this condition. As shown by Waksman and Starkey (11), dessication or drying of the soil samples

[1] Only fusaria of Section Elegans isolated. [2] Fallowed area.

per gram of soil isolated at different depths.

Progreso C–46%			Progreso SCL			Los[2] Angeles C—39%		Los Angeles C—39%	Los Angeles C—41%	Tiqui-sate SC	Tiquisate SCL		Nagualate VFSL	
a	b	c	a	b	c[1]	a	b[1]	a	a	a	a	b[1]	a	b
oxysporum f. 3.														
—	—	—	125	—	63	—	—	313	—	—	—	—	—	—
13	63	—	—	—	—	—	—	—	—	125	—	—	—	—
—	13	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	125	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	63	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	1750	—	—	—	—	—
oxysporum f. 5.														
—	75	—	—	—	—	—	—	63	—	—	63	—	—	—
—	—	—	—	125	63	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
var. *aurantiacum*														
—	—	63	—	—	—	—	—	—	—	63	63	—	—	—
var. *lutulatum*														
—	—	—	—	—	—	—	—	—	—	—	125	—	—	—

may produce a great difference in counts. The vegetative portions and certain spore types of the various fusaria are readily killed upon drying. All samples of soil analyzed in the present investigation were plated as soon as possible after collecting and precautions were used to prevent each from drying, and also to prevent accumalation of moisture that would produce a damp chamber effect. The Guatemala West Coast samples were the only ones that were not plated out immediately.

Table 17 (continued). Average number of fusaria

Depth in Inches	Guaymas Peat		Guaymas VFSL	Guaymas C—34%	Guaymas C—41%		Quebrada Seca C—37%	Quebrada Seca FS	Progreso C—33%
	a	b	a	a	a	b[1]	a	a	a
									Fusarium solani
1	—	—	13	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—
18	—	—	—	—	—	—	—	—	—
									Fusarium solani
1	—	667	788	333	333	—	2125	813	1625
2	—	166	213	500	166	—	1313	313	1688
3	—	—	125	166	166	—	625	250	563
4	—	—	75	167	—	—	563	63	438
5	—	—	75	—	—	—	500	—	375
6	—	—	88	166	—	—	63	63	625
7	—	—	38	—	—	—	—	—	313
8	—	—	—	—	—	—	—	—	313
9	—	—	25	—	—	—	—	125	438
10	—	—	—	—	—	—	313	—	563
11	—	—	13	—	—	—	—	—	813
12	—	—	—	—	—	—	250	—	313
13	—	—	—	—	—	—	63	63	63
14	—	—	—	—	—	—	63	188	188
15	—	—	13	—	—	—	—	—	250
16	—	—	—	—	—	—	—	—	250
17	—	—	—	—	—	—	—	—	—
18	—	—	—	—	—	—	—	—	250
19	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—
21	—	—	—	—	—	—	685	63	125
22	—	—	—	—	—	—	—	—	—
23	—	—	—	—	—	—	—	—	—
24	—	—	—	—	—	—	750	—	63

[1] Only fusaria of Section Elegans isolated. [2] Fallowed area.

per gram of soil isolated at different depths.

Progreso C—46%			Progreso SCL			Los[2] Angeles C—39%		Los Angeles C—39%	Los Angeles C—41%	Tiquisate SC	Tiquisate SCL		Nagualate VFSL	
a	b	c	a	b	c[1]	a	b[1]	a	a	a	a	b[1]	a	b
var. *minus.*														
—	—	—	—	—	—	—	—	—	—	63	63	—	—	—
63	63	—	—	—	—	—	—	—	—	63	—	—	—	—
13	—	—	—	—	—	—	—	—	—	63	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
88	—	—	—	—	—	—	—	—	—	—	—	—	—	—
38	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	13	—	—	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	63	—	—	—	—	—	—	—	—	—	—	—	—	—
75	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—
var. *martii* f. 1.														
585	2300	1583	6313	5313	—	125	—	688	375	1563	4850	—	—	63
612	1600	1813	938	3875	—	63	—	750	500	1188	5788	—	—	125
500	1188	1125	813	938	—	500	—	188	250	875	4000	—	—	—
375	638	875	750	1135	—	250	—	563	63	875	1875	—	—	—
200	525	563	188	1250	—	63	—	125	63	313	4125	—	—	—
562	335	500	250	1750	—	313	—	125	—	250	1625	—	—	—
325	363	63	125	1063	—	375	—	250	125	125	3438	—	—	—
188	550	125	—	313	—	63	—	188	63	250	2063	—	83	—
213	138	313	188	500	—	63	—	—	63	125	8750	—	167	63
175	238	—	63	625	—	—	—	250	125	—	250	—	—	—
200	1375	63	125	500	—	63	—	63	63	313	563	—	83	—
13	1424	—	250	250	—	—	—	—	—	63	250	—	—	—
88	338	—	—	375	—	—	—	63	—	—	563	—	—	—
75	250	63	63	63	—	—	—	—	—	—	375	—	—	—
150	825	438	63	63	—	—	—	—	—	63	688	—	—	—
100	—	—	—	—	—	—	—	—	—	—	625	—	—	—
250	—	—	—	—	—	—	—	—	—	—	375	—	—	—
100	113	313	63	188	—	—	—	—	—	—	188	—	—	—
50	500	—	250	—	—	—	—	—	—	—	250	—	—	—
—	50	500	500	500	—	—	—	—	—	—	—	—	—	—
75	325	63	63	63	—	—	—	—	—	—	—	—	—	—
—	—	—	—	250	—	—	—	—	—	—	1375	—	—	—
—	300	250	—	—	—	—	—	—	—	—	875	—	—	—
—	250	125	63	63	—	—	—	—	—	—	813	—	—	—

Table 17 (continued). Average number of fusaria

Depth in Inches	Guaymas Peat		Guaymas VFSL	Guaymas C—34%	Guaymas C—41%		Quebrada Seca C—37%	Quebrada Seca FS	Progreso C—33%
	a	b	a	a	a	b[1]	a	a	a
									Fusarium solani
1	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—
4	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—
8	—	—	13	—	—	—	—	—	—
9	—	—	13	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—
18	—	—	—	—	167	—	—	—	—
21	—	—	125	—	—	—	—	—	—
23	—	—	—	—	—	—	—	63	—
									Fusarium javanicum
1	—	—	13	167	—	—	—	—	—
2	—	667	13	167	—	—	—	63	—
3	—	333	—	—	—	—	—	—	—
4	—	—	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—
9	—	167	—	—	—	—	—	—	—
10	—	167	—	—	—	—	—	—	—
11	—	—	125	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—

The media used for isolations are important. This is especially true if a total count of all fungi is to be obtained, as many fungi are selective in the medium for growth. In the present investigation only one genus of fungi was isolated, and it was found that the use of one medium was highly successful.

The use of acidified potato agar with a p_H of 4.0—4.5 may have excluded certain fusaria and may have reduced the actual count per gram of soil and possibly in rarer instances the comparative count between fusaria. These possible variations were not considered great enough to change the relative conditions and thereby the general conclusions.

Waksman and Starkey (11) have shown that if the ordinary extreme dilutions used for the determination of the number of bacteria are used

[1] Only fusaria of Section Elegans isolated. [2] Fallowed area.

per gram of soil isolated at different depths.

Progreso C—46%			Progreso SCL			Los[2] Angeles C—39%		Los Angeles C—39%	Los Angeles C—41%	Tiqui-sate SC	Tiquisate SCL		Nagualate VFSL	
a	b	c	a	b	c[1]	a	b[1]	a	a	a	a	b[1]	a	b
var. *eumartii.*														
—	63	—	—	—	—	—	—	—	—	—	63	—	—	—
—	125	—	—	—	—	—	—	—	—	—	—	—	—	—
63	63	—	—	—	—	—	—	—	—	—	125	—	—	—
—	63	—	—	—	—	—	—	—	—	—	63	—	—	—
—	125	—	—	—	—	—	—	—	—	—	—	—	—	—
—	63	—	—	—	—	—	—	—	—	—	—	—	—	63
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	125	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—
38	63	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
var. *theobromae.*														
13	—	—	—	—	—	—	—	—	—	—	63	—	—	—
—	63	—	—	—	—	—	—	—	—	—	63	—	—	—
—	—	—	188	—	—	—	—	—	—	—	125	—	—	—
—	—	—	—	—	—	—	—	—	—	—	251	—	—	—
—	—	63	—	—	—	—	—	—	—	—	63	—	—	—
—	—	—	—	—	—	—	—	—	—	—	1688	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	125
—	—	—	—	—	—	—	—	63	—	—	—	—	—	—

for the determination of the number of fungi, the probable error involved is so great as to make the results absolutely worthless. By the use of a low dilution, they found that a more accurate count and a low probable error resulted. Duplicate plates, or better, ten plates of each sample should be made to obtain the most accurate results, especially if all soil fungi are being isolated. The writers found that in dealing with one group of soil fungi as the fusaria, that dilutions of 1/50, 1/250, and 1/500 were satisfactory for the majority of different conditions encountered. The dilution of 1/250 was most commonly used, as it generally gave counts accurate enough for comparative purposes.

A check on possible variations in counts of total fusaria in ten different samples of soil showed that no significant difference in numbers was found in each sample when plated at dilutions of 1/50, 1/250, and 1/500. Since twenty-five different samples were used for isolation from each soil type in our investigations, and an average of these isolations was taken for numbers present in each soil type, it was decided that no duplicate plates of each individual sample of the twenty-five were necessary.

In studying and comparing the various results on distribution, it must be borne in mind that the absence of an organism in the soil, as indicated in the various tables , does not necessarily mean that the organism was not present. It means that the organism was found to be present in numbers per gram of soil equal to that which the dilution should show, or in greater numbers. In our studies we have compared counts secured from dilutions of 1/50, 1/250, and 1/500. It is recognized that a discrepancy may arise in certain instances by comparing these counts; i. e., in soils in which a particular organism is present in numbers much below 250 to the gram, the dilution 1/250 would not give a true count. By experience, however, in isolations it was found that only for special fusaria and local soil conditions was it necessary to use a dilution as low as 1/50 to obtain accurate counts for correlation purposes. In depth soil isolations it would have been more accurate had we used the 1/50 dilution.

In the evaluation of results from the various counts discussed in this investigation, only wide differences in results were taken into consideration for a significant meaning. The significant test for the abundance of an organism in a soil is the ease in which that particular fungus can be isolated, provided the proper media and technique is employed. After having taken into consideration the probable errors that might enter into the present investigation, the authors believe that the technique employed gave a rough, quantitative measurement of the various fusaria, that was sufficiently accurate to provide data for use in a relative correlation between numbers of different fusaria in the soil types investigated.

Twenty four different fusaria, included in eight different *Fusarium* sections, were isolated from the various soil types. The largest number of different fusaria were isolated from section Elegans that includes the wilt disease producing organisms. Eight different types were isolated from this section. Section Martiella contained the next largest number with five different fusaria. With the exeption of *F. moniliforme* those fusaria that were found in greatest abundance in the soil produced chlamydospores.

The identifications of the fusaria were made in Tela, Honduras, and verified by the senior author at the Biologischen Reichsanstalt in Berlin-Dahlem, Germany, where access was had to a *Fusarium* collection and consultations were possible with Dr. H. W. Wollenweber. The ease in which most of the identical types of fusaria were isolated in this investigation as compared with a former investigation for Honduras (4) clearly proves that the various species and types retain their identity and that the morphological basis, along with the physiological characteristics on different media, is fundamental for classification purposes. The systematic arrangement of the species of *Fusarium* into sections and the nomenclature used in the present paper follows the recent classification by WOLLENWEBER (14).

The results of the classification of the twenty four different fusaria according to the fourteen different soil types, within which they were found, shows that certain types are commonly found in all soils tested, while other types were found only in some soil types. One would infer that there are distinct soil fusaria and others that are merely soil invaders whose presence is limited to certain areas, due to some local conditions such as the presence of the host plant and a difference in the soil constituents.

Because of their widespread presence in surface or depth of the various soil types, the following fungi have been provisionally classified as soil fusaria: *F. dimerum*, *F. equiseti* var. *bullatum*, *F. moniliforme*, *F. bulbigenum*, *F. oxysporum* f. 5, *F. oxysporum* var. *aurantiacum*, *F. solani* var. *minus*, *F. solani* var. *martii* f. 1, *F. solani* var *eumartii*, and *F. javanicum* var. *theobromae* (*Hypomyces ipomoeae*).

Because of the scarcity of isolations, and because of special local conditions under which some isolations were made, the following fungi have been provisionally classed as mere soil invaders: *F. decemcellulare*, *F. chlamydosporum*, *F. semitectum*, *F. camptoceras*, *F. diversisporum*, *F. scirpi*, *F. scirpi* var. *caudatum*, *F. moniliforme* var. *maius*, *F. orthoceras*, *F. orthoceras* var. *triseptatum*, *F. oxysporum*, *F. oxysporum* f. 3, *F. vasinfectum* var. *lutulatum*, and *F. javanicum* var. *ensiforme*.

While a large number of isolations have been made in order to provisionally classify the various fusaria into soil fungi and soil invaders, it is possible that further studies may, in certain instances, change the grouping. It may be that studies of each soil type at frequent intervals throughout the year would establish the true identity of some of the types listed in the various classes above. Our long contact with the various fusaria classed above leads us to believe that the classes as given are as accurate as can be established for the present.

A knowledge of the conditions under which the isolations were made and the presence of the host, for known pathogens, is essential for a true classification from a soil standpoint. An analysis of the various tables showing the numbers of *Fusarium oxysporum* f. 3 in the soil would lead one to conclude, without taking into consideration the environmental conditions under which these isolations were made, that this organism is a distinct soil organism. Out of fifteen detailed isolations made from different soil types, only five were from areas that were not about diseased plants. Three of these were from soils about healthy mats, one was from a fallowed area that had been in diseased bananas, and one was in a soil virgin to banana culture. *F. oxysporum* f. 3 was only isolated from the soil about the diseased plants and never from the soil about healthy plants, or from the soil virgin to banana culture. These same results were obtained in numerous isolations made in various parts of the Caribbean region not mentioned in this report. Because of the inability to isolate this fungus from soils free from the diseased host, it has been classed as a soil invader that grows in the soil about diseased plants. If we judge by the results of these isolations and former inoculation studies (3), we should conclude that *F. oxysporum* f. 3 is a much more distinct parasite than heretofore has been thought to be the case. If *F. oxysporum* f. 3 is merely a soil invader, closely associated with the diseased plant, it would appear that it has been transported primarily by carrying diseased plants to areas virgin to banana cultivation, or by the transference of the organism from diseased plantations to healthy ones through the agency of man, animals, birds, or insects. It is highly probable that this organism was originally introduced into the Caribbean region from the Far East — Malay, or India regions — by transporting diseased banana plants.

Some apparently pathogenic wilt and rot producing fusaria have been isolated from the soil in these and other investigations (2) (4). While fusaria classified as pathogens have been isolated from the soil, their true pathogenicity has not always been established. Studies made with *F. oxysporum* f. 3 indicate that this organism is a soil invader and a distinct parasite. This belief would lead us to question whether or not the supposed pathogens isolated in general soil isolations, without the presence of the host, are so highly specialized.

F. oxysporum f. 5 and *F. bulbigenum* were found to be common soil organisms in most of the fourteen type soils investigated. The originally described forms of these organisms have been proved to be parasitic and produce a wilt of tobacco and a rot of bulbs. The question of whether or not these two fusaria collected in tropical soils will cause a wilt or rot of their respective hosts remains to be proved. The only determined pathogen isolated in the present investigation was *F. oxysporum* f. 3 that causes a wilt of the banana (3). The fact that *F. oxysporum* f. 3, in these investigations, could only be isolated from the soil about diseased banana plants and could not be isolated from soil about healthy banana plants, or in soils virgin to banana growth would lead one to believe that it is only an occasional soil invader and requires the host plant for a prolonged existence. The abundance of *F. oxysporum* f. 5 and *F. bulbigenum* in the absence of their host plants, would indicate that they are not so highly specialized from a disease standpoint as is the case with *F. oxysporum* f. 3.

Whether or not those species collected in tropical soils and determined as known pathogens in the temperate zone, actually will produce the wilts or rots and decays on their principal hosts remains to be proved. Systematic inoculation investigations on different host plants are essential for a determination of the parasitic nature of these types of fusaria.

The number and distribution of the various organisms isolated varied in the twenty-five square areas analyzed in each one hundred square foot area. Some organisms were found to be equally distributed throughout, while other organisms were not so uniformly distributed. The absence of fungi in certain squares may have been due to the fact that the particular dilution used for isolating was too great to include those fungi that may have been present in lower numbers. *Fusarium solani* var. *martii* f. 1 was present generally in all squares of soil in most of the soil types analyzed. The number of organisms found in each square, when all soil types are considered, varied from 250 to 143,500 per gram of soil. The latter unusually large number found in one square probably was due to that particular sample having been taken in a localized area where sporulation had just taken place. Apparently the soil type does not have, in all cases, such a distinct influence on the ability of this typical soil fungus to grow, as is true with some other fusaria. In the case of soil invaders it is probable that these organisms are localized in different soil types according to the vegetative growth present. The distribution of *F. equiseti* var. *bullatum* and *F. oxysporum* f. 5 was fairly regular, but not so uniform as *F. solani* var. *martii* f. 1.

Apparently a correlation exists between the average number of fusaria per gram of surface soil, the texture, and the p_H. According to our findings, some of the more common soil organisms apparently grew better in the heavier soil than in the light textured soils, but the majority preferred the lighter textured soils. Most of the more common soil fusaria investigated preferred an acid soil to an alkaline soil. The most common soil *Fusarium*, *F. solani* var. *martii* f. 1, apparently preferred the alkaline soils. The apparent ability to grow better in lighter textured soils may be due to a mere physical factor or to an oxygen relationship, but from studies made elsewhere it would seem that it is due to a combination of these factors with differences in the chemical constituents of the soil (10). Undoubtedly the p_H value of these soils is not the only factor that influenced the development of the fungi. Other investigations (10) have shown that frequently the total abundance of some organisms is a function of the soil reaction.

Apparently fallowing the soil in a semi-arid region has a pronounced effect, during the dry period, on reduction in numbers of fusaria, at least in the surface one inch. From one to three inches and lower the effect of fallowing was not so noticeable. Irrigation in these semi-arid regions might also have an effect influencing growth of surface fusaria, the larger population occurring in the areas that are uniformly irrigated. This latter point was not definitely established. Apparently the number of fusaria present in a semi-arid region may be, in certain instances, smaller than in the tropical areas with a more equal distribution of rainfall. No definite correlations were found for these latter factors. Common soil fusaria, however, were present in varying numbers in the soil types of the semi-arid region, as well as in the soil types with a larger and more equal distribution of rainfall. Conclusions must be guardedly drawn when only two soil factors are considered, as the organisms growing in the soil are subject to all of its components. Investigations made by WAKSMAN (10) and others apparently have shown this to be the case. WAKSMAN and STARKEY (11) have pointed out that, "The soil is inherently a complex system, where chemical, physical, and biological systems are active". Also that "The composition of the soil microbial population, both qualitatively and quantitatively, is thus a resultant of numerous factors, which can be traced to the soil and atmospheric agencies, as well as to the nature of the plant and animal populations".

Depth soil isolations showed that in general most fusaria thrive best in the surface one-half inch of practically all soil types investigated. The one exception apparently is development in the fairly light textured soil in the semi-arid regions of the Guatemala West Coast where a hot and dry surface soil exists throughout the dry season. Isolations made at the end of the dry season indicated that, especially in the fallowed area, the fusaria were found on the average in the greatest abundance at and below the first inch of soil. Most fungi are distinctly aerobic organisms and would naturally be expected to be present in largest numbers in the surface soil where a relatively high oxygen content is present. Generally there is more organic matter in the surface soil and this also would be a factor that might produce a more favorable condition for development.

The data obtained in the depth soil isolations show that the number of fusaria generally decreases rapidly with the depth. Very few of the different fusaria isolated were found in any great abundance below 15″. Some of the fusaria penetrate deeper than others and generally are found further down in the lighter textured soil than in those with a greater per cent of clay. *Fusarium solani* var. *martii* f. 1 was the most common depth soil fungus. In certain soils it was found in abundance down to 24″ and undoubtedly penetrated deeper. *Fusarium equiseti* var. *bullatum* also was found scattered generally through many soil types down to 24″. Some fungi, while not generally found in the majority of the surface soil types were found to be present in the depth soil of some of the soil types. These fungi were from section Martiella. The ability to grow in many soil types should not be the only criterion of a soil fungus. If fungi thrive in the soil down to 15″ or 24″, especially in heavier textured soils and soils with normal organic content at this depth, it appears that they should be regarded as soil organisms, at least for that particular soil type.

V. Summary and Conclusions.

1. Fifteen tropical soils, of which fourteen were distinct soil types, were investigated for the presence of parasitic and other species in the genus *Fusarium* Link, of the so-called "fungi imperfecti". The relative number and distribution per gram of soil for these fusaria were determined for each different soil type and condition.

2. A variety of soil and meteorological conditions are represented in the investigation.

3. The method of sampling soils and plating for determination of kind and number of fusaria, we believe, gave a rough, quantitative measurement, that was sufficiently accurate to provide data to determine which of these fusaria were true soil organisms and which were merely soil invaders, and to determine whether these soil fusaria varied according to the different soil types and climatic conditions.

4. Ordinary acidified potato agar, with a p_H of 4.0—4.5, was used for isolations. By the use of acid media the bacteria were excluded, but the fusaria were favored.

5. Twenty-four different fusaria, included in eight different *Fusarium* sections, were isolated from the various soil types.

6. The largest number of different fusaria isolated were from section Elegans that includes the vascular wilt disease producing organisms as well as others less specialized or not as well known from a disease standpoint.

7. The results of the classification of the twenty four different fusaria according to the fourteen different soil types, within which they were found, show that certain types are commonly found in all soils tested, while other types were found only in some soil types.

8. The different fusaria isolated were classed according to their ability or lack of ability to develop generally in the surface and depth of various soil types into two classes; i. e., typical soil fusaria, and soil invaders.

9. In the case of wilt producing fusaria, such as *Fusarium oxysporum* f. 3, the presence of the host apparently influences their ability to develop

in soils. The determination of this factor is of utmost importance in placing fungi of this character into one of the two classes.

10. *Fusarium oxysporum* f. 3 was only isolated from soil types about wilt diseased banana plants. It was never isolated about healthy banana plants in disease—free areas nor in soil types virgin to banana culture.

11. From the results of these investigations, *Fusarium oxysporum* f. 3, has been considered as a distinct parasite, being much more highly specialized in this respect than heretofore generally supposed. It is very closely associated with its diseased host.

12. *Fusarium oxysporum* f. 5 and *Fusarium bulbigenum* were found to be common soil organisms in the fourteen soil types investigated. The former produces a wilt of tobacco and the latter a rot of bulbs. Their abundance in tropical soils, in the absence of the host plants, would indicate that they are not so highly specialized from a disease standpoint as is the case with *F. oxysporum* f. 3.

13. The number and distribution of each fungus isolated in surface and soil depth varied according to soil type.

14. Apparently a correlation exists between the average number of fusaria per gram of surface soil and the texture and the p_H. In the various correlations, conclusions must be guardedly drawn, when only two factors are considered, as the organisms growing in the soil are subject to all of its components.

15. Surface and depth soil isolations show that, in general, most fusaria thrive best in the surface one-half inch of practically all soil types investigated. We may have an exception to this in those lighter textured soil types in semi-arid regions with a hot and dry surface. In this case the fusaria may be more prevalent from the first to the third inch depths and in some instances at lower depths.

16. Some fusaria penetrate deeper than others, most being found to penetrate deeper in the lighter textured soils.

17. Very few of the different fusaria isolated were found in any great abundance below 15″. Some of them were present in abundance down to at least 24″ where our sampling stopped.

18. Because of their wide spread presence in surface or depth of the various soil types, the following fungi have been provisionally classified as soil fusaria: *F. dimerum*, *F. equiseti* var. *bullatum*, *F. moniliforme*, *F. bulbigenum*, *F. oxysporum* f. 5, *F. oxysporum* var. *aurantiacum*, *F. solani* var. *minus*, *F. solani* var. *martii* f. 1, *F. solani* var. *eumartii*, and *F. javanicum* var. *theobromae* (*Hypomyces ipomoeae*).

19. Because of the scarcity of fungi, and because of special local conditions under which some isolations were made, the following fungi have been provisionally classed as mere soil invaders: *F. decemcellulare*, *F. chlamydosporum*, *F. semitectum*, *F. camptoceras*, *F. diversisporum*, *F.*

scirpi, *F. scirpi* var. *caudatum*, *F. moniliforme* var. *maius*, *F. orthoceras*, *F. orthoceras* var. *triseptatum*, *F. oxysporum*, *F. oxysporum* f. 3, *F. vasinfectum* var. *lutulatum* and *F. javanicum* var. *ensiforme*.

Zusammenfassung der Ergebnisse.

1. 15 tropische Böden, von denen 14 der Art nach verschieden waren, wurden auf den Grad ihrer Verpilzung durch pflanzenparasitäre und andere Vertreter der Formgattung *Fusarium* LINK der sogenannten „fungi imperfecti" geprüft durch Feststellung der Zahl keimfähiger Elemente je Gramm des Bodens unter genauer Bestimmung der in den verschiedenen Bodenschichten vorhandenen Sichelsporlinge.

2. Eine Anzahl Boden- und Klimafaktoren sind bei der Untersuchung berücksichtigt worden.

3. Nach der Art der Probeentnahme läßt sich die *Fusarium*-Flora der geprüften Böden quantitativ verhältnismäßig gut schätzen, ebenso ihre Abhängigkeit von Faktoren des Bodens, Klimas und Pflanzenwuchses erkennen und ihr Anteil an heimischen bzw. eingewanderten Pilzen beurteilen.

4. Als Nährsubstrat aller isolierter Pilze diente ein durch Zusatz von Milchsäure auf eine Wasserstoff-Ionenkonzentration von 4,0—4,5 p_H abgestimmter Kartoffelsaftagar. Durch diese Ansäuerung wurden Bakterien zurückgehalten, Fusarien dagegen begünstigt.

5. 24 verschiedene Fusarien aus 8 Gruppen wurden aus den betreffenden Böden isoliert.

6. Die höchste *Fusarium*-Ziffer in den Böden betraf die Gruppe Elegans mit einigen bekannten Erregern gefäßparasitärer Welkekrankheiten sowie anderen, weniger spezialisierten oder noch strittigen Vertretern.

7. Gewisse Fusarien fanden sich in allen untersuchten Bodenklassen, andere dagegen nur in einzelnen Böden.

8. Nach dem Vorkommen in den verschiedenen Böden und deren Schichten können einige Fusarien als heimische, andere als eingewanderte Vertreter der Bodenflora gelten.

9. Bei dem Erreger der Bananenwelke, *Fusarium oxysporum* f. 3, übt die Gegenwart der Wirtspflanze offenbar einen beherrschenden Einfluß auf seine Bodenverbreitung und damit auf seine Einreihung in eine der beiden Herkunftsgruppen aus.

10. *Fusarium oxysporum* f. 3 war nur im unmittelbaren Bodenbereich kranker Bananen bzw. an der Pflanze selbst nachzuweisen, niemals dagegen im Bodenbereich gesunder Bananen, noch in Böden, die niemals Bananen getragen hatten.

11. Nach den Untersuchungsergebnissen scheint *Fusarium oxysporum* f. 3 in viel höherem Maße, als man früher vermutete, spezialisiert,

d. h. an anfällige Sorten seiner Wirtspflanze aus der Gattung *Musa* gebunden zu sein.

12. Auffällig war die Feststellung von *Fusarium oxysporum* f. 5 und *F. bulbigenum* als gewöhnliche, in 14 untersuchten tropischen Böden verbreitete Vertreter der Bodenpilzflora, zumal ersterer Pilz Tabakwelke, letzterer Blumenzwiebelfäule in der gemäßigten Zone bewirkt. Ihre Verbreitung in tropischen Böden unter Ausschluß ihrer speziellen Wirtspflanze deutet auf eine geringere Spezialisierung hin, als sie bei *F. oxysporum* f. 3 zu erkennen ist.

13. Die Zahl und Verbreitung der aus oberflächlichen und tieferen Bodenschichten isolierten Pilze war je nach Bodentyp verschieden.

14. Die Zahl der Fusarienkeime je Gramm der Bodenkrume scheint abhängig zu sein von der Zusammensetzung sowie von der Wasserstoff-Ionenkonzentration des Bodens, abèr auch von anderen Faktoren, die modifizierend auf die Pilzflora einwirken mögen.

15. *Fusarium*-Isolierungen aus oberflächlichen und tieferen Bodenschichten ließen erkennen, daß die meisten Fusarien in den ersten 2 cm der Bodenkrume am besten gedeihen. Nur in den leichteren Böden halbtrockener Gebiete findet sich eine reichliche *Fusarium*-Flora auch in 2—7 cm unter der Bodenoberfläche liegenden Schichten, gewisse Fusarien sogar in noch größerer Bodentiefe.

16. Einige *Fusarium*-Arten dringen tiefer als andere in den Erdboden ein; die meisten erreichen in leichteren Böden die größte Tiefe.

17. Sehr wenige der isolierten Fusarien wurden in größerer Anzahl tiefer als 38 cm unter der Oberfläche im Boden nachgewiesen, jedoch fanden sich einzelne sogar in Bodentiefen bis 60 cm, unter welche die vorliegenden Studien nicht hinabreichten.

18. Wegen ihrer außerordentlichen Verbreitung in oberflächlichen und tieferen Schichten verschiedener Böden können folgende Fusarien vorläufig als typische Bodenpilze angesprochen werden:

Fusarium dimerum, *F. equiseti* v. *bullatum*, *F. moniliforme*, *F. bulbigenum*, *F. oxysporum* f. 5, *F. oxysporum* v. *aurantiacum*, *F. solani* v. *minus*, *F. solani* v. *martii* f. 1, *F. solani* v. *eumartii* und *F. javanicum* v. *theobromae* (= *Hypomyces ipomoeae*).

19. Wegen der Seltenheit ihres Vorkommens und der besonderen örtlichen Bedingungen, unter denen die Isolierungen vorgenommen wurden, sind folgende Fusarien zunächst als Gelegenheitsgäste des Bodens betrachtet worden:

Fusarium decemcellulare, *F. chlamydosporum*, *F. semitectum*, *F. camptoceras*, *F. diversisporum*, *F. scirpi*, *F. scirpi* v. *caudatum*, *F. moniliforme* v. *maius*, *F. orthoceras*, *F. orthoceras* v. *triseptatum*, *F. oxysporum*, *F. oxysporum* f. 3, *F. vasinfectum* v. *lutulatum* und *F. javanicum* v. *ensiforme*.

VI. Literature cited.

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