3-1967

A study of the control root and stem rot of snap beans

Van B. Jackson

To the Graduate Council:

I am submitting herewith a thesis written by Van B. Jackson entitled "A study of the control root and stem rot of snap beans." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Landscape Architecture.

B. S. Pickett, Major Professor

We have read this thesis and recommend its acceptance:

Homer D. Swingle, Joe S. Alexander

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

January 19, 1967

To the Graduate Council:

I am submitting herewith a thesis written by Van B. Jackson entitled "A Study of the Control of Root and Stem Rot of Snap Beans." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Horticulture.

B. W. Pickett
Major Professor

We have read this thesis and recommend its acceptance:

Homer D. Swingle

Joe S. Alexander

Accepted for the Council:

Hilton A. Smith
Vice President for
Graduate Studies and Research

A STUDY OF THE CONTROL OF ROOT AND STEM ROT OF SNAP BEANS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Van B. Jackson

March 1967

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Gratitude is expressed to the writer's wife, Carrie, for typing the rough draft of the thesis.

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CHAPTER I

INTRODUCTION

There are many types of beans classified as *Phaseolus vulgaris* *L.*, the most important species of beans grown in the United States. They are produced for market as snap beans, green-shelled beans and dry beans. Only snap beans will be dealt with in this thesis.

Snap beans have become an important vegetable crop in the United States, particularly in the Southern States, Northwest, Northeast and parts of the West. However, too frequently crop yields are considerably reduced by soil-inhabiting fungi which destroy the roots and often girdle the stem at or immediately below the soil surface. This disease condition is commonly referred to as root rot, but a more correct name is root and stem rot, since both are affected. The condition is usually associated with a complex of pathogenic fungi inhabiting the soil. The most important species of the fungi are *Rhizoctonia solani*, *Pythium butleri* and *Sclerotium rolfsii* (18).

The infection of the roots and base of the stem causes stunting and wilting of the plant, often followed by death, which results in reduced yields due to poor plant stands.

R. solani is the fungus which is considered to be the major cause of root rot of snap beans. The pathogenicity of this organism has been extensively studied in the laboratory and a limited number of experiments has been conducted to control the parasite in beans under field conditions. Control measures have consisted mainly of the application of pentachloronitrobenzene, a soil fungicide, at planting time. Results have been erratic. In addition to pentachloronitrobenzene, some other experimental chemicals have been used. Those tried also failed to give satisfactory control.

The purpose of the first phase of this study was to determine the effectiveness of chemical treatments applied in several ways as means of controlling the root rot complex of snap beans in the field. The second phase of the study was to determine the effectiveness of chemicals for the control of *R. solani* in snap beans and was conducted in a greenhouse.

CHAPTER II

REVIEW OF LITERATURE

The literature concerning R. solani on beans has revealed, according to Baker (1), that as early as 1904 there were records indicating that the fungus had been discovered in pods in contact with infested soil, and that seeds from infected pods were also infected. Mycelium and sclerotia of the fungus were present in the seed coats.

In 1935 Weber (20) reported on an aerial species of Rhizoctonia on snap beans and Fordhook Lima beans. The disease occurred on all above ground parts of the host plants but was most destructive on the foliage. Leaf blades were killed from the point of attachment of the petiole and blade as the fungus advanced over them in typical thread-blight fashion from the stem and petiole or from an invaded part to a non-invaded part when there was contact. Subcuticular hyphae invaded the host cells killing them, while superficial hyphae were spread over the leaf blade surfaces.

According to Briton-Jones (3) and Person (9), R. solani has distinct strains or forms differing in morphology, cultural characters and pathogenicity. Strains seem to be specific in their choice of a host crop. Specificity is of particular interest when control measures, such as crop rotation, are being considered. For example, large numbers of isolates from Irish potatoes were tested for pathogenicity on sugar beets. Nearly all were non-pathogenic on this host. The strain on beans is classified as *R. solani forma phaseoli*.

Referring to the injurious effect of Rhizoctonia on beans, Hyre (7) indicated that in Sevier County, Tennessee, in a garden planting of bush beans 34 per cent of the pods were infected. In Knox County, Tennessee, in one experimental plot of Giant Stringless Green Pod bush bean, Rhizoctonia stem and pod rot was severe; and in a garden planting of the same variety of beans, stem and pod rot caused 20 per cent loss of the crop. In commercially grown beans crop losses often attain proportions of significance (6).

In regard to temperature requirements for optimum growth of the root rot organism, Person (9) concluded that it appears to grow best at 77° F. Some isolates grow well at a temperature as high as 86° F. Some are especially pathogenic at a temperature as low as 59° F.

The organism is generally considered to be a cool season parasite. Person (9) states that the strain on beans grows best at cool temperatures. However, just as much damage is caused to snap beans in Tennessee during late summer as under cooler spring conditions.

Person (9) stated that bean stands were reduced by the disease about equally at 40, 60, and 80 per cent soil moisture. The average degree of infection was more severe at 60 and 80 per cent than at 40 per cent.

The availability of nitrogen in the soil may also influence the severity of the disease. In laboratory experiments, Snyder, Schroth and Christou (15) have shown that _R. solani_ and other root rot organisms are favored by a high level of nitrogen in the soil. They found that when mature barley straw, wheat straw, corn stover, or pine shavings were added to soil 10 days previous to planting beans there was good control of root rot. Bacteria multiply rapidly when straw is added to soil and utilize the soil nitrogen in decomposing the energy source, thus rendering less nutrients available for the growth and reproduction of root rotting fungi. Under these competitive conditions the fungi are unable to act as pathogens.

If nitrogen is added with organic amendments, increasing the amount of available nitrogen, the pathogens again become active and cause severe root rot. Leguminous residues with low carbon/nitrogen ratios, such as those from soybeans and alfalfa, increased root rot when added to the soil. High carbon/nitrogen ratios in soils tend to control the disease. Incidence of the disease in the summer may be due to over-fertilization of the crop or frequent incorporation into the soil of organic residues from previous bean crops containing appreciable amounts of organic nitrogen.

It is more likely that plants will be attacked when soil and weather conditions are unfavorable for best plant growth.

Another environmental factor which apparently influences the growth, development, and pathogenicity of Rhizoctonia is oxygen. Briton-Jones (3) observed that the organism did not grow well in liquid nutrient media in the laboratory perhaps due to the absence or limitation of oxygen.

Sanford (12) studied the virulence of Rhizoctonia in both cultivated and virgin soil. He observed that 1 part of inoculum of the pathogen grown in steam sterilized soil with 15 parts of natural soil was more effective in inducing the disease than larger proportions of inoculum. When the mycelium can be easily seen, and especially when it masses heavily, susceptible host tissue is usually afforded protection from infection despite the fact that the fungus is potentially very virulent. The pathogen is most virulent when the hyphae are very young, very thin, still hyaline, and difficult to find on the susceptible host tissue. There are indications that if equal parts of inoculum and natural soil or steam sterilized soil are used the virulence is reduced, perhaps due to certain products deposited by the vigorously growing pathogen.

Sanford (12) also discovered that soil-grown inoculum 6 days old was as virulent as that at least 150 days old; after 150 days virulence appears to decrease.

Person (9) conducted tests with inoculum-boosted soil in which beans were planted at the time of soil inoculation and 3 days after inoculation. In each case the fungus prevented seedling emergence.

Insofar as seedling infection and disease symptoms are concerned, Bateman (2) states that the fungus may spread in the host tissues by growing intercellularly. Following intracellular penetration and growth, cells are penetrated and collapse. This results in the development of reddish-brown lesions on the hypocotyls and roots of infected plants.

Sunken or concave areas appear on these plant parts. The collapse of cells is due to the action of a cellulolytic enzyme, cellulase, produced by the fungus.

According to Goode (6) the recommended method of controlling the disease in commercial plantings of snap beans consists in the use of pentachloronitrobenzene, or Terraclor, as it is known commercially.. This product is at present the most commonly used fungicide since it has given the best control of the disease.

Recommended applications of Terraclor per acre (16) vary from 2 to 3 pounds of 75 per cent wettable powder in 15 to 20 gallons of water sprayed into the furrow over the seed and covering soil at planting time to 5 to 10 pounds of 75 per cent wettable powder in 10 gallons of water sprayed in a band 6 to 12 inches wide over the seed and surrounding soil as the beans are planted. Terraclor dust formulations are also used in the furrow applications.

In Arkansas, Good (6) tested experimental fungicides BOS 50, GB 65, BOG 13, DuPont 1823 and Lanstan in an attempt to control Rhizoctonia root and stem rot. The test plot was established on a field where beans had not been grown previously in order to minimize the occurrence of other diseases. Soil-borne fungal inoculum, prepared by mixing field soil with infested soil in which the fungus was killing beans, was added to the test plot, followed by chemical treatments previous to seeding. Under these conditions none of the chemicals gave satisfactory control of Rhizoctonia rot.

CHAPTER III

MATERIALS AND METHODS

EXPERIMENT I. FIELD STUDIES

The area selected for Experiment I was situated on the Plant Science Farm. A Sequatchie silt loam soil with a 2 per cent slope, rapid internal and external drainage and limited moisture-holding capacity was used. Sequatchie soils are moderately fertile although rather low in organic matter. Organic matter content of soil samples from the plots ranged from 1.07 to 2.08 per cent. The soil pH ranged from 5.0 to 5.4.

The plots were on land that had been used for growing sweet sorghum in 1964. It was fall plowed and winter fallowed. In the spring of 1965 a snap bean crop was grown. The crop residues were turned under and the land disked, turned, and disked again in early August and dragged just previous to planting. A randomized block design, with 4 replications of 10 treatments, was used. A replicate consisted of 2 rows, 38 inches apart, 90 feet long.

Table I shows the treatments, rates per acre of formulated material, and methods of application used. In addition, Table I shows the control treatment and mechanical treatment in which no chemical was applied. In the mechanical treatment an 8-inch band of soil was stirred by using a soil incorporator to a depth of 1 inch

TABLE I

TREATMENTS USED IN FIELD STUDIES IN THE CONTROL OF ROOT AND STEM ROT OF SNAP BEANS

Treatment	Rates per Acre in lbs.	Methods of Application
Daconil 2787, 75 W	1.20	In furrow and on surface at seeding
Dexon 70 W	1.11	Same
DuPont 1823, 75 W	3.00	Same
Parzate 65 W + Captan 50 W + Terraclor 75 W	2.00 1.50 2.50	Same
Zerlate 76 W	2.00	Same
Terraclor 75 W	2.50	Same
Terraclor 75 W	2.50	Surface incorporated pre-seeding
Terraclor 75 W	2.50	Surface non-incorporated pre-seeding
Mechanical	-	-
Control	-	-

just previous to planting. The chemical composition of the fungicides is shown in Appendix A, page 29 . The fungicides were applied at planting time on September 3, 1965.

Some materials were applied as a spray in the furrow as the beans dropped from the planter. This placed the material at a depth of 1 inch in a band 2 inches wide. In addition, the spray was applied to the covering soil behind the press wheel in a band 2 inches wide. This method of application is designated as "in the furrow and on the surface." One half of the material was applied at each location. In order to accomplish this two nozzles were used per furrow, one applied the material in the furrow in an 80-degree fan spray before covering the seed and the other placed it on the surface, also in an 80-degree fan spray, but after covering the seed.

In addition to the "furrow and surface" application two other Terraclor treatments were used. Terraclor was sprayed on the surface in a band 8 inches wide and then incorporated in the upper 1 inch of soil. The second treatment was done by spraying an 8 inch band on the surface.

The desired amount of each material was applied in water at the rate of 15 gallons per acre at 40 pounds of pressure per square inch. The amount of Terraclor per acre remained the same regardless of the method of application. The tractor was operated at a speed of 3.5 m.p.h.

Although planting was done as carefully as possible, stand was not as uniform as had been expected.

Planting

Seeds of the Wadex variety of snap beans were planted with a two-row, tractor-mounted planter to a depth of 1 inch, with approximately 8 seeds per foot of row, using 80 to 90 pounds of seeds per acre. Seeds were of the 1964 crop, Ceresan-treated, and showed 80 per cent germination on test.

Application of Fertilizer

A 5-10-5 fertilizer was applied to both sides of the row (double banded) at the time of planting, at the rate of 450 pounds per acre.

Cultural Practices

Plants were cultivated 3 and 5 weeks after planting. A tractor-mounted cultivator operated at low speed was used. Ridging of the soil around the plants was avoided.

The soil was too dry for seed germination and the plots were irrigated by the sprinkler method five days after planting and again three weeks later. A total of 3 inches of water was applied during the period of the field studies, which were terminated on October 20, 1965. Rainfall data for September and October are shown in Appendix B, page 30.

Sevin was applied three times to control insects.

Records

Data on the relative amount of injury due to root and stem rot were taken 2, 3, 4 and 5 weeks after germination. At each period 40 plants, selected at random from each replicate (160 plants per treatment), were removed and washed. The roots and stems were examined for lesions and placed in one of the 5 following infection classes:

0 = No lesion

1 = One to few shallow lesions

2 = One to several lesions extending into the cortex

3 = Lesions girdling stems

4 = Plants killed.

These are illustrated in Figure 1, showing plant conditions two weeks after germination.

EXPERIMENT II. GREENHOUSE STUDIES

Isolation and Culture of the Rhizoctonia Fungus

In preparation for the greenhouse phase of this work Rhizoctonia-infected plants from the field plots in Experiment I were used as a source of *R. solani f. phaseoli* from which inoculum was prepared.

The fungus was maintained in the laboratory and finally increased on a medium of oat seeds by modification of the methods used by Person (9).

Soil Sterilization

Soil from field plots in Experiment I was steam sterilized in wooden flats at 250° F for 1 hour. After the soil was sterilized precautions were taken to prevent recontamination before inoculation. The flats were watered every two days (for 4 weeks) to leach out of the soil any ammonia that might have accumulated as result of sterilization.

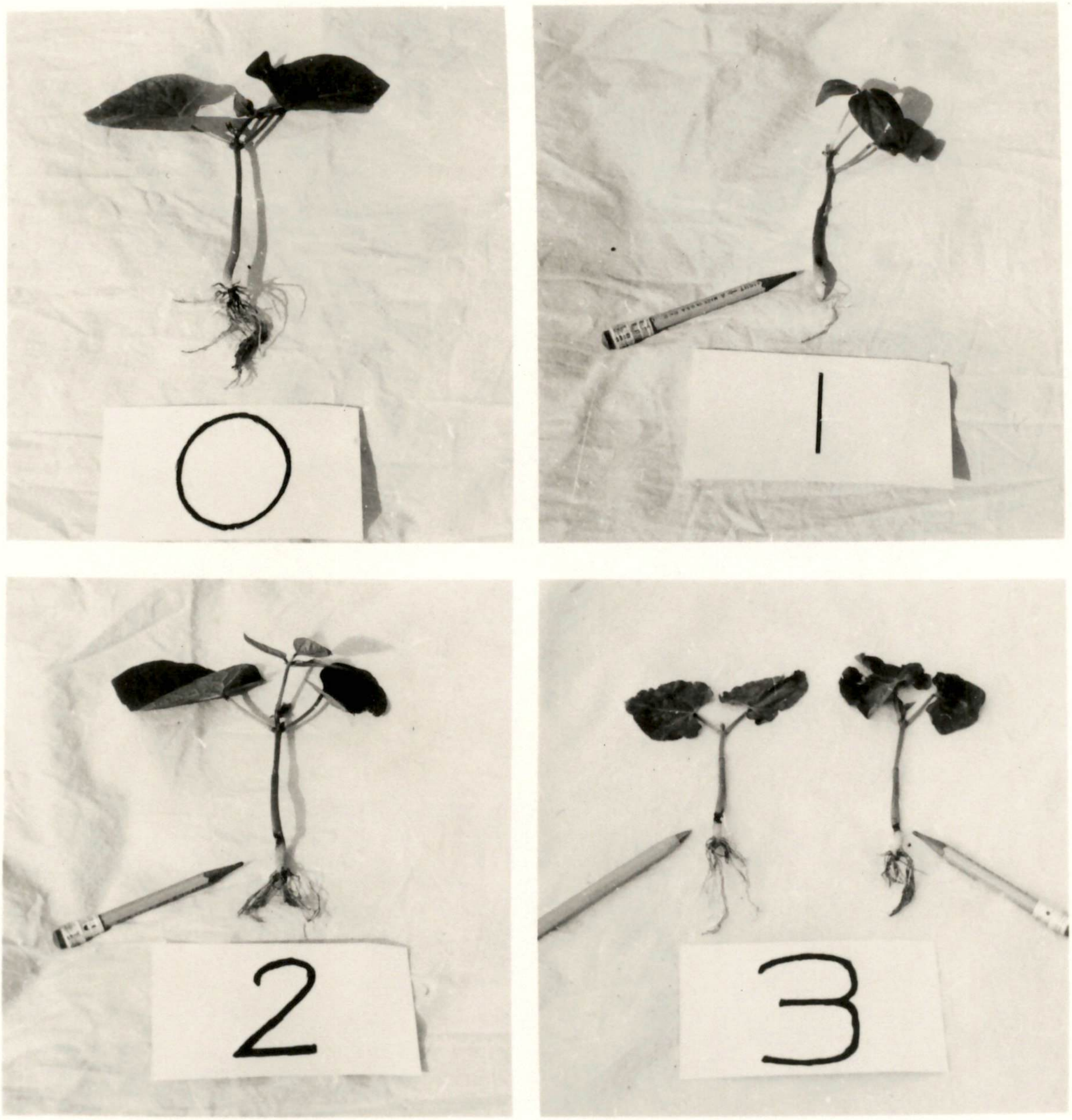

Figure 1. Bean plants grown in Rhizoctonia - infested soil under different treatments in Experiment I showing 4 infection classes: 0, no lesion; 1, a shallow lesion on the stem; 2, a deep lesion extending into the cortex; and 3, lesions girdling stems.

Soil Inoculation

After virulence of the inoculum was established a mixture of inoculum was prepared by mixing 2 parts of one-week-old inoculum with 1 part of three-week-old inoculum. Seventy-five grams of this mixture was incorporated into the soil to a depth of 2 inches in each of 12 flats which measured 18 x 12 x 3 inches.

Seeding of Flats and Application of Fungicides

Three days after inoculating the soil seeds of the Wadex variety were planted 1 inch deep, 1 inch apart, in furrows 12 inches long. There were 4 furrows per flat spaced 5 inches apart. Half of the fungicide was sprayed on the seeds and soil around them before covering the seeds and the other half was applied to the surface after covering. Three of the 4 furrows in each flat were treated with fungicides, the other furrow was untreated. There were 10 treatments, each treatment was replicated 4 times, and all treatments were randomized.

Table II lists the fungicides, rates per acre, and methods of application used in the greenhouse experiment. Rates are expressed as pounds of formulated material. Each fungicide was applied in water at the rate of 37.5 gallons per acre.

Greenhouse Temperatures

The temperatures of the soil in the flats fluctuated between 65° F and 80° F. Air temperatures for the period of April 7 to 20, 1966, varied between 52° F and 103° F as shown in Appendix C, page 31.

TABLE II

TREATMENTS USED IN GREENHOUSE STUDIES IN THE CONTROL OF RHIZOCTONIA ROOT AND STEM ROT OF SNAP BEANS

Treatment	Rates per Acre in lbs.	Methods of Application
DuPont 1823, 75 W	3.00	In furrow and on surface at seeding
DuPont 1823, 75 W	4.50	Same
DuPont 1823, 75 W	6.00	Same
Terraclor 75 W	2.50	Same
Terraclor 75 W	5.00	Same
Terraclor 75 W	7.50	Same
Lanstan 4 E. C.	4.44	Same
Lanstan 4 E. C.	6.66	Same
Lanstan 4 E. C.	8.88	Same
Control	-	-

Records

The plants were allowed to grow two and a half weeks. They were pulled and classified according to the amount of injury on roots and stems as described on page 12. Stand counts were taken and recorded as number of plants per row 12 inches long.

Degree of infection of the plants was computed by adding the infection class values of individual plants in each treatment and dividing by the number of plants. The average class values were then analyzed by the analysis of variance method.

Satisfying Koch's Rules of Proof

In order to ascertain that *R. solani* was the cause of the disease, cultures of the fungus in diseased plants were made. The organism recovered was compared with the original isolates from plants in Experiment I and was identified as the same organism. The disease symptoms of plants in the greenhouse were typical Rhizoctonia symptoms like those exhibited by plants in the field.

CHAPTER IV

RESULTS AND DISCUSSION

I. THE EFFECTS OF FUNGICIDES AND METHODS OF APPLICATION ON AMOUNT OF ROOT AND STEM ROT INJURY (EXPERIMENT I)

In the field phase of this study, as early as a week after germination there was evidence of a low degree of infection due to Rhizoctonia. The infection spread during the observation period even though climatological conditions were not favorable.

Two weeks after germination plants were rated for injury on a 0 to 4 scale as indicated under records in Chapter III. Three later ratings were made and the data averaged and analyzed. The means of these data and least significant difference values for the effects of fungicides and methods of application on the amount of injury are shown in Table III. Data were assigned class values so that lower rates of infection indicate less injury to the plants and greater effectiveness in disease control.

DuPont 1823, Terraclor, Daconil 2787 and the Parzate, Captan-Terraclor mixture used "in the furrow and on the surface" were significantly more effective in disease control (at the 5 per cent level) than Zerlate, Dexon, Terraclor "surface incorporated," Terraclor "surface non-incorporated," control, or mechanical treatments. DuPont 1823 gave significantly better control than Daconil 2787, or the mixture of fungicides, and was within the limits of error of the experiment,

TABLE III

EFFECTS OF FUNGICIDES AND METHODS OF APPLICATION ON AMOUNT OF ROOT AND STEM ROT OF SNAP BEANS IN FIELD STUDIES (EXPERIMENT I)

Treatment	Rates per Acre in lbs.	Methods of Application	Mean Infection Class*
Daconil 2787, 75 W	1.20	In furrow and on surface at seeding	0.60
Terraclor 75 W	2.50	Same	0.43
DuPont 1823, 75 W	3.00	Same	0.28
Parzate 65 W	2.00		
+ Captan 50 W	1.50	Same	0.62
+ Terraclor 75 W	2.50		
Zerlate 76 W	2.00	Same	0.94
Dexon 70 W	1.11	Same	1.17
Terraclor 75 W	2.50	Surface incorporated pre-seeding	1.10
Terraclor 75 W	2.50	Surface non-incorporated pre-seeding	1.14
Mechanical		-	1.38
Control		-	0.95
L S D at 5 per cent			0.233
L S D at 1 per cent			0.315

*Lower numbers indicate less injury.

equal to the Terraclor treatment.

There was no significant difference in efficiency of disease control among Zerlate, Dexon, Terraclor "surface incorporated," Terraclor "surface non-incorporated," or the control. However, these treatments gave significantly more control than was obtained from the mechanical treatment which had the highest degree of infection. Plants in the mechanical treatment had significantly more and deeper lesions than those in other treatments. This might have been due to less oxygen available to the fungus in the undisturbed soil in the other treatments. The Rhizoctonia organism is often present near the surface of the soil where, as a rule, there is a greater supply of air.

Terraclor when applied only on the surface, or in the upper inch of soil, was not as effective in controlling root rot as when part of the material was applied in the furrow before covering the seeds.

II. THE EFFECTS OF FUNGICIDES ON AMOUNT OF RHIZOCTONIA INFECTION AND STAND OF SNAP BEAN PLANTS IN THE GREENHOUSE (EXPERIMENT II)

In the greenhouse studies DuPont 1823 and Terraclor treatments, at all rates, improved plant stands over the control or Lanstan treatments. Table IV shows the effects of treatments on Rhizoctonia infection and stand. There was no significant difference (at the 5 per cent level) in infection class ratings between the rates used of these two materials. The lower rates of these fungicides were as satisfactory as the higher rates in affording control. The infected plants in DuPont

TABLE IV

EFFECTS OF FUNGICIDES ON AMOUNT OF RHIZOCTONIA INFECTION AND STAND OF SNAP BEAN PLANTS IN GREENHOUSE STUDIES (EXPERIMENT II)

Treatment	Rates per Acre in lbs.	Mean Infection Class*	Mean Plant Stand per foot of Row
DuPont 1823, 75 W	6.00	0.06	8.25
Terraclor 75 W	7.50	0.14	8.25
Terraclor 75 W	2.50	0.57	7.25
DuPont 1823, 75 W	3.00	0.07	7.00
Terraclor 75 W	5.00	0.39	7.00
DuPont 1823, 75 W	4.50	0.12	6.75
Lanstan 4 E. C.	6.66	3.17	1.50
Lanstan 4 E. C.	4.44	2.75	1.25
Lanstan 4 E. C.	8.88	3.50	0.50
Control	-	4.00	0.00
L S D at 5 per cent		3.21	1.72
L S D at 1 per cent		N S	2.33

*Lower numbers indicate less injury.

1823 and Terraclor treatments were only lightly infected, and there were many plants which were not infected two and a half weeks after germination.

Neither of the three rates of Lanstan afforded satisfactory control of the disease as indicated by plant stand. There was no significant difference in either measurement of stand or infection class due to the rates of Lanstan. Seedling emergence in the Lanstan treatments was almost nil, and the few plants which emerged were severely infected. These plants died shortly after emerging from the soil as a result of lesions extending into the stems and girdling the plants.

In the greenhouse experiment the incidence of disease was high in the untreated plots as evidenced by lack of seedling emergence. Figure 2 shows an absence of seedlings in the untreated plots, whereas, those treated with DuPont 1823 and Terraclor show a marked improvement in plant stands. This figure also shows an absence of seedlings in two of the plots treated with Lanstan and in the other plot only two seedlings emerged.

Under greenhouse conditions, with an ample supply of moisture and much fungal inoculum present, the Rhizoctonia organism proved to be more destructive in the control plots than in control plots in the field experiment. In the field less moisture was available to the fungus, and competition with other soil organisms was certain to have been greater than in the greenhouse experiment.

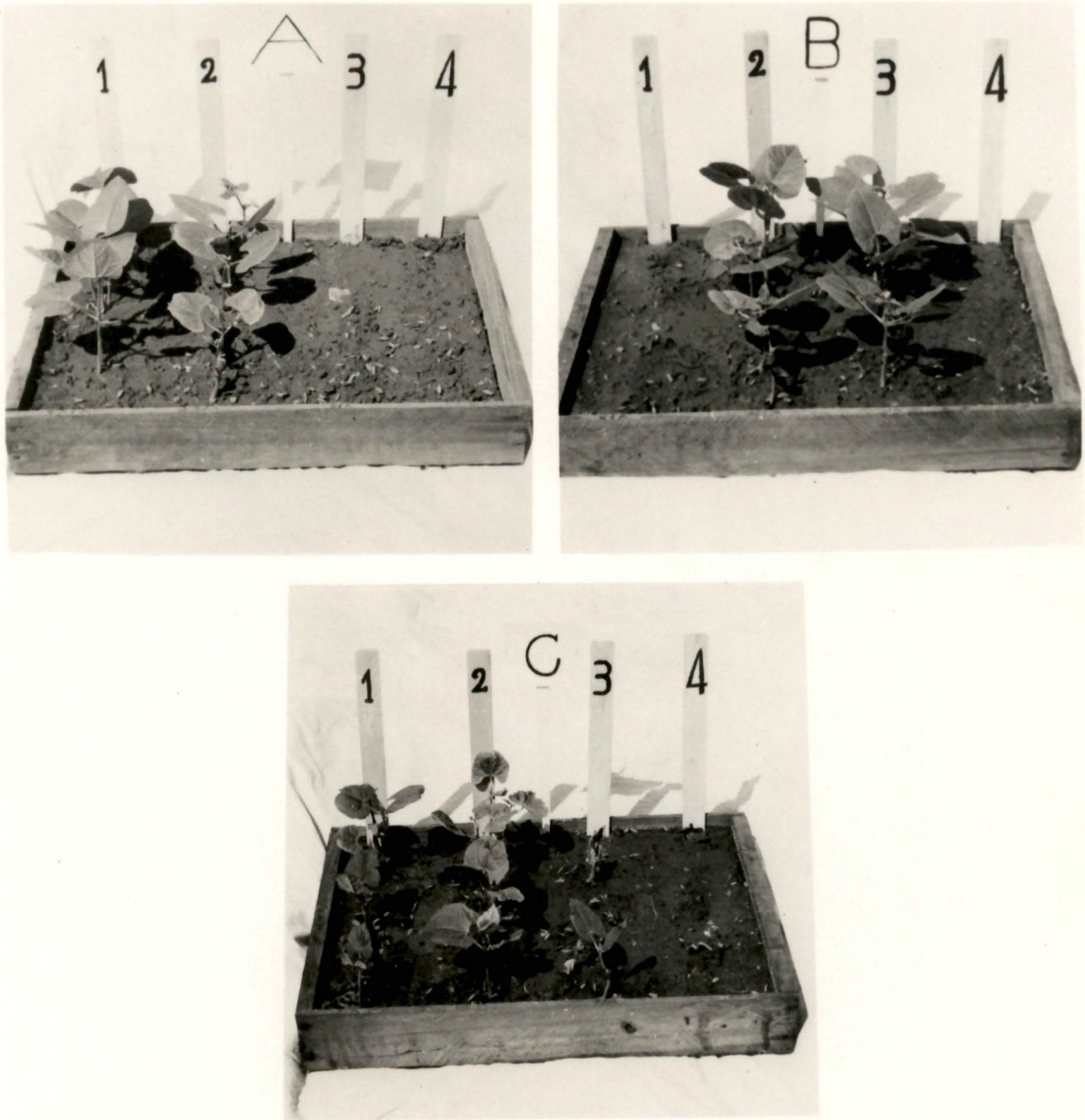

Figure 2. Effects of three fungicides upon plant stand in Experiment II: (A) 1, Terraclor 2.50 lbs.; 2, DuPont 1823, 3.00 lbs.; 3, Lanstan 4.44 lbs. per acre; and 4, control. (B) 1, Lanstan 8.88 lbs.; 2, Terraclor 7.50 lbs.; 3, DuPont 1823, 6.00 lbs. per acre; and 4, control. (C) 1, Terraclor 5.00 lbs.; 2, DuPont 1823, 4.50 lbs.; 3, Lanstan 6.66 lbs. per acre; and 4, control.

The variation of the environment in the field and greenhouse, and to some extent the amount of inoculum, probably accounted for the difference in virulence of the disease in the field and in the greenhouse studies.

CHAPTER V

SUMMARY

Experiments were conducted to determine the effectiveness of several fungicides, using various methods of application, in the control of root and stem rot of snap beans. Evaluation of the fungicidal treatments was based on the extent of lesions present on young plants and on plant stands.

Under field conditions, DuPont 1823, Terraclor, Daconil 2787 and a mixture of Parzate, Captan and Terraclor gave a higher degree of disease control than did Zerlate or Dexon. These materials were applied in the seeding furrow and on the surface after seeding. DuPont 1823 afforded a significantly higher degree of disease control than other treatments with the exception of Terraclor applied in a similar manner.

Terraclor used only on the surface, or incorporated in the upper inch of soil was unsatisfactory and less effective than Terraclor applied in the furrow in addition to on the surface.

In a greenhouse study, isolates of the Rhizoctonia organism secured from plants used in the field study, were used to inoculate sterile soil in which bean seeds were planted.

DuPont 1823, Terraclor, and Lanstan were applied in the seeding furrow and on the surface after seeding in the inoculated soil. DuPont

1823 and Terraclor improved plant stands considerably and were superior to other treatments in the control of the organism. There was no significant difference in disease control due to the rates used of these two fungicides. Lanstan afforded little control.

Under the conditions of this study, DuPont 1823 and Terraclor when applied both in the furrow and on the surface at seeding, afforded the best control of root and stem rot of snap beans in both field and greenhouse studies.

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APPENDIXES

APPENDIX A

TABLE V

CHEMICAL COMPOSITION OF FUNGICIDES

1. Captan 50 W: 50 per cent N-Trichloromethylthio-tetrahydroptha-limide.
2. Daconil 2787, 75 W: 75 per cent Tetrachloroisopthalonitrile.
3. Dexon 70 W: 70 per cent p-(Dimethylamino) benzenediazo sodium sulfonate.
4. DuPont 1823, 75 W: 75 per cent 1,4-dichloro-2, 5-dimethoxy-benzene.
5. Lanstan 4 E. C. (4 pounds of active ingredient per gallon of emulsifiable concentrate): 1-chloro-2-nitropropane.
6. Parzate 65 W: 65 per cent zineb (Zinc ethylenebisdithiocarbamate).
7. Terraclor 75 W: 75 per cent pentachloronitrobenzene.
8. Zerlate 76 W: 76 per cent ziram (Zinc dimethyldithiocarbamate).

APPENDIX B

TABLE VI

TEMPERATURE AND PRECIPITATION DATA, AGRICULTURAL EXPERIMENT STATION, KNOXVILLE, TENNESSEE, SEPTEMBER AND OCTOBER 1965

	September				October			
	Temp.	°F		Rain	Temp.	°F		Rain
Date	Max.	Min.	Mean	Inches	Max.	Min.	Mean	Inches
1	85	66	75.5	0.06	77	66	71.5	0.15
2	75	60	67.5		81	56	68.5	
3	77	62	69.5		72	52	62	
4	86	63	74.5		77	50	63.5	
5	83	64	73.5		68	44	56	
6	85	68	76.5		64	44	54	
7	88	65	76.5		71	55	63	0.50
8	88	62	75.5		70	58	64	0.02
9	89	64	75.5		71	49	60	
10	89	66	77.5	0.04	71	45	58	
11	91	69	80		69	45	57	
12	91	71	81	0.75	73	57	65	
13	79	71	75		73	43	58	
14	81	63	72		72	49	60.5	
15	84	67	75	0.16	78	53	65.5	
16	88	66	77	0.24	80	54	67	
17	89	69	79	0.18	79	56	67.5	
18	90	69	79.5		81	54	67.5	
19	88	68	78		75	58	66.5	
20	88	69	78.5		77	62	69.5	
21	88	65	76.5		74	61	67.5	0.39
22	90	66	78		66	54	60	0.02
23	88	65	76.5	0.30	63	51	57	
24	84	63	73.5	0.55	64	42	53	
25	70	46	58		53	32	42.5	
26	68	48	58		58	34	46	
27	73	57	65		65	37	51	
28	76	55	65.5		68	39	53	
29	77	57	67		64	38	51	
30	81	65	73	0.20	60	34	47	
31	--	--	--		63	37	50	
Total				2.48				1.08

APPENDIX C

TABLE VII

MAXIMUM, MINIMUM AND MEAN AIR TEMPERATURES IN THE GREENHOUSE FROM APRIL 7 to 20, 1966

	Temperatures °F		
April	Max.	Min.	Mean
7	90	62	76
8	75	61	68
9	82	60	71
10	92	62	77
11	90	52	71
12	87	59	73
13	96	64	80
14	79	62	70.5
15	82	60	71
16	92	60	76
17	94	53	73.5
18	103	63	83
19	72	58	65
20	92	56	74