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THE CONTROL OF RHIZOCTONIA DAMPING-OFF OF PEPPER AND EGGPLANT IN PUERTO RICO

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INTRODUCTION

Serious outbreaks of damping-off of vegetable crops have frequently been reported from almost every locality in the Island. The disease is more likely to occur during periods of heavy rainfall, when conditions of soil moisture and temperature are unsuitable for proper seedling development. Farmers sometimes complain of poor viability of seed when it is apparent that the low percentage of germination is due to pre-emergence failure caused by damping-off organisms. Heavy damping-off losses have occured in seed and plant beds of pepper and eggplant. In many instances, several thousand seedlings of these vegetables have succumbed to the disease. The disease has appeared in naturally contaminated soils as well as in artificially recontaminated, steamed or formaldehyde treated, soils.

Damping-off of vegetable crops in Puerto Rico has been ascribed by various workers to attacks by fungi of the genera *Pythium*, *Phytophthora*, *Phomopsis* and *Rhizoctonia*.

Nolla (10) found *Phomopsis vexans* (Sacc. & Syd.) Harter responsible for damping-off, blight and fruit rot of eggplant. *Pythium debaryanum* Hesse and species of *Phytophthora* were reported causing damping-off of tomato, pepper and eggplant.

Matz (7), in a study of the *Rhizoctonias* of Puerto Rico, reported isolates from beet, carrot, celery, tomato, citrus, eggplant, lettuce, corn, pepper, celeriac, banana, field pea, Natal plum (*Carissa grandiflora*), bean, "yautía" (*Xanthosoma* sp.) and hollyhock. No attempt was made to establish pathogenicity. The Rhizoctonia were studied morphologically and physiologically and cataloged by species, i. e., *R. microsclerotia*, *R. dimorpha*, *R. macrosclerotia*, *R. grisea*, *R. solani*, *R. ferrugena*, *R. pallida*, *R. alba* and *R. melongena*.

Tucker (16) reported strains of *Phytophthora capsici* Leonian, *P. palmivora* Butler and *P. parasitica* Dast. causing damping-off of tomato and eggplant. In Puerto Rico *P. capsici* has been found attacking only peppers.

Other organisms might possibly be associated with damping-off of pepper, tomato and eggplant seedlings in seed and plant beds in Puerto Rico. Aside from Nolla's (11) work on the control of damping-off of tomato, pepper and eggplant caused by *Pythium debaryanum*, *Phytophthora nicotiana* and *Phomopsis vexans*, the latter attacking only eggplant, very little attention has been given to the serious matter of controlling damping-off of vegetables in Puerto Rico.

Fungicides for seed and soil treatments have been tested and recommended in other countries to minimize losses due to damping-off of vegetables and other crops. It is a well-known fact that damping-off organisms react differently to fungicidal treatments. This depends not only upon their specificity for toxic chemicals, but also upon variations of soil composition and climate. The occurrence of different physiological strains of fungi is also recognized. These factors account for the apparent discrepancies in effectiveness of fungicides for the control of certain plant diseases.

The present paper, therefore, treats of essential information regarding the occurrence of a damping-off of pepper and eggplant in seed and plant beds in Puerto Rico, the causal agent, the symptoms produced on infected seedlings, the life history of the pathogen, the influence of environmental conditions on damping-off, and the effect of seed and soil treatment with fungicidal chemicals for control of the disease.

CAUSAL ORGANISM

During the summer and fall rainy season of the years 1941, 1942 and 1943, the Genetics Department of this Station was confronted with a serious case of damping-off of pepper (*Capsicum annuum* and *C. frutescens*). Several hundred seedlings obtained from crosses of the hot Mexican pepper known as "Cuaresmeño" and the variety "California Wonder", grown in flats in steamed soil (15 pounds for 2 hours), or formaldehyde treated (1 part to 40 of water), were completely lost due to damping-off. The soil used in every instance was a mixture of three parts of alluvial clay loam soil and one part of "cachaza", decomposed filter press cake from the sugar mills. Cultures in agar plates were made by planting pieces of infected tissues of pepper seedlings showing symptoms of damping-off. Tissue plantings were also made from diseased eggplant varieties "Rosita" and "Puerto Rican Beauty" seedlings found in seed and plant beds. Tissue plantings of diseased tomato, pepper and eggplant seedlings from the field were made during the course of the two years.

In a great majority of plates a rapidly growing fungus with coarse, septate, and branching mycelium, was obtained. The mycelium turned slightly brownish or dark-brown with age, grew irregularly, and formed large, aerial, coriaceous masses of sclerotia in culture. The characteristics of the organism in culture and in plants indicate a strain of *Rhizoctonia solani* Kühn.

The general cultural characters of the isolates from pepper and eggplant seedlings conformed very closely with those already described by Matz (7) for *R. solani*. Several *Fusaria* were also obtained on poured plates and were isolated in pure culture. Fifty isolates of *R. solani* were compared morphologically and physiologically, and there were no apparent differences among them. Pure cultures of *R. solani* and other organisms were obtained by spore and hyphal-tip isolations and were labelled R-1, R-3, R-50, F-1, F-2, F-15; indicating *Rhizoctonia* and *Fusarium*, respectively.

ECONOMIC IMPORTANCE AND DISTRIBUTION

The widespread occurrence of *Rhizoctonia* damping-off and the fact that the pathogen can live indefinitely in the soil, makes this a very serious disease of vegetable crops in Puerto Rico.

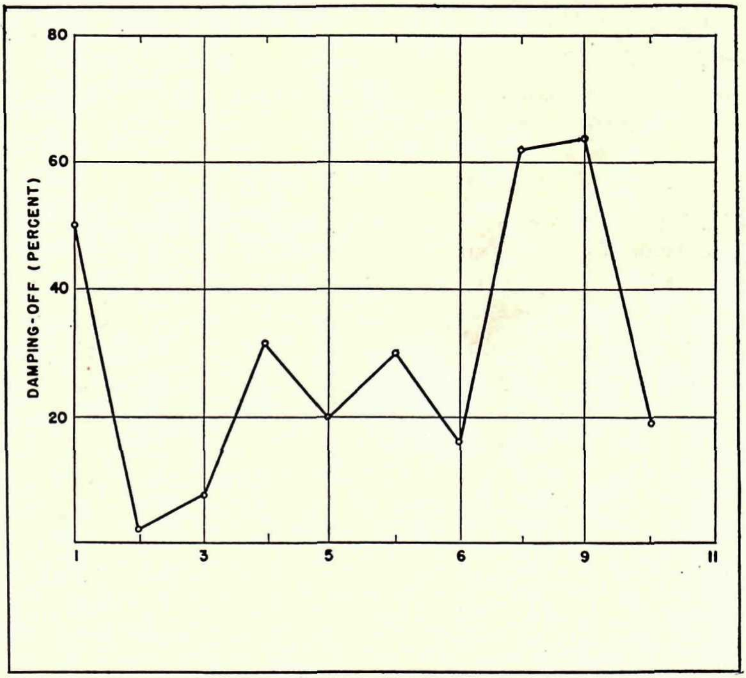

FIG. 1. Distribution of *Rhizoctonia solani* in various fields in Station ground

Damping-off in seed and plant beds has been very serious and 100 per cent losses have frequently been reported.

Preliminary observations of the incidence of the disease in pepper and eggplant seedlings have revealed a high degree of soil infestation of *Rhizoctonia* sp. in various fields at the Station.

The general distribution of these organisms in various fields is shown in graph No. 1. Fig. 1.

PATHOGENICITY

Eight isolates of *Rhizoctonia solani* from different seedbeds were tested for pathogenicity. Four *Fusaria* were similarly selected for comparative tests with the *R. solani* isolates.

Four-inch pots filled with a soil mixture of three parts alluvial, clay loam soil and one part of "cachaza" were steamed for two hours at 15 pounds pressure. Soon after cooling, the pots were arranged in 10 blocks of 13 pots each, on a cement table inside the plant pathology greenhouse. Pots of each block were numbered 1 to 13 at random, thus allowing 10 replicates for each culture.

Each corresponding pot of each block was infested with a corresponding culture. This was accomplished by taking one inch of soil from each of the 10 corresponding pots, mixing the soil in a steam sterilized, enameled pan; and adding to the soil a mixture of small pieces of mycelium and sclerotia from a mycelial mat 10 cm. in diameter. One separate culture of *R. solani* or one of *Fusarium* sp. was used in each soil treatment. The mycelial mat was obtained by growing the organisms separately in Coon's solution. The *Rhizoctonia* and the *Fusaria* grew well in this medium, the former producing abundant sclerotia and the latter abundant conidia. The mycelial mat of each culture was macerated with sterile sand in a sterile mortar thus obtaining a uniform mixture of the soil and macerate. One inch of the infested soil mixture was added to each corresponding pot in each block so that a uniform distribution of inoculum resulted.

Control pots were treated similarly but were not infested; sand only was added. Thirty eggplant seeds of the variety "Rosita" were sown in each replicate pot, totalling 300 seeds per treatment. The seed was sown one half inch deep and watered immediately. The rapid evaporation of water in clay pots necessitates daily watering. Records of germination, pre-emergence and post-emergence failures were taken daily for a period up to 15 days after germination. Damping-off occurred and killed most seedlings within the first three to five days after emergence (table 1).

The results obtained show that all *R. solani* isolates from eggplant and pepper seedlings, causing damping-off in seedbeds at the Station, are virulent and perhaps belong to the same strain. No significant differences existed among them, though there existed a marked difference in pathogenicity between the *R. solani* isolates and those of *Fusaria*. The results also show that the latter organisms are of no apparent importance in producing damping-off in pepper and eggplant. Tomato seedlings showed marked resistance to *Rhizoctonia*.

Reisolations from each corresponding group of 10 replicates of all damped-off seedlings yielded, in every instance, the fungus *R. solani*.

THE DISEASE

Post-emergence symptoms of damping-off of pepper and eggplant were characterized by the appearance of water-soaked areas on succulent stems at the soil level. The affected areas became black, necrotic, shrunken, and

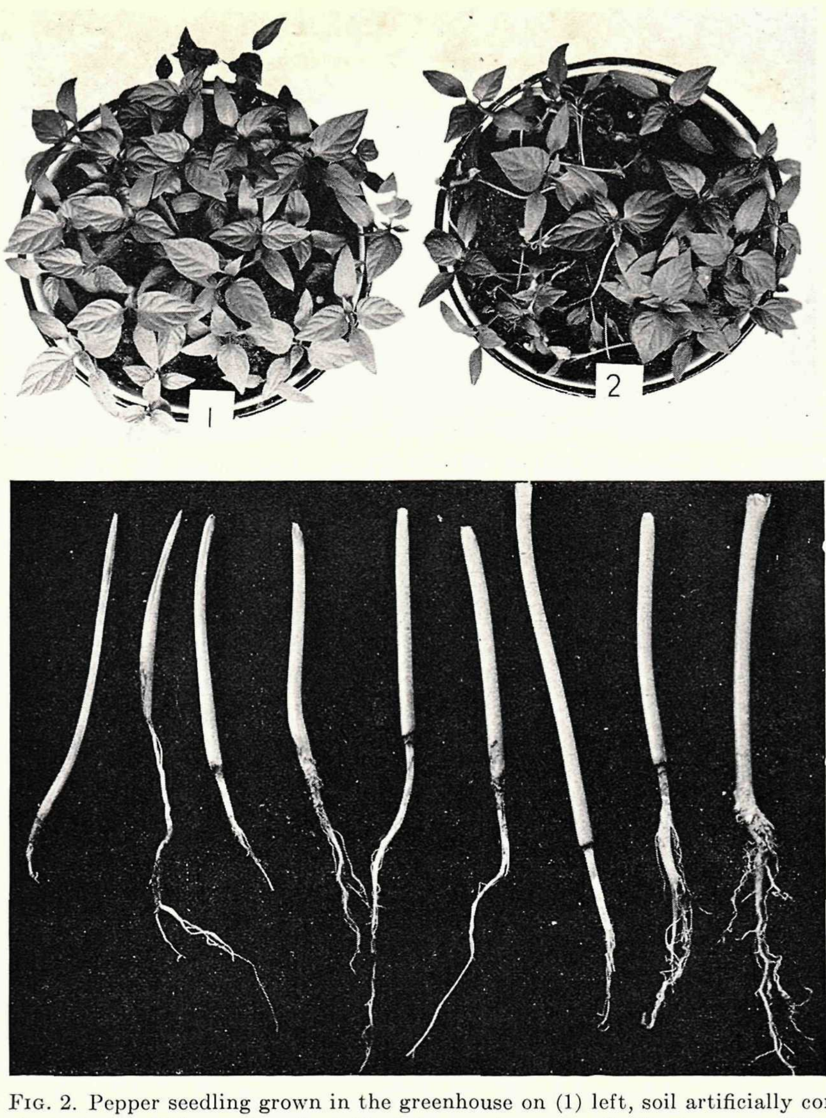

FIG. 2. Pepper seedling grown in the greenhouse on (1) left, soil artificially contaminated with *Rhizoctonia solani* (2) right, on steamed soil (3). Pepper seedlings grown on contaminated soil showing collar rot injury due to infection with *Rhizoctonia solani*.

the plants toppled over and dried up. The symptoms appeared almost immediately after emergence of seedlings, or within the first week of growth, when the tissues were succulent and more susceptible.

TABLE 1

Pathogenicity trial with single-hyphal-tip and monosporial cultures of fungi upon eggplant in steamed soil. Three hundred eggplant seeds variety "Rosita" were sown for each treatment*

Fungus	Culture number	Damping-off—failures				Total failure§	
		Pre emer-gence†	Pre emer-gence‡	Pre emer-gence	Post emer-gence		
		number	*number*	*per cent*	*per cent*	*number*	*per cent*
Rhizoctonia solani	R-1	200	40	85	100	240	100
Strains	R-2	189	40	84	79	229	95
"	R-3	167	39	69	50	196	81
"	R-7	215	25	89	100	240	100
"	R-9	195	39	81	86	234	97
"	R-11	199	22	82	53	221	92
"	R-15	222	17	92	94	239	99
"	R-41	211	20	91	78	231	96
Fusarium spp.	F-1	30	5	12.5	2.4	35	14
	F-7	19	0	8	0	19	8
	F-9	10	7	4.5	3	17	7
	F-13	17	3	7	1.2	20	8.5
Control	¶	5	—	2	0	5	2

* Three hundred seeds 80 per cent germination in control.

† Pre-emergence failure, per cent $= \frac{\text{240-seed germinated}}{240}$.

‡ Post-emergence failure, per cent $= \frac{\text{Post-emergence failure}}{\text{240-seed germinated}}$.

§ Total failure, per cent $= \frac{\text{Pre} \div \text{post-emergence failures}}{240}$.

¶ Not inoculated.

Analysis of variance for mean-square difference between organisms, according to data for table 1

	Degrees of freedom	Sum of squares	Mean square	F[1]
Total	129	14.404		
Blocks	9	8.479		
Treatment	12	3.913	326	12**
Error	108	2.012	18.6	

** Significant at the 1 per cent point

Pepper and eggplant were very susceptible during the first week after emergence. There was a marked resistance with increasing age of seedlings. Under field conditions, damping-off of pepper and eggplant was characterized by the blackening and shrinking of stem tissues at the soil level and extending up the stem, never down to the roots. In very wet soils, or during periods of heavy rainfall, the fungus was observed as a white web on the necrotic stem lesions. No sclerotia, however, were found on infected tissues of diseased plants (fig. 2. photo of diseased pepper seedlings).

TEMPERATURE

Temperature Relations of Rhizoctonia Solani

Cultures of *R. solani* were grown on potato two per cent dextrose agar and incubated at different temperatures. Four duplicates were made for

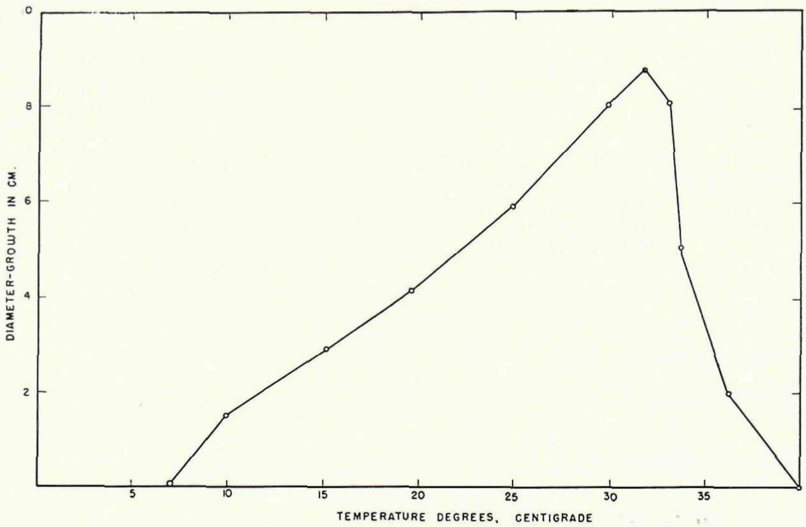

FIG. 3. Growth of *Rhizoctonia solani* in 90 hours at various temperatures

each incubation temperature. Measurements of two diameter at right angles to each other for each colony were taken daily and increments in diameter of growth during a three day period also were taken. The average diameter for each set of four plates was recorded. Maximum growth appeared to be at 28–32°C., and a sudden decrease occurred at 34°C. Very slow growth resulted below 20°C.

High temperatures were found favorable to the occurrence of *Rhizoctonia* damping-off. Pathogenicity tests conducted in greenhouses (22–40°C.) showed significant results as to the amount of damping-off caused by strains of *Rhizoctonia*. The incidence of the disease, therefore, seems to substantiate the published statements that strains of *Rhizoctonia* cause damping-off at high temperatures. In our tests, the average temperature was approximately 28°C.

ACIDITY

Effect of pH of Substrate on Growth

To determine a possible correlation of soil acidity with the development of the organism, *R. solani* was grown on potato two per cent dextrose agar adjusted to varying pH value. Lots of four plates, each lot adjusted to a different pH value, were separately planted with mycelial disks, approximately 0.5 cm. in diameter, of the fungus and set aside at 28°C., in the dark. Twenty-four hour increments in diameter-growth of the colonies were recorded. These measurements showed that the organism grew favorably at pH values near neutrality or slight alkalinity.

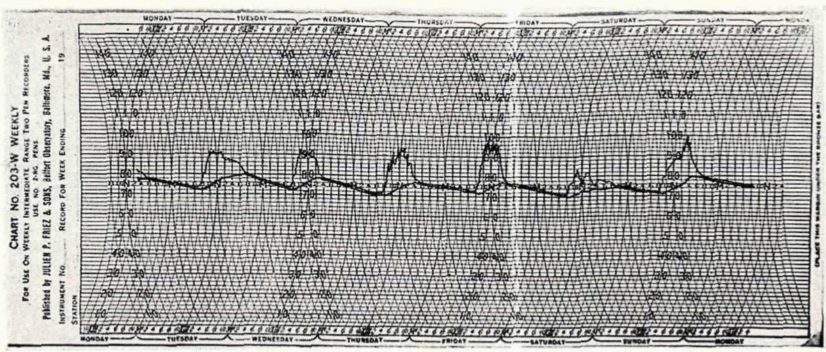

FIG. 4. Graph showing weekly fluctuation of soil and air temperatures in the greenhouse. Smooth curve represents soil temperature and broken curve air temperature.

The growth of *R. solani* species at varying pH values of substrate has been determined by many investigators and there is much divergence among the observations reported (6, 13). The variations reported for the optimum acidity for growth may be explained on the basis of diversified strains of the fungus.

Acidity and Damping-off

No experiments were conducted to determine the effect of soil acidity on the occurrence of damping-off. It was observed that all the pH determinations of soil samples taken from seed and plant beds where the disease had been serious, ranged from pH 5.00–6.50. Observations reported for similar investigations have shown that damping-off caused by *Rhizoctonia* spp. is abundant in either acid or alkaline soils (3, 13).

Soil mixtures of three parts of alluvial, clay loam soil and one part of "cachaza" are generally used in the Station in seed and plant beds. They water at all times. The practical aspect of the problem has primarily been considered.

.The percentage of damping-off was very high. The surface layers of the soil were saturated in all cases because water was added daily to replace that lost by evaporation.

The results revealed that the amount of soil moisture is very important, provided that the water is near the surface layers. In all probability, different results could have been obtained if water had been supplied from the bottom by capillarity. Farmers apply water by means of sprinklers and use capillary irrigation in only a few instances.

TABLE 2

Varietal behavior of Capsicum annuum and C. frutescens when grown on Rhizoctonia solani artificially infested soil

Number	Variety of pepper	Amount viable seed sown	Damping-off failure				Failure	
			Pre-emergence failure	Post-emergence failure	Total			
					Pre-emergence	Post-emergence		
			number	*number*	*per cent*	*per cent*	*number*	*per cent*
1	Early Giant	800	415	83	52	22	498	62
2	Windsor A	800	400	175	50	43	575	72
3	Tabasco	800	242	177	30	32	419	52
4	King of the North	800	350	59	44	13	409	51
5	Red Chili	800	131	43	16	6	174	22
6	Maule's Red Hot	800	135	136	17	20	271	34
7	Sweet Meat Glory	800	114	57	14	8	171	21
8	Large Early Neapolitan	800	165	57	21	9	222	28
9	Large Red Cheyenne	800	70	140	9	19	210	26
10	Hungarian's Way	800	144	127	18	19	271	34
11	Chinese Giant	800	155	56	19	9	211	26
12	Fordhook	800	496	85	62	28	581	73
13	Large Chemy	800	85	40	11	6	127	16
14	Sweet Banana	800	301	55	38	11	356	45
15	World Beaters	800	63	82	8	11	145	16
16	Yellow Oskosh	800	66	43	8	6	109	14
17	Ruby King	800	341	81	43	18	422	53
18	Bull Nose	800	152	96	19	15	248	31
19	California Wonder	800	247	97	31	18	344	43
20	Large Bell Hot	800	242	54	30	10	296	37
21	Sunny Broock	800	338	44	42	10	382	48

$$\text{Per cent pre-emergence} = \frac{\text{seed sown} - \text{seed germinated}}{800}.$$

$$\text{Per cent post-emergence} = \frac{\text{post-emergence failure}}{\text{seed sown} - \text{pre-emergence failure}}.$$

Summary of analyses of variance for data of table 2

Comparison of failures	DF	Sum of squares	Variance	F.
Post-emergence (per cent basis) failure				
Total	167	76,000		
Blocks	7	4,447		
Varieties	20	7,337	366.8	0.80
Error	140	64,216	458.7	
Pre-emergence failure				
Total	167	121,875.9		
Blocks	7	20,249.8		
Varieties	20	41,549.6	2,077.5	4.84*
Error	140	60,076.4	429.1	
Total failure				
Total	167	132,826		
Blocks	7	12,286		
Varieties	20	36,358	1,817.9	3.02*
Error	140	84,182	601.3	

* Significant at the 1 per cent level.

Reports of the Weather Bureau for the last 36 years show that eight months in a year have a monthly average rainfall of more than 6 inches. The heavy nature of the soil around Río Piedras and the abundant rainfall favor the development of damping-off.

VARIETY TEST

Testing Pepper Varieties for Resistance to Damping-off

Twenty-one varieties of sweet and hot peppers *Capsicum annuum* and *C. frutescens* were tested for resistance to damping-off caused by *Rhizoctonia solani*. One hundred seeds of each variety were sown in rows in blocks in a pan and replicated eight times, a total of 800 viable seeds per variety, considering in each case the percentage of germination in sterilized soil. The soil used was the above-mentioned mixture with "cachaza," to which macerates of sclerotia and mycelium of pure cultures of the organism were added. The seed was sown ½ inch deep and the soil was watered immediately after sowing with a sprinkler, until saturation resulted. The pan was drained at the bottom to prevent water logging.

Diseased seedlings from each row were pulled up for tissue plating. *R. solani* constantly was associated with damping-off.

There were significant differences in susceptibility in the pre-emergence stage of development of the pepper varieties investigated. It is apparent, therefore, that at this early stage of development some varieties are either more susceptible to attack by *R. solani* than others, or the possibility exists that even though an equal amount of seeds was sown, based on germination tests, they did not germinate according to expectancy.

Records obtained during the post-emergence stage demonstrated no differences in susceptibility of varieties tested. Analysis of pre- and post-emergence failures showed that some varieties were more susceptible than others. All varieties were equally susceptible to damping-off, if only the post-emergence failure was considered.

Analysis of variance of a varietal test with eggplant varieties "Rosita," "Puerto Rican Beauty" and "Black Beauty" showed no significant differences in susceptibility. Tomatoes were also attacked by the isolates of *R. solani*. Pritchard and Porte (12) found in a study of collar rot of tomatoes that a strain of *R. solani* caused only three per cent infection in seedbeds, while *Verticillium lycopersicii* and *Macrosporium solani* produced 64 and 75 per cent infection, respectively.

FUNGICIDAL TREATMENT

Effect of Seed and Soil Treatment in Controlling Damping-off

The value of seed and soil treatment for the control of damping-off of many vegetable crops has been well established. Seed and soil treatment is most effective in soils with a moderate "inoculum potential". The effectiveness of various fungicidal dusts recommended for seed and soil disinfection was tested for the control of damping-off of pepper and eggplant caused by *Rhizoctonia solani*. Both naturally and artificially inoculated soils consisting of three parts of alluvial, clay loam soil and one part "cachaza," pH 6.54, were used in the tests.

Two hundred four-inch pots were filled to one inch from the top with the above-mentioned soil mixture. The pots were steamed for two hours at 15 pounds pressure and soon after cooling were placed on sand beds in an insect-free insectary inside a greenhouse. The plan for the test was a random-block design consisting of 10 blocks of 40 pots each. Twenty of the 40 pots of every block were filled with naturally infested soil. Pots not steamed were labelled with odd numbers from 1 to 39. Steamed pots were labelled from 2 to 40. Pots 2 to 40 were infested with equal proportions of macerates of mycelial mats of *Rhizoctonia solani* grown in Coon's liquid medium.

Seed Treatment

Five hundred seeds in each case were treated separately with one chemical, except groups 19 and 20 which served as checks. Sufficient chemical dust was added to every lot of seed to cover its surface. The surplus chemical was separated by means of a fine-mesh-wire screen.

Twenty-five seeds of each treatment were sown in corresponding pots in each block. The pots were watered with sterile water immediately after sowing the seed.

Analysis of the results indicated a very definite effect upon the type of infestation and the effectiveness of the fungicides. Significant differences were obtained among the fungicides tested when compared with either naturally or artificially infested soil. The mean square of variance corresponding to differences between fungicidal treatments and the type of infestation, the interaction of type and infestation, and their mean square for error, exceeded the one per cent level, indicating, therefore, the degree of effectiveness of the treatments.

Interpretation of Results Obtained from Analysis of Variance

Pre-emergence Failure:

On naturally infested soil: The least significant difference among treatments showed that the degree of damping-off during the pre-emergence stage of seedlings development was low, indicating a low "inoculum potential" of the soil. None of the fungicidal treatments tested seemed to promote a better germination of the seed because of either fungicidal or perhaps stimulatory effects. Statistically, these fungicides were equally ineffective when compared with the check, number 19. This can be interpreted on the basis of low "inoculum potential" of the soil which enabled the seed of all pots to germinate equally well.

However, "Spergon," "Arasan," "1155 H. H.," "2% Ceresan" and "New Improved Ceresan" apparently were injurious to the seed. This is indicated by the low percentage of germination which statistically is significant when compared with the check, number 19.

On artificially infested soil: "Semesan," "Z-O," "Dipdust," "Cuprous Oxide," "Zinc Oxide" and "Coppercarb" were equally effective in controlling pre-emergence failure. The percentage of germination was statistically higher when compared with the corresponding number of seedlings emerging in the check, number 20.

"New Improved Ceresan," "1155 H. H.," and "2% Ceresan" again proved toxic to the seed, and reduced viability materially and statistically when compared with the check, number 20.

Post-emergence Failure:

On naturally infested soil: "Coppercarb," "Barbak D.," "Fermate" and "Dipdust" showed some harmful effects because the percentage of failure was statistically higher than that obtained in the check, number 19 which was zero. Other treatments were equally ineffective in preventing post-emergence damping-off.

On artificially infested soil: "Spergon," "Cuprous Oxide," "1155 H. H.," "2% Ceresan," "Cupric Oxide" and "Barbak D." were equally effective in preventing post-emergence failure. The percentage of surviving seedlings was statistically higher than that obtained in the check, number 20. "New Improved Ceresan," "Semesan Jr." and "Dipdust" treatments were statistically inferior when compared with the check, number 20.

Pre- and Post-Emergence Failure:

On naturally infested soil: No fungicide caused statistically higher percentages of germination and development of emerged seedling than that observed in the check, number 19. "Spergon," "1155 H. H.," "2% Ceresan" and "New Improved Ceresan," however, reduced the germination and development of seedlings below that of the check, number 19.

On artificially infested soil: "Bayer Compound No. 1494" was effective in preventing post-emergence damping-off of seedlings, either before or after emergence of the seedlings. The effect was statistically higher than that obtained in the check, number 20. "New Improved Ceresan" demonstrated once more a toxic effect on the seed, as shown statistically in comparison with the check, number 20.

Soil Treatment

The same procedure used in preparing pots for testing the effectiveness of the seed treatment was followed, except that the soil and not the seed was treated with chemical dusts. All treatments were applied at the rate of 1.0 gram per square foot of soil, except that for zinc oxide, which was applied at the rate of 10.00 grams per square foot of soil. The soil for each treatment was separately and evenly mixed with one chemical. After a thorough mixing, the infested soil was placed in 10 corresponding pots and one pot was distributed in each block.

Result of Analysis of Variance for Soil Treatment:

Pre-emergence Failure: On naturally infested soil: In accordance with results obtained from soil treatment, all fungicides were apparently equally ineffective in preventing damping-off, when compared statistically with the check, number 19. None of the treatments were either better or worse than the check. No treatment showed toxic effects upon the viability of the seed.

On artificially infested soil: All treatments were equally ineffective in preventing pre-emergence failure and none were better or worse than the

TABLE 3

Effect of seed treatment on pre-emergence, post emergence and total emergence failure of eggplant seedlings, variety "Rosita." Seed sown, 250. Soil infested with Rhizoctonia solani (isolated from eggplant seedlings)

Number	Trade name	Treatment	Manufacturing house	Damping-off: Pre-emergence	Damping-off: Post-emergence	Damping-off: Total: Pre-emergence	Damping-off: Total: Post-emergence	Total failure	
				number	*number*	*per cent*	*per cent*	*number*	*per cent*
1	Arasan	Tetramethyl-	Bayer-Semesan Co.	25	0	10	0	25	10
2	"	thiurum-bisulfide. 50%.	"	81	138	32	82	219	88
3	Spergon	Tetrachloro-para-	U. S. Rubber Co.	67	18	27	10	85	34
4	"	benzoquinone	"	95	91	38	59	186	74
5	New improved ceresan	Ethyl-mercury-phosphate 5%	Bayer-Semesan Co.	247	0	99	0	247	99
6	" "		"	249	0	100	0	249	100
7	Fermate	Ferric-dimethyl-	Graselli Chem. Div.	32	20	13	9	52	21
8	"	di thio-carbamate	" "	82	108	32	64	188	75
9	Du Bary 1155 H. H.	Ethyl-mercury-iodide 5%.	Bayer-Semesan Co.	151	1	60	1	152	61
10	" "		"	173	31	69	40	204	82
11	Dipdust	Hydroxy-mercury-	Bayer-Semesan Co.	23	23	9	10	46	18
12	"	chloro-phenol-sulphate 6%	"	45	171	18	83	216	86
13	Semesan	Hydroxy-mercury-	Bayer-Semesan Co.	23	0	9	0	23	9
14	"	chlorophenol. 30%	"	21	161	8	70	182	73
15	2% Ceresan	Ethyl-mercury-	Bayer-Semesan Co.	219	0	88	0	219	88
16	"	chloride. 2%	"	224	9	90	35	233	93
17	Z-O			22	0	8	0	22	9
18	"			30	141	12	64	171	68
19	Check			27	0	11	0	27	11
20	"			138	70	55	25	208	83
21	Coppercarb	Copper carbonate	Tennessee Copper	35	33	14	15	68	27
22	"	" "	Corp.	74	131	30	74	205	82
23	Cuprocide	Cuprous oxide	Rahn & Hass Co.	34	20	14	9	54	22
24	"	" "	"	93	80	37	51	173	69
25	ZN-O		Rahn & Hass Co.	27	0	11	0	27	11
26	"		"	73	106	29	60	179	72
27	Cupric oxide	Cupric oxide	General Chemical	33	7	13	3	40	16
28	" "	" "	Co.	123	38	49	30	161	64
29	Uspulun	Chlorophenol mercury	Bayer-Semesan Co.	61	2	24	1	63	25
30	"	" "	"	144	85	58	80	229	92
31	Barbak D	Mercuric phenyl cyanamid 6%	Am. Cyanamid & Chem. Co.	98	1	39	0	99	40
32	"	"	"	161	35	64	39	196	78
33	Dupont no. 1		E. I. Dupont Co.	15	8	6	3	23	9
34	"		"	164	46	66	53	210	84
35	Cuprous oxide	Cuprous oxide	Mallinckrodt Co.	25	1	10	0	26	10
36	" "	" "	"	165	85	66	100	250	100
37	Semesan Jr.	Ethyl mercury phos-	Bayer-Semesan Co.	40	22	16	10	62	25
38	"	phate 1%	"	80	149	32	88	229	92
39	Bayer compound no. 1494		Bayer-Semesan Co.	66	20	26	11	86	34
40	" "		"	147	74	59	72	221	88

(1) Odd numbers = naturally infested soil.
(2) Even numbers = artificially infested soil.
(3) Per cent calculation on the basis of 250 seeds that germinated in controls.

Analysis of variance for table 3

Failures	Degrees of freedom	Sum of squares	Variance	F.
Pre-emergence				
Total	399	26,094.1		
Blocks	9	572.28		
Treatments	39	18,060.2	463.08	21.78*
Kind of infestation	1	2,475.0	2,475.0	116.46*
Types	19	6,923.0	364.0	17.12*
Infestation x types	19	8,662.2	456.0	21.45*
Error	351	7,461.62	21.25	
Post emergence (per cent basis)				
Total	399	530,526		
Blocks	9	6,880		
Treatments	39	446,162	1,145.0	52.0*
Kind of infestation	1	327,177	327,177	1,032.0*
Types	19	28,342	1,491.2	6.7*
Infestation x types	19	1,563.27	8,227	37.3*
Error	351	77,484	220.0	
Total failure				
Total	399	35,301.5		
Blocks	9	609.5		
Treatments	39	22,511.3	577.2	16.6*
Kind of infestation	1	13,294.1	13,294.1	38.3*
Types	19	5,498.4	289.3	8.3*
Infestation x types	19	3,718.8	195.2	5.6*
Error	351	12,180.7	34.7	

* Significant at the one per-cent level.

check, number 20; but "Spergon," "Dipdust," "Fermate," "New Improved Ceresan" and "Semesan Jr.," apparently reduced germination.

Result of Analysis of Variance for Total Failure: On naturally infested soil: "Spergon," "1105 H. H.," "Zinc Oxide," "Bayer Compound No. 1494," "Semesan," "Dipdust," "2% Ceresan," "Z-O," "Uspulun," "Fermate," "Dupont No. 1." "Cupric Oxide," "Coppercarb," "Arasan," "New Improved Ceresan," "Cuprous Oxide," "Barbak D.," "Cuprocide" and "Semesan Jr." were equally effective in controlling damping-off. None of the treatments was inferior to the check number 19.

On artificially infested soil: "Zinc Oxide" applied at the rate of 10 grams per square foot of soil was effective in preventing damping-off when compared statistically with the check, number 20. "Dipdust," "Cuprous Oxide," "Cuprocide," "Dupont No. 1," "Semesan," "Spergon," "2% Ceresan" and "1155-H. H." were equally ineffective and showed no significant difference to the check.

"Fermate," "Z-O," "Arasan," "New Improved Ceresan," "Coppercarb," "Cupric Oxide," "Uspulun," "Barbak D.," "Semesan Jr." and "Bayer Compound No. 1494" were statistically considered, equally inferior to the check.

TABLE 4

Effect of soil treatments on pre-emergence and post-emergence failure of eggplant seedlings, variety "Rosita." Seed sown, 250. Fungicides applied one week before sowing seed at the rate of 1.0 gram per square foot of soil. Soil naturally and artificially infested with Rhizoctonia solani (isolated from eggplant seedlings)

Number	Trade name	Treatment	Manufacturing house	Damping-off failures: Pre-emergence	Damping-off failures: Post-emergence	Damping-off failures: Total: Pre-emergence	Damping-off failures: Total: Post-emergence	Total failure	
				number	*number*	*per cent*	*per cent*	*number*	*per cent*
1	Arasan	Tetramethyl-	Bayer-Semesan Co.	60	0	24	0	60	24
2	"	thiurum-bisulfide. 50%	"	246	4	98	100	250	100
3	Spergon	Tetrachloro-para-	U. S. Rubber Co.	44	17	18	8	61	24
4	"	benzoquinone	"	173	50	69	75	223	89
5	New improved ceresan	Ethyl-mercury-phosphate. 5%	Bayer-Semesan Co.	43	21	17	10	64	26
6	" "		"	200	45	80	90	245	98
7	Fermate	Ferric-dimethyl-	Graselli Chem. Div.	57	0	23	0	57	23
8	"	dithio-carbamate	of E. I. DuPont Co.	189	55	76	90	244	98
9	Du Bary 1155-H. H.	Ethyl-mercury-iodide 5%	Bayer-Semesan Co.	27	0	11	0	27	11
10	" "		"	215	33	86	94	248	99
11	Dipdust "	Hydroxy-mercury-chlorophenol-sulphate 6%	Bayer-Semesan Co. "	56	3	22	2	59	24
12	Dipdust "	Hydroxy-mercury-nitrophenol sulphate 2%	"	178	47	71	65	225	90
13	Semesan	Hydroxy-mercury-	Bayer-Semesan Co.	49	4	20	2	53	21
14	"	chlorophenol. 30%	"	74	162	30	92	236	94
15	Ceresan	Ethyl-mercury-	"	56	0	22	0	56	22
16	"	chloride. 2%	"	128	95	51	78	223	89
17	Z-O		"	46	10	18	5	56	94
18	"		"	151	98	60	99	249	100
19	Check	Check		66	163	26	89	229	92
20	"	"		93	108	37	69	201	80
21	Coppercarb	Copper carbonate	Tennessee Copper	43	39	17	19	82	33
22	Corona	"	Corp.	117	133	47	100	250	100
23	Cuprocide	Cuprous oxide	Rahn & Hass Co.	32	72	13	33	104	42
24	Yellow Copper oxide	"		73	150	29	85	223	89
25	Aaz	Zinc oxide	Rahn & Hass Co.	31	0	12	0	31	12
26	Speal	"		68	129	27	71	197	79
27	Cupric oxide	Cupric oxide	General Chemical	33	43	13	20	76	30
28	"	"	Co.	72	178	29	100	250	100
29	Uspulun	Chlorophenol mer-	Bayer-Semesan Co.	36	21	14	10	57	23
30	"	cury	"	125	125	50	100	250	100
31	Barbak D	Mercuric phenyl	Am. Cyanamid &	60	41	24	22	101	40
32	"	cyanamid 6%	Chem. Co.	132	118	53	100	250	100
33	Dupont No. 1		E. I. Dupont Co.	59	20	24	10	79	32
34	"		"	93	157	37	100	250	100
35	Yellow Copper oxide	Cuprous oxide	Mallinckrodt Co.	49	18	20	9	67	27
36	"	"	"	109	118	44	84	227	91
37	Semesan Jr.	Ethyl mercury phos-	Bayer-Semesan Co.	72	37	29	21	109	44
38	"	phate 1%		207	43	83	100	250	100
39	Bayer 1494		Bayer-Semesan Co.	46	0	18	0	46	18
40	"		"	130	119	52	99	249	100

(1) Odd numbers = naturally infested soil.
(2) Even numbers = artificially infested soil.
(3) Per cent calculation on the basis of 250 seeds that germinated in controls.

Analysis of variance for table 4

Failures	Degrees of freedom	Sum of squares	Mean squares	F.	Least square difference
					per cent
Pre-emergence					64.75
Total	399	34,566.76			
Blocks	9	5,308.96	589.74		
Treatments	39	22,773.76	583.94	31.61*	
Kind of infestation	1	526.2	526.2	28.48*	
Type	19	13,904.2	731.5	39.06	
Type x infestation	19	8,343.36	439.12	23.12	
Error	351	6,484	18.47		
Total Failures					18.65
Total	399	32,390.2			
Blocks	9	156.3			
Treatments	39	29,232.9	749.0	131*	
Kind of infestation	1	27,208.5	27,208.5	477.3*	
Type	19	1,587.85	83.5	14.4*	
Type of infestation	19	536.55	28.2	4.9*	
Error	351	2,001.9	5.7		

* Significant at the one per-cent level.

TABLE 5

Greenhouse toxicity test with eggplant seed "Rosita" dusted with fungicidal chemicals before sowing on steam-sterilized soil. Air temperature inside greenhouse 70–100° F. Relative humidity 40–60%. Soil saturated twice daily

No.	Chemical trade name	Total emergence from 250 seeds	
		number	*per cent**
1	New Improved Ceresan	101	43
2	Du Bary 1155-HH.	139	60
3	2% Ceresan	125	54
4	Check	232	100
5	Spergon	234	100
6	Arasan	209	90
7	Dipdust	232	100
8	Bayer 1494	196	84

* Calculated on the basis of 232 seeds germinated in control.

Analysis of variance for table 5

Emergence	D.F.	Sum of squares	Variance	F.
Total	79	2933		
Blocks	9	84	9.3	
Treatment	7	2037	291	25.9†
Error	63	712	11.3	

† Significant at the 1% level.

It is evident from the results analyzed that the soil treatment was effective in those soils with a low "inoculum potential".

Some fungicides are powerful poisons and under certain conditions might cause death of vegetable seeds. In these studies, 2% "Ceresan," "Du Bary 1155-H. H." and New Improved Ceresan showed this toxicity to eggplant seeds. The results of a toxicity test are shown in table 5.

The least square difference among dust treatments show that "New Improved Ceresan," "Du Bary 1155-H. H." and "2% Ceresan," were equally and significantly injurious to eggplant seed.

CONCLUSIONS AND SUMMARY

Damping-off of vegetable crops in Puerto Rico is of great economic importance. Studies of the causative agent or agents, the symptomatology of the disease, the host-parasite relationship, the distribution, epiphytology and saprogenesis were considered necessary before attempting to formulate pertinent measures of control for this particular problem.

It is apparent from the data obtained that *Rhizoctonia solani* and possibly other organisms are chiefly responsible for the damping-off losses of pepper and eggplant seedlings both in seed and plant beds and in the field.

Damping-off was serious during the first three to seven days after seedling emergence. Thereafter, the ability of the organism to cause damping-off diminished rapidly as the age and hardness of the tissues increased. The injury to recently emerged seedling was a soft, wet and dark rot of stems near the soil level, which soon spread upward and seldom downward. The infected seedlings toppled and finally died. In older plants, the infected stem tissues turned dark and became shrunken. Old plants withstood the disease much better than seedlings. Many plants in the field succumbed to the disease during periods of heavy rainfall.

The *Rhizoctonia* species responsible for the damping-off were very active under our climatic conditions, i.e., a high temperature ranging from 26 to 30°C. the year round, and a high soil and air moisture content. The high water-holding capacity of soils around Río Piedras, and the high rainfall of this locality are important factors for the development of the disease.

The organism grew well at varying pH values of the substrate, particularly at pH values approximately neutral. Considering that pH determinations of top layers of soil from various fields and soil mixtures (three parts of alluvial, clay loam soil and one part of "cachaza") were found to be more alkaline than a pH of 6.00, the presence of the parasite and the development of the disease would be expected in these soils.

The *Rhizoctonia* under consideration has not been observed to produce sclerotia in tissues of diseased pepper or eggplant. However, sclerotia are produced profusely in culture media, particularly in Coon's synthetic liquid medium. Though it has not been possible to find sclerotia on infected plants, the occurrence of the organism in the soil is apparent from observations made repeatedly upon soil samples. Samples of soil mixtures taken from time to time have shown constantly the presence of the parasite.

Soil sterilization with steam for three hours at 15 pounds pressure was found very effective in preventing damping-off. Formaldehyde was especially effective at a concentration of one part to 20 of water. If precautions were not taken, damping-off was likely to appear in steamed and formaldehyde treated soils due to re-contamination. Many failures occurring in our seed and plant beds were attributed to re-contamination.

In view of the importance of rendering soil mixtures for pots, flats and plant beds free from damping-off organisms, and also in view of the impossibility for many farmers to practice steaming or treating the soil with formaldehyde because of its relatively high cost, several fungicidal dusts were tested for effectiveness in controlling damping-off.

Among the fungicides tested, "Semesan," "Z-O," "Dipdust," "Cuprous Oxide," "Coppercarb," "Zinc Oxide," "Semesan Jr.," "Arasan," "Fermate" and "Spergon" were found equally effective as seed disinfectants for the control of the pre-emergence phase of *Rhizoctonia* damping-off. The small dose used for seed treatment had no residual effect to control post-emergence damping-off. Considering that great losses result every year due to pre-emergence failure, diminishing pre-emergence damping-off is a great saving of time and money.

All treatments for soil disinfection proved equally ineffective in preventing post-emergence failure.

Analysis of total failure, however, showed the effectiveness of soil treatment with "Spergon," "1155 H. H.," "Zinc Oxide," "Bayer Compound 1494", "Semesan," "Dipdust," "2% Ceresan," "Z-O," "Uspulun," "Fermate," "Dupont No. 1," "Cupric Oxide," "Coppercarb," "Arasan," "New Improved Ceresan," "Cuprous Oxide," "Barbak D.," "Cuprocide' and "Semesan Jr." in preventing damping-off in naturally infested soil.

It is apparent that mercurial and copper fungicides have a decided fungicidal effectiveness as seed and soil treatments for controlling *Rhizoctonia solani*. Montieth and Harmon (8) obtained similar results in the case of brown patch of turf caused by *Rhizoctonia* spp. "Uspulun," "Semesan," "Germesan," "Corona 620" and "Corona 640" were found effective. These workers found that mercurials in the form of sulphate, oxide, chloride and nitrate were effective for controlling the disease. Mercurous chloride was the most effective and the most economical considering that

$\frac{1}{5}$ of a pound was as good as one pound of "Uspulun" or "Semesan". Thomas (15) found copper carbonate, mercuric bichloride and "Uspulun" effective at the rate of 1.0–3.0 grams; 0.5–1.00 grams; and 1.0–2.0 grams per square foot of soil, respectively, for controlling damping-off of tomato caused by *Phytophthora* spp. Nolla (11) found: 1) That soil drenching with a one to 50 formaldehyde solution, or applications of 4–4–50 Bordeaux mixture, were effective for controlling damping-off of eggplant caused by *Phomopsis vexans*, though formaldehyde was the most effective and economical. 2) Treatment of soil with corona copper carbonate, at the rate of four grams per square foot of soil, was effective for control of damping-off of tomato, pepper and eggplant caused by *Pythium debaryanum*. 3) Application of copper stereate, at the rate of eight grams per square foot, was found ineffective for control of *Phytophthora parasitica*, but apparently controlled *Pythium debaryanum*. 4) Bayer dust and "Uspulun" were ineffective for controlling damping-off caused by *P. parasitica* and *P. debaryanum*. 5) Two applications of Bordeaux (4–4–50 and 5–5–50 strength at the rate of one half gallon per square foot of soil) were effective in controlling *P. parasitica* and *P. debaryanum*, but were ineffective after damping-off has appeared in seedbeds. 6) Uspulun and Bayer dust were found injurious to tobacco seedlings and ineffective for controlling damping-off. 7) Copper sulphate solution (4–5 pounds in 50 gallons of water) was ineffective at the rate of one half gallon per square foot of soil. 8) Effectiveness of copper fluorosilicate was questionable. 9) Acetic acid (1.0 and $\frac{1}{2}$ per cent solutions) applied at the rate of one half gallon per square foot of soil, did not prove effective for controlling *P. parasitica* and *P. debaryanum*.

These investigations showed that damping-off is a complex problem and many organisms are involved. A combination of control methods appeared, therefore, necessary to assure the destruction of the various pathogens. Steam and formaldehyde are the best methods of soil sterilization. However, our experience has shown that great care has to be exerted if re-contamination of the soil is to be avoided. Bordeaux mixture 4–4–50, applied during the first week after the seedlings emerge, should accompany soil sterilization in order to minimize the chance of damping-off due to reinfestation of the soil.

The Bordeaux was applied at the rate of one half gallon per square foot of soil.

Soil sterilization with steam or formaldehyde are practices that many of our farmers are in no position to use at the present time. It would be very convenient, therefore, to control damping-off by the use of seed and soil treatments with fungicidal dusts already on the market.

Damping-off of tomato, pepper and eggplant in Puerto Rico is, so far as our knowledge is concerned, caused by species or strains of *Phomopsis*, *Phytophthora*, *Pythium* and *Rhizoctonia*.

Some mercurial and copper compounds have demonstrated their effectiveness for controlling these damping-off organisms in Puerto Rico. The possibility of using one or perhaps a combination of fungicides for controlling these types of damping-off appears to be a very satisfactory control measure.

RESUMEN EN ESPAÑOL

La podredumbre de semillas y plantitas de tomates, pimientos y berenjenas en los semilleros, ya en cajones o ya en el campo, presenta con harta frecuencia un carácter alarmante en nuestro ambiente. Esta podredumbre, conocida comúnmente por "salcocho," representa uno de los problemas más serios que confronta el hortelano.

En Puerto Rico se ha encontrado que varios organismos de los géneros *Pythium*, *Phytophthora*, y *Phomopsis* son responsables de enfermedades de esta clase. Recientemente apareció en semilleros de berenjenas y pimientos en la Estación Experimental una endofitotia de salcocho. Se pudo comprobar que dicho salcocho era causado por el ataque de un hongo cuyas características morfológicas y fisiológicas lo catalogan como una raza de *Rhizoctonia solani* Kühn.

La siembra de semillas de pimientos y berenjenas en tiestos con muestras de tierra representativas de varios campos de la Estación Experimental revelaron claramente la diseminación del hongo mencionado y la gran infestación de dichos terrenos. Este parásito es extremadamente agresivo, atacando las plantitas mucho antes de emerger del terreno y también después de haber emergido.

Los síntomas del salcocho aparecen durante la primera semana de surgir las plantitas, cuando los tejidos del tallo son más susceptibles al ataque del organismo. La enfermedad disminuye gradualmente según van envejeciendo y endureciéndose los tejidos del tallo. Los síntomas se caracterizan por la aparición de manchas acuosas en los tejidos del tallo, a flor de tierra. Luego ennegrecen estos tejidos infectados, síguele un constreñimiento de la parte afectada, y la planta termina por acostarse sobre el terreno del semillero y secarse.

Puede colegirse por lo expuesto anteriormente, que las pérdidas causadas por la podredumbre o salcocho en el estado pre-emergente, como también después de emerger la semilla, son considerables en muchos casos.

La enfermedad aparece más frecuentemente en terrenos húmedos debido a su naturaleza impermeable o por estar mal desaguados, o bien por factores climáticos, principalmente abundante precipitación pluvial. El pH del terreno, según muchos investigadores, es factor de importancia para el curso de la enfermedad, particularmente en aquellos terrenos en que su pH fluctúa entre 6.00 y 7.00 o es ligeramente alcalino. Dentro de nuestro ambiente, en que prevalece una temperatura bastante alta durante todo el año y que fluctúa entre los 28°C y 30°C., y en que la precipitación pluvial es abundante—en Río Piedras en este caso en que nos ocupamos es de aproximadamente 6 pulgadas por mes—la patografía de la enfermedad se manifiesta con rapidez. Varias pruebas fisiológicas realizadas con este hongo demostraron su gran capacidad para crecer rápidamente en substratos húmedos, de pH variable, entre los 4.44 y 7.15, y a temperaturas entre los 7°C. y 34°C. En general, el hongo crece más rápidamente en un pH alrededor de 7, y a temperaturas entre 28 y 30°C. Este organismo puede crecer en infinidad de medios azucarados. En la disolución de Coon el patógeno produjo abundante micelio y esclerocios.

En la tabla número 1 del texto en inglés, se demuestra biométricamente que los diferentes cultivos de *Rhizoctonia*, obtenidos de pimientos y berenjenas enfermas en varios semilleros, son igualmente virulentos. Esto hace suponer que todos estos cultivos correspondan a una misma raza del patógeno.

Otros organismos del género *Fusarium* fueron también aislados. En las pruebas de patogenia estos organismos no revelaron en momento alguno estar relacionados con el desarrollo del salcocho, comportándose, por lo tanto, como meros saprófitos. Aislado ya en cultivo el patógeno, conocida su morfología y fisiología, y su comportamiento dentro de nuestras condiciones ambientales, se procedió inmediatamente a probar patogénicamente un sinnúmero de variedades de pimientos y berenjenas con el fin de determinar el grado de susceptibilidad al patógeno. En la tabla número 2 del texto en inglés se demuestra en su análisis que todas las variedades de pimientos y ajíes son igualmente susceptibles al salcocho. Las pruebas con variedades de berenjenas "Rosita," "Puerto Rican Beauty," "Pompadour" y "Black Beauty" revelaron que todas estas variedades son igualmente susceptibles a la *Rhizoctoniosis*.

En vista de que las variedades de pimientos y berenjenas no son resistentes a esta enfermedad, se hicieron varias pruebas con un sinnúmero de productos químicos con el fin de ver si alguno o varios de ellos resultaban efectivos en combatir la enfermedad.

En primer término, se dudó de la eficacia de esterilizar con vapor el terreno por dos horas a 15 libras de presión y también con formalina en dilución de una parte por 20 de agua, y aplicada esta dilución a razón de un galón por pie cuadrado de terreno. Los resultados demostraron la efectividad de estos tratamientos en evitar el salcocho.

El tratamiento del terreno con caldo bordelés 4-4-50 a razón de medio galón por pie cuadrado de semillero, y con sulfato de cobre en la proporción de cuatro libras por 50 galones de agua y a razón de un galón por pie cuadrado de terreno, fué bastante efectivo, aunque no tan eficaz como los métodos anteriormente indicados. El caldo bordelés aplicado en la fórmula arriba indicada, después de germinar las semillas, contribuyó grandemente a evitar la propagación del patógeno a partir de brotes esporádicos de salcocho en los semilleros. Los mejores resultados en caso de brotes se obtuvieron aplicando a la zona infestada formalina en la dilución indicada.

Dada la imposibilidad de muchos agricultores de usar los métodos de desinfección del terreno mencionados anteriormente por ser bastante costosos, se resolvió probar varios polvos fungicidas de precios módicos actualmente en el mercado. Las pruebas tenían por objeto determinar el comportamiento de estos fungicidas dentro de nuestras condiciones climáticas, ya que se sabe que estos productos químicos varían en su efectividad dentro de diferentes condiciones ambientales y de acuerdo con la naturaleza de la enfermedad. Las pruebas se hicieron en tiestos llenos de tierra naturalmente infestada con *Rhizoctonia*, o, y con tierra infestada artificialmente con el mencionado organismo. De este modo se establecieron dos experimentos paralelos, uno con tierra de un índice bajo de infestación y otro con un índice alto de infestación por la incorporación de gran cantidad de micelio y esclerocios del organismo. En la primera prueba se polvorearon semillas de berenjenas con un desinfectante determinado antes de sembrarse. En la siguiente prueba 10 tiestos fueron tratados con un gramo del producto químico respectivo, para un tratamiento, por cada pie cuadrado de terreno. Cada tratamiento en las pruebas en ambos casos, tratando las semillas y tratando el terreno con fungicidas, comprendían 10 tiestos distribuidos al azar en 10 bloques distintos, bajo techo de cristal. Los resultados aparecen en las tablas 4 y 5, y según el análisis biométrico de los datos obtenidos, se llegó a las siguientes conclusiones:

1. En las pruebas en que se desinfectó la semilla antes de sembrarse, los productos "Semesan," "Z-O," "Dipdust," "Cuprous Oxide," "Corona Coppercarb," "Zinc Oxide," "Semesan Jr.," "Arasan," "Fermate" y "Spergon" demostraron igualmente su efectividad en evitar el salcocho en la fase preemergente de desarrollo de las plantas, pero fueron ineficaces todos en evitarlo después de emerger las plantitas.

2. Los productos "Dipdust," "Cuprous Oxide," "Dupont No. 1," "Zinc Oxide," "Semesan," "Spergon," "2% Ceresan," "1155-H. H.," "Fermate," "Z-O," "Arasan," "New Improved, Ceresan," "Corona Coppercarb," "Cupric Oxide," "Uspulun," "Barbak D.," "Semesan Jr.," "Cuprous Oxide," "Cuprocide" y "Bayer 1494" demostraron ser igualmente efectivos en disminuir el por ciento de infección al compararse con los datos de los testigos.

Las pruebas tienden a demostrar la eficacia de los tratamientos de compuestos de cobre y mercuriales en inhibir o quizás destruir al *Rhizoctonia solani.* Estos fungicidas son efectivos si se incorporan al terreno antes de sembrar la semilla, pero son ineficaces después de aparecer el salcocho. Podemos, por lo tanto, concluir que es una práctica muy recomendable y poco costosa la de desinfectar la semilla y también el terreno del semillero para evitar la aparición de los salcochos. De acuerdo con los trabajos de Nolla (9–11), los salcochos de pimientos, berenjenas y tomates causados por hongos de los géneros *Phytophthora* y *Pythium* pueden evitarse desinfectándose la tierra con vapor *de agua y formalina,* como hemos indicado; con "Corona Coppercarb" a razón de cuatro gramos por pie cuadrado de semillero; y también con dos aplicaciones de caldo bordelés 4-4-50 a razón de medio galón por pie cuadrado de semillero antes de regarse la semilla, seguido de otra aplicación una semana después de haber germinado la semilla. De acuerdo con los trabajos de este investigador, ningún mercurial probó ser efectivo en el combate de *Phytophthora* y *Pythium.*

En vista de los resultados obtenidos en este trabajo, podemos indicar la conveniencia de usar combinaciones de los tratamientos arriba expuestos y aplicaciones de caldo bordelés para evitar la aparición del salcocho causado por el *Rhizoctonia, Pythium* y *Phytophthora.*

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LITERATURE CITED

1. Anderson, H. W., K. J. Kadow and S. L. Hopperstead. The evaluation of some cuprous oxides recommended as seed-treatment products for the control of damping-off. Phytopath., **27** (4): 575-587, 1937.
2. Gratz, L. O. Wire stem of cabbage. New York (Cornell) Agr. Exp. Sta. Bul. 85, 60 pp., illus. 1925.
3. Hartley, C. Damping-off in forest nurseries. U. S. Dept. Agr. Bul. 934, 99 pp., illus., 1921.
4. Henderson, R. G. Testing copper fungicides for control of tomato blight in southwest Virginia. Virginia Agr. Exp. Sta. Tech. Bul. 89, 18 pp. 1943.
5. LeClerg, E. L. Parasitism of *Rhizoctonia solani* on sugar beet. Jour. Agr. Res. **49** (5): 407–431, illus., 1934.
6. Matsumoto, T. Studies in the physiology of the fungi. XII. Physiological specialization in *Rhizoctonia solani* Kühn. Missouri Bot. Gard. Ann., **8:** 1–62, 1921.
7. Matz, J. The *Rhizoctonias* of Puerto Rico. Jour. Dept. Agr. Puerto Rico, **5** (1): 1–31, illus., 1921.

8. MONTIETH, J., JR., AND T. CARTER HARMON. Fungicidal control of brown patch of turf. (abstract) Phytopath., **17** (1): 50, 1927.

9. NOLLA, J. A. B. The black-shank of tobacco in Puerto Rico. Jour. Dept. Agr. Puerto Rico, **12** (4): 185–215, 1928.

10. NOLLA, J. A. B. The eggplant blight and fruit rot in Puerto Rico. Jour. Dept. Agr. Puerto Rico, **13** (2): 35–57, 1929.

11. NOLLA, J. A. B. The damping-off of tobacco and its control in Puerto Rico. Jour. Dept. Agr. Puerto Rico, **16** (2): 285–324, 1932.

12. PRITCHARD, F. J., AND W. S. PORTE. Collar rot of tomato. Jour. Agr. Res., **21** (3): 179–184, 1921.

13. ROTH, L. F., AND A. J. RIKER. Influence of temperature, moisture, and soil reaction on the damping-off of red pine seedlings by *Pythium* and *Rhizoctonia*. Jour. Agr. Res., **67** (7): 273–293, 1943.

14. RYKER, T. C., AND F. S. GROOCH. *Rhizoctonia* sheath spot of rice. Phytopath., **27** (4): 233–246, 1937.

15. THOMAS, H. E. Chemical treatment of soil for control of damping-off fungi. Phytopath., **17** (4): 499–506, 1927.

16. TUCKER, C. M. Taxonomy of the Genus *Phytophthora* de Bary. Missouri (University) Agr. Exp. Sta. Res. Bul. 153, 1931.