THE INTERACTION OF FOUR HERBICIDES WITH *RHIZOCTONIA SOLANI* ON SEEDLING COTTON

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Cotton enters into the daily life of more of the world's peoples than any other product except salt (23). In Oklahoma, cotton ranks second to wheat as a cash crop. In 1965, approximately 585,000 acres of cotton was grown with an approximate production of 390,000 bales.

Within the last ten years we have seen cotton farming develop into a very complex business. With government regulations on acreage planted, today's farmers are concentrating on quality and yield of their cotton. Today's farmers are planting improved varieties, adding plant nutrients in the form of fertilizers, controlling weeds, controlling insects, controlling diseases, improving their methods of planting and harvesting, and where it is possible, supplying water through irrigation. Due to the high cost of labor, farmers are annually treating more acres with herbicides to control weeds. Because of such intensified farming on limited acreage, many problems have developed. With the development and use of herbicides and other pesticides in cotton, the possibility exists that there could be an interaction between herbicides and other pesticides, or between pesticides and plant pathogens. With the tremendous increase in herbicide usage, farmers and research personnel have postulated an increase in seedling diseases in fields treated with herbicides.

The primary purpose of this study was to determine if prometryne, trifluralin, fluometuron or SD11831 herbicides have any influence on the degree of injury caused by *Rhizoctonia solani* Kuehn on cotton.

Both growth chamber and field studies were conducted to investigate the possibilities of such an interaction.

REVIEW OF LITERATURE

Cotton

Cotton belongs to the botanical genus Gossypium, a member of the Malvaceae family. The plant has a tap root with secondary roots that branch laterally from the primary root. The secondary root growth occurs primarily close to the soil surface and forms a dense mass of lateral roots (69).

There are three climatic factors which are essential for the economical production of cotton. The plant requires about a 180 - 200 day growing season with a mean annual temperature of over 60° F. for maximum production. The minimum rainfall requirement is 20 inches and a maximum of 60 inches with suitable seasonal distribution (20).

The most critical stage in the development of a cotton plant is the seedling stage. There are many factors that affect the development of the cotton seedling. Three of these major factors are: soil temperature, soil moisture, and the presence and activity of seedling disease organisms (21). The optimum temperature for the cotton seedling from germination to emergence is somewhere around 75 to 85° F. (66). Camp and Walker have shown that at 95 to 97° F. germination was very rapid, and at 60° F. germination was quite slow. Germination and growth of cotton seedlings were stopped at 57° F. (18).

The presence and activity of seedling disease organisms can play a major role in the development of the cotton seedling. The organisms are most active on cotton seedlings when temperatures are below the optimum temperature for germination and seedling growth. The best soil moisture for seedling development is also favorable for seedling disease development (16).

Rhizoctonia solani Kuehn

According to Ray and McLaughlin (50), *Rhizoctonia solani* is the most important fungus involved in diseases of cotton seedlings because of its high degree of virulence and its frequency in Oklahoma soil.

R. solani has the following characteristics:

> "Young mycelium colorless; branches constricted at points of origin from main axis; older mycelium colored, wefts of brownish yellow to brown strands, organized into dense groups of hyphae, sclerotia, made up of short, irregular, angular or somewhat barrel-shaped cells." (67).

The spores are usually smooth-walled and colorless or pale ochreous (26).

R. solani was first described by Kuehn in 1858 as a disease on potatoes. In 1895, Atkinson (5) in Alabama reported the cause of soreshin on cotton. But only since 1950, has the economic importance of *R. solani* been recognized in cotton (55, 15). An estimated 2.5 percent reduction in Oklahoma cotton yields caused by seedling diseases was reported in 1965 (41). In Oklahoma, there are three main fungi which compose the seedling disease complex; they are *Rhizoctonia solani*, *Pythium* sp. and *Fusarium* sp., with *Rhizoctonia solani* being the most important of the three.

Damage from infection by *R. solani* occurs from planting until well into the growing season. Maier and Staffeldt (38), in 1963, concluded that the likelihood of seedling infection caused by seed-borne

R. solani was small because they did not find the fungus on or in any cottonseed.

Pre-emergence damping-off caused by *R. solani* occurs between germination and emergence. The organism may infect the hypocotyl and/or the primary root. Infection in the hypocotyl usually occurs at the crook of the hypocotyl. Usually the seedling is so weak from this type of infection that it does not emerge (56).

R. solani also produces a post-emergence damping-off of cotton called soreshin. Sinclair (56) gives the following description of *R. solani* on emerged cotton seedlings:

> "At first the plants appear stunted and light green in color. As the disease progressed lesions at or near the soil line appear on the hypocotyl or stem of the seedlings. The lesions are at first light brown, changing to dark brown, then to black. With development of the fungus on the stem tissue, the infected area becomes collapsed. If favorable conditions continue to exist for the development of the disease, the infected plants will topple over and die."

The penetration and infection of the hypocotyl by *R. solani* has been described by Sinclair (55) as follows:

> "The fungus mycelium orients itself longitudinally on the hypocotyl and forms infection cushions. Penetration of the host tissue takes place under the infection cushion, through the cuticle. The mycelium then grows between and through the host cells. The fungus mycelium can penetrate without infection cushions where the epidermis and cuticle of the hypocotyl has been opened by the enlargement of gland cells or injury. After initial penetration, the fungus grows into adjacent tissue both above and below the soil line and causes a conspicuous lesion on the hypocotyl."

There exists several factors that affect the parasitism of *R. solani* on cotton. Soil temperature has a strong effect on the incidence and virulence of *R. solani* (4,22,33,35). Soil moisture does not have as much influence on the pathogenicity of R. solani as soil temperature; however, soils that are neither too wet nor too dry are most conducive to infection (36).

There exists considerable variation in the parasitism of cultures of R. solani (44,38,36,39,71). In general, R. solani isolates are stable. Papavizas (44) has reported that the cultural characteristics, virulence and host range of 15 single spore isolates of R. solani did not change after their passage through the soil and reisolation from bean hypocotyls. Maier (39) states that generally the pathogenicity of the more virulent strains increases with temperature, while the less virulent show little change.

In 1953, there was no satisfactory control of R. solani in cotton (42). At present, the most effective fungicide for the control of seedling diseases is PCNB (56,38).

Sinclair (56) has shown that there is a tendency for an isolate of R. solani to become more tolerant to PCNB after three passages through soil treated with PCNB at 1000 ppm. Maier (39) has reported that no correlation existed between pathogenicity and sensitivity of R. solani to chemicals.

Cotton Herbicides

Trifluralin

Trifluralin (a,a,a- triflubro -2,6- dinitro -N, N-dipropyl-p-toluidine) was first described by Alder (3) as being a slightly volatile, selective, pre-emergence herbicide. Trifluralin is sold under the trade name of "Treflan" as a 4 pound per gallon emulsifiable concentrate. Trifluralin, when used as a surface spray, gives excellent annual grass and broadleaf weed control at four to six pounds per acre (46). Trifluralin gives good control of annual grasses and many broadleaf weeds in cotton when preplant incorporated at rates of 0.5 to 1.5 pounds per acre (lbs/A) on light sandy to heavy clay soils, respectively (28,45).

Some of the methods used for incorporation are PTO-driven rotary hoe, double disc, bed conditioner, rolling cultivator and ground-driven rotary hoe (28). Trifluralin must be incorporated two to four inches deep for best results (43,60).

Standifer (60) has shown that four applications in one season of one pound per acre each of trifluralin did not ultimately affect the plant height or yield of cotton. Stunting and restriction of lateral root development in cotton is characteristic of trifluralin (30,34,43, 60).

Prometryne

Prometryne [2, 4- bis (isopropylamino)-6- methylmercapto -s-triazine] is an 80% wettable powder which can be used as a preplant, pre-emergence, post-emergence, or layby herbicide. "Caparol" is the trade name for prometryne.

Prometryne controls most annual broadleaf weeds and has also proved effective in control of annual grasses, such as crabgrass, watergrass and goosegrass in cotton. It does not control established Johnsongrass, Bermudagrass and other established perennials (26).

In general, the triazine compounds do not inhibit the germination of seeds, but kill susceptable seedlings (37,9). The seedlings turn yellow or brown and die within a very short period (37). Prometryne does not show any phytohormonal effects (9). Prometryne is used at rates of one to three and one-half pounds per acre depending on soil type plus the time and type of application (26).

Fluometuron

Fluometuron [3- (m-trifluoromethylphenyl) -1,1-dimethylurea] is used as a pre-emergent, early post-emergent or layby herbicide. Fluometuron is sold under the trade name of "Cotoran" as an 80% wettable powder. At rates of one to two pounds per acre fluometuron will control most broadleaf and grass weeds, such as pigweed, morninglory, brachiaria, cocklebur, goosegrass and crabgrass (26,27,70). Incorporation of fluometuron can cause an overall decrease in weed control (53, 8). At rates above two pounds per acre fluometuron causes leaf chlorosis and slight stunting of the cotton plants (17). McCutchen (40) has demonstrated that cotoran will go into suspension in a nitrogen solution readily. At four pounds per acre he reduced the stand and vigor and yield of cotton.

SD11831

SD11831 [4 - (methylsulfonyl) -2, 6 - dinitro -N, N- diproply aniline] is a 75% wettable powder, sold under the commercial name of "Planavin."

SD11831 is applied at rates of 0.5 to one pound per acre in cotton (7,26,32) and is more effective when incorporated into the soil. SD11831 gives excellent control of weedy grasses (32), whereas broadleaf control has been marginal (7).

Hughes (32) reports that the mode of action for SD11831 appears to be the inhibition of plant cell division. Root growth inhibition is common in SD11831 treated soil. The elongation of cells does not appear to be inhibited by SD11831.

It has been observed that a post-emergence application of SD11831 will stop the development of crabgrass seedlings which are in the two-leaf stage and have not developed a secondary root system, and eventually kill them (32).

Interactions

Herbicides have been found to have an influence on the environment and biological systems of plants. In 1945, Smith (58) noted that herbicides had varying effects on various groups of soil microorganisms. He found that fungi were stimulated by ammonium thiocyanate, but were not stimulated by sodium chlorate. 2,4-D had no significant effect on fungi.

On the other hand, microorganisms play a major role in the success or failure of many herbicides. For 2,4-DES to be an active herbicide, *Bacillus cereus mycoides* (Flugge) Smith et al. must hydrolyze it to 2 (2,5-dichlorophenoxy) ethanol, which is then oxidized to 2,4-D (11).

One of the main pathways for the decomposition of herbicides is through microbial decomposition. For general agricultural use, it is desirable to use a herbicide that will decompose within 6 to 12 months. Thus, the possibility of an accumulative effect, which may be toxic to sensitive plants, can be avoided. For most industrial sights or non-crop land areas, it is desirable to use a herbicide that will persist when used as a soil sterilant (61).

The investigation of interactions between soil microorganisms and new pesticidal organic chemicals has developed within the last fifteen years (12). Several difficulties are encountered when studying the interactions of pesticides and soil microorganisms in the laboratory or greenhouse (11). Several of these difficulties are: 1) extremely low rates of application used in field studies are hard to reproduce uniformly with the small amounts of soil used in the laboratory; 2) laboratory studies on soil under controlled conditions may give results that do not follow those obtained from the field because of changes in environmental factors, drainage and variables introduced by the plant roots; and 3) there are physical and chemical as well as microbial factors involved in the transformation of chemicals applied to the soil (12).

In 1966, Ranny (48) states that with the rapid development of chemicals for weed, insect and disease control, there exists a problem in knowing which one to select and which chemicals can be combined for a given situation. In the past there have been results published which show that under certain conditions some combinations of chemicals for pest control will reduce crop stands and cause plant damage.

With the application of a fungicide containing hexachlorophenecaptan in combination with either of the systemic insecticides, phorate or Di-syston, there exists a deleterious interaction which results in root abnormalities and an increase in disease loss (49). Hacskaylo (29) reports that the herbicides diuron or monuron, in combination with either of the systemic insecticides, phorate or Di-syston, caused an increase in the phytotoxicity of the herbicides. While Boling (13) reports no deleterious interaction between the insecticide UC21149 and diuron, trifluralin, dacthal or CIPC.

In Arkansas, a study to measure the effect of early season practices on the growth and yield of cotton was conducted. They found that a deleterious interaction occurred at the Pack test site between the herbicide diuron and the fungicide combination PCNB-captan. There also existed a deleterious interaction between the fungicide combination PCNB-captan and the insecticide toxaphene at the Pack test site (65).

Schweizer and Ranney (54) have reported that when the systemic insecticide phorate was used with herbicide combination EPTC-diuron, irrespective of the fungicide treatment, a slight stand reduction occurred. When the herbicide trifluralin was used, a slight beneficial effect was obtained. Yield was not significantly reduced on trifluralin was used, a slight beneficial effect was obtained. Yield was not significantly reduced on trifluralin plantings irrespective of the fungicide or insecticide treatments. However, the use of fungicide-treated cottonseed resulted in significant yield increase when the herbicide combination EPTC-diuron was used. Gohlke (25) has also reported that there is no interaction between trifluralin and the fungicide combination lanstan-PCNB.

In 1959, Bingham and Upchurch (10) postulated that diuron and phosphorus interact, and that the effect of diuron on growth was partially regulated by the phosphorus level.

Since interactions exist between various pesticides and between various pesticides and soil nutrients, it is highly possible that an interaction exists between pesticides and plant pathogens.

It was noticed in 1954, by Chappell and Miller (19) that peanut fields treated with herbicides were more vigorous than the non-treated fields. Laboratory studies were conducted and it was found that certain herbicides were effective against several parasitic fungi and the sting nematode. Bain (6) has tested the effect of 3- (3,4 - dichlorophenyl) -1, 1- dimethylurea (diuron) on three fungi. He found that R. solani and Sclerotium rolfsii generally were more sensitive than Sclerotium bataticola. Sinclair (57) has shown that different isolates of R. solani differ in their sensitivity to the fungicides PCNB, captan and dichlone, alone or in combination.

In 1958, Boyle, et al (14) found that some peanut fields treated with 2, 4- dichlorophenoxyethyl sulfate (seasone) for weed control had very poor emergence of peanuts. From previous experiments and farm plantings, it was known that peanuts were tolerant to sesone. They concluded that there was a combined action of sesone and a disease complex of bacteria and fungi causing the reduced emergence. They gave special reference to R. solani.

In Colorado, Altman and Ross (2) reported that there was a slight stunting without stand reduction of sugar beet plants grown on steamed greenhouse soil treated with 4.5 pounds per acre of s-propyl butylethylthiocarbamate (PEBC) or 6.5 pounds per acre of 5- amino -4-chloro -2-phenyl -3 (2H)- pyridazinone (PCA). It was observed that R. solani alone caused an appreciable reduction in the number of sugar beet plants. In addition, R. solani in combination with the herbicide treatments caused even larger stand reductions.

Literature on the interaction of cotton herbicides and R. solani is limited. The possibility of an interaction existing has been postulated by several workers (34,62). Pinckard and Standifer (47) have shown that seedling growing in trifluralin treated soil is more susceptible to damping-off. They found that the incidence of pathogenic

R. solani was increased; whereas, the occurance of *Fusarium* sp. was not changed when trifluralin was applied . The percentage of seedling infected with *R. solani* in the non-treated area was 30%. In plots receiving 0.75 pound of trifluralin, the percentage of seedling infected raised to 69%.

In other studies, Standifer (59) states that where pre-emergence herbicides were applied at high rates, it appeared that the plants were dying from seedling disease rather than a direct effect of the herbicides. He goes on to state that the ultimate phytotoxicity of pre-emergence herbicides in cotton may depend on pathological complications and on the presence or absence of soil fungicides.

In Georgia, trifluralin was used in a soil fungicide and a seed treatment test. Each plot consisted of four rows treated with 0.75 pound per acre of trifluralin and four non-treated rows. It was found that both seedling count and growth in the non-trifluralin plots were superior to that in the trifluralin area. Where trifluralin was used the difference in stand count was reduced. With or without the use of trifluralin there developed no strong trends in the population of the fungi. They found that *Rhizoctonia* sp. and *Pythium* sp. were more predominant in the early samples, while *Fusarium* sp. was more predominant in the later warm weather samples (51).

Studies have been conducted in Arizona on the effects and interactions of trifluralin, PCNB and *R. solani*. It was found that trifluralin at 0.5 to 8 pounds per acre reduced the fresh weight of cotton seedling, and that root inhibition was more predominant than inhibition of top growth. Likewise, the use of PCNB at all rates caused a reduction in the weight of the cotton seedling. The incidence of *R. solani* was higher at a soil temperature of 75° F. than at the 85° F. When _R. solani_ was inoculated into soil treated with trifluralin at 0, 0.5 and 1 pound per acre, there existed no significant interaction with reference to percent emergence or hypocotyl infection. When PCNB was applied to the _R. solani_ and trifluralin-treated soil, an increase in cotton emergence and fresh weight was obtained, while there was a decrease in hypocotyl infection at 75° F. (1).

MATERIALS AND METHODS

Growth Chamber Studies

Greenhouse studies were conducted at the Weeds Laboratory, Oklahoma State University to determine a satisfactory method of evaluating the effects of *R. solani* on cotton seedlings. A standardized ranking system was found to be the most useful. This system consisted of ranking the plants according to the scale:

0 - no visible organism damage to the cotton seedlings

1 - discoloration and appearance of small lesions on the cotton seedling stem just beneath the soil surface

2 - the presence of larger lesions which may encircle the stem

3 - large lesions which encircle the stem and are sunken in appearance on the stem, the stem having a concave appearance

4 - plants dead as a result of the organism.

A pathogenic isolate of *R. solani* was obtained from the Department of Botony and Plant Pathology[1]. The optimum temperature for growth of the strain was 30° C. The strain has the ability to cover a petri dish containing potato dextrose agar (PDA) with mycelium in three days at 23° C.

Herbicide rates were determined from previous data collected on their use as a cotton herbicide in Oklahoma. Two rates of each

[1] Mr. R. E. Hunter, Department of Botany and Plant Pathology.

herbicide was selected, the lower rate being the recommended rate for a given soil type. The higher rate was set at a level which would place the cotton seedling under a stress and give a slight appearance of crop injury.

To investigate the possibility of a herbicide and R. solani interaction, growth chamber studies were conducted as a factorial arranged in a randomized block design. The experiments were conducted at the Climate and Environmental Research Laboratory at Oklahoma State University. Initial studies were conducted with R. solani to determine the optimum temperature to produce a 50% growth reduction of cotton seedlings. A 50% growth reduction was obtained when the plants were reduced 50% on the average in plant height, plant weight, percent alive at harvest and a 50% increase in the mean disease rating. Constant high, constant low, and variable high and low temperature schemes were conducted. It was found that a temperature program of 75° F. at night and 85° F. in the day, with fourteen hour days, would give a growth reduction of 50%. A constant 3,000 foot-candles of light was used for the light periods in all growth chamber studies.

The level of R. solani that gave a 50% growth reduction at 75° F. at night and 85° F. in the day was obtained by the following procedure. The cultures of R. solani were allowed to grow on 15 ml. of PDA for seven days. On the seventh day, a stock solution was made by placing the content of the petri dish and 200 ml. of distilled water in a Waring blender for 30 seconds at the high speed setting. The stock solution was then filtered through a Buchner funnel without any filter paper to remove the large pieces of agar. The stock solution was diluted with distilled water to obtain a .25 parts per hundred (pph) suspension. It was found that the .25 pph suspension caused a 50% growth reduction. Other levels of R. solani used in some of the preliminary studies were .50 pph, .75 pph, 1.00 pph, 2.00 pph, 4.00 pph and 8.00 pph.

Four square inch greenhouse pots were used in all of the growth chamber studies. The soil used consisted of 83.5% sand, 11.5% silt and 5% clay with a pH of 6.5 and organic matter content of .53%.

The herbicide and rates used varied from one experiment to the next. The following list will show the herbicide and rates employed: trifluralin - 0.5, 0.75, 1, 1.5 and 2 pounds per acre (lb/A); SD11831 - 0.75 and 1.5 lb/A; prometryne - 1, 1.5, 2, 3 and 3.5 lb/A, and fluometuron - 1, 2 and 2.5 lb/A. Trifluralin and SD11831 were incorporated in the pots while prometryne and fluometuron were applied to the soil surface. In all instances commercial formulations of the herbicides were used.

The preparation of a single study consisted of the following procedure. The pots to be treated with incorporated herbicides were filled with steam sterilized soil and the herbicide applied to the surface. Then the herbicide in each pot was incorporated by shaking and rolling the soil in a large plastic bag. Pots treated with pre-emergence herbicides were filled to within 0.5 inch of the top. To each pot requiring inoculation, 10 ml of the desired level of R. solani was applied with a pipette. Five sound cotton seeds were hand-selected of the variety Paymaster 111 and planted 0.5 inch deep in each pot. The seed was acid delinted and treated with an insecticide, heptachlor. The pots receiving pre-emergence herbicides were then treated.

A greenhouse chamber sprayer was used to make the herbicide applications. A 8003-E spray tip traveling 2 miles per hour delivered 40 gallons per acre at 34 pounds per square inch pressure to each stationary pot. Each pot was placed in a five inch saucer in the growth chamber and sub-watered the first three days.

Twenty-one days after planting, the plants were harvesting and evaluated as to mean disease rating, plant height, number of plants alive at harvest, number of plants that germinated, total dry weight of the tops and total dry weight of the roots.

Field Studies

In the spring and summer of 1966, field studies were conducted on the Oklahoma State University Agronomy farms at Stillwater and Perkins, Oklahoma. The field studies were conducted as a factorial arranged in a randomized block design, with 4 or 5 replications. A plot consisted of one row, 80 feet long, with the row divided into two parts. The first 50 feet were for yield data and the back 30 feet were for disease rating and sampling. The row spacing was 40 inches and the planting rate at Perkins was 28 pounds per acre and 23.6 pounds per acre at Stillwater. The Parrott variety cotton seed was acid delinted and seed treated with an insecticide heptachlor.

A planter was adapted to plant the cotton through the planter box and R. solani inoculum was applied through the fertilizer box in one operation. The seed bed was prepared by conventional methods.

R. solani inoculum was prepared by the following method. Fresh harvested grain sorghum was sieved and seed of about the same size was used. The seed was soaked in water for 24 hours then steam sterilized for 0.5 hour on each of two days. On the third day the sorghum was inoculated with *R. solani*. After the mycelium had grown downward to the bottom of the containers the inoculated sorghum seed was spread on a table to dry. In the planting operation the sorghum seed inoculum was placed in the fertilizer box and the rate of flow was constant from the box. In both studies the rate of inoculum was 25 inoculated sorghum seeds per one foot of row. Two inoculum levels were obtained by placing the inoculum 1.5 inches and 3 inches from the planted row of cotton. The third level (check) contained no inoculum.

The rates of herbicides used are as follows: trifluralin - 0.75 and 1.25 lb/A; prometryne - 2.5 and 3.5 lb/A; SD11831 - 0.75 and 1.25 lb/A; fluometuron - 2 and 2.5 lb/A.

Trifluralin and SD11831 were applied as preplant herbicides incorporated with a tandem disk. The plots were disked twice in opposite directions to a depth of about four inches. Prometryne and fluometuron were applied as pre-emergence herbicides.

The application of the herbicides was made with an experimental plot sprayer mounted on a cub tractor which applied 30 gallons per acre. The following tables will show the cultural practices performed on the fields:

Stillwater, Oklahoma:

Cultural Practices	Date Performed
Planted	May 7
Rotary Hoed	May 14, 23
Replanted	May 23
Cultivated	June 10, 23
Sprinkle Irrigated	July 6
Water Furrows Run	August 3
Furrow Irrigated	August 4, 14
Harvest	October 8, 28
Harvest	November 15

Perkins, Oklahoma:

Cultural Practices	Date Performed
Planted	June 14
Sprinkle Irrigated	June 28
Cultivated	July 6
Cultivated	July 18
Sprinkle Irrigated	August 18
Harvest	November 15

The first killing frost at both locations was on October 15, 1966.

The following tables will describe the environmental conditions existing on each planting date:

Stillwater, Oklahoma:

Environmental Conditions	Data
Air Temperature	65° F
Soil Temperature	71° F
Wind Speed	4-5 mph
Soil Moisture	Good
Soil Condition	Fine
Sun	Bright; clear skies

Perkins, Oklahoma:

Environmental Conditions	Data
Air Temperature	80° F
Soil Temperature	80° F
Wind Speed	6 mph
Wind Direction	From SE
Soil Moisture	Good
Soil Condition	Fine
Sun	Bright; clear skies

The soil type at Stillwater was a Port silty clay loam; the soil type at Perkins was a Vanoss loam.

Data obtained from the field studies consisted of the following:

A - Mean Disease Rating - A total of 50 plants per treatment were rated for *R. solani* damage.

B - Herbicide Damage - A visual rating on the basis of 0 equals no damage up to 10 equals plants completely killed were taken over the entire plot area for each treatment.

C - Plant Counts - The early season plant counts at Perkins consisted of 30 feet of treated row. The final counts made at

Perkins and Stillwater consisted of 150 and 160 feet of treated row, respectively.

D - Plant Height - A total of ten plants per treatment were measured in inches.

E - Plant Weight - A total of 15 feet of row was harvested, oven dryed at 72° C. and weighed in grams.

F - Seed Cotton Yield - A total of 125 feet of row was pulled and weighed in pounds per treatment. This weight was then converted to pounds per acre.

Tables X through XIII in the Appendix contain the rainfall data and the maximum and minimum temperatures for both Stillwater and Perkins field studies.

RESULTS AND DISCUSSION

Growth Chamber Studies

Experiment Number I

Trifluralin was applied at 1.0 and 2.0 lbs/A, and *R. solani* at 2 and 4 pph. A wide range was used on *R. solani* and trifluralin both to locate any possible interaction points and to find the upper rate limits of each (Figure 1). In all graphs, some rates are shaded in order to aid in distinguishing between rates. Plant top growth was significantly reduced by both *R. solani* and trifluralin.

No significant interaction occurred probably due to the high rates of *R. solani* and trifluralin used. A high coefficient of variability was obtained with the collection of certain types of data.

Experiment Number II

In this study trifluralin was applied at .75 and 1.50 lbs/A, and *R. solani* at .5 pph, 1 pph and 2 pph. As shown in Figure 2, the pathogen significantly reduced the height, plant top dry weight, and percentage of live plants at harvest.

Trifluralin significantly reduced plant top dry weight. No significant interactions were observed, again probably due to the fact that the level of *R. solani* was still too high, and it masked any interactions that may have occurred.

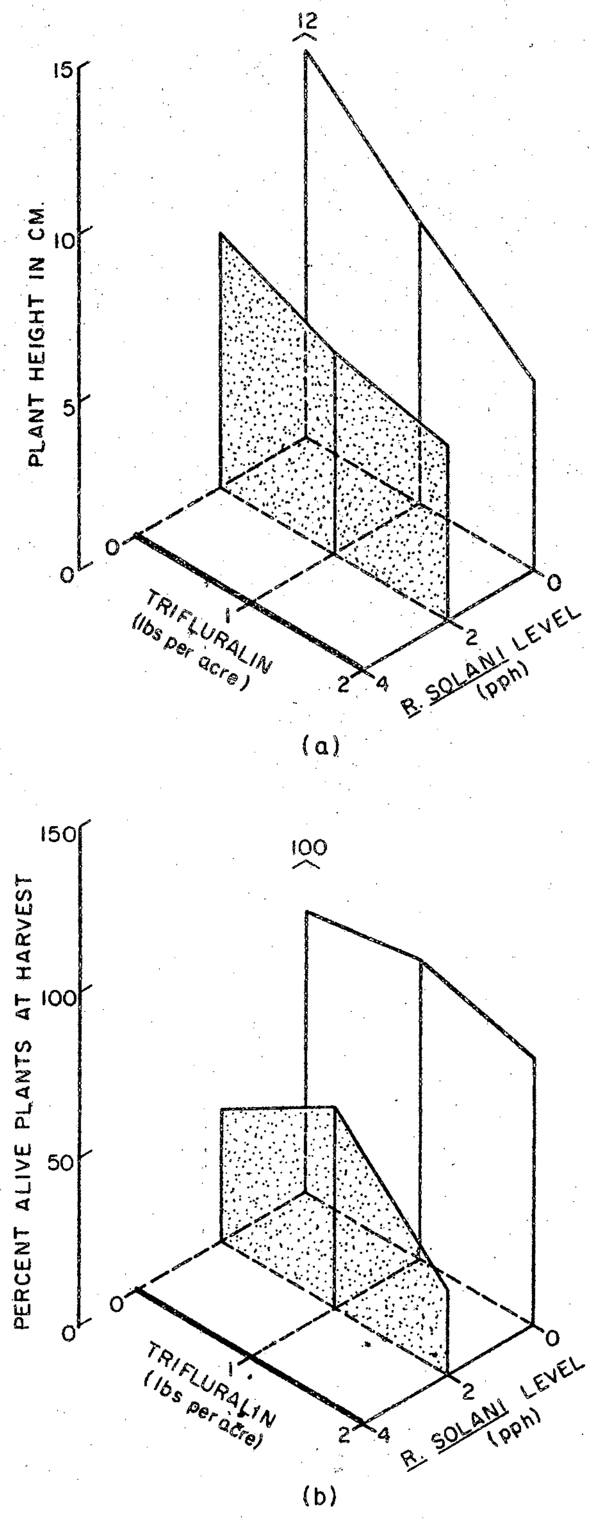


Fig. 1. The Effect of Trifluralin and *R. solani* on the Growth and Survival of Cotton. Growth Chamber Study I.

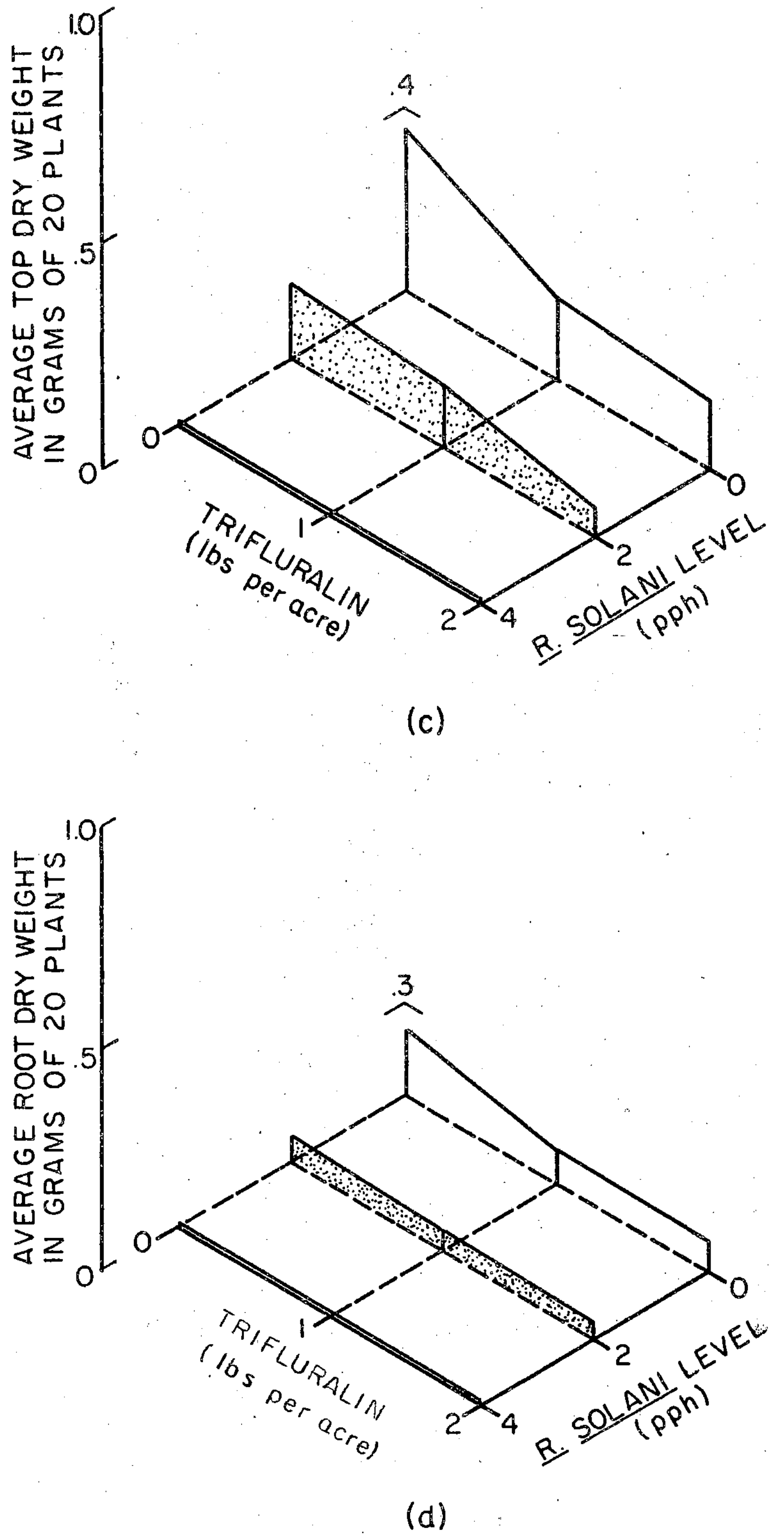


Fig. 1. The Effect of Trifluralin and R. solani on the Growth and Survival of Cotton. Growth Chamber Study I.

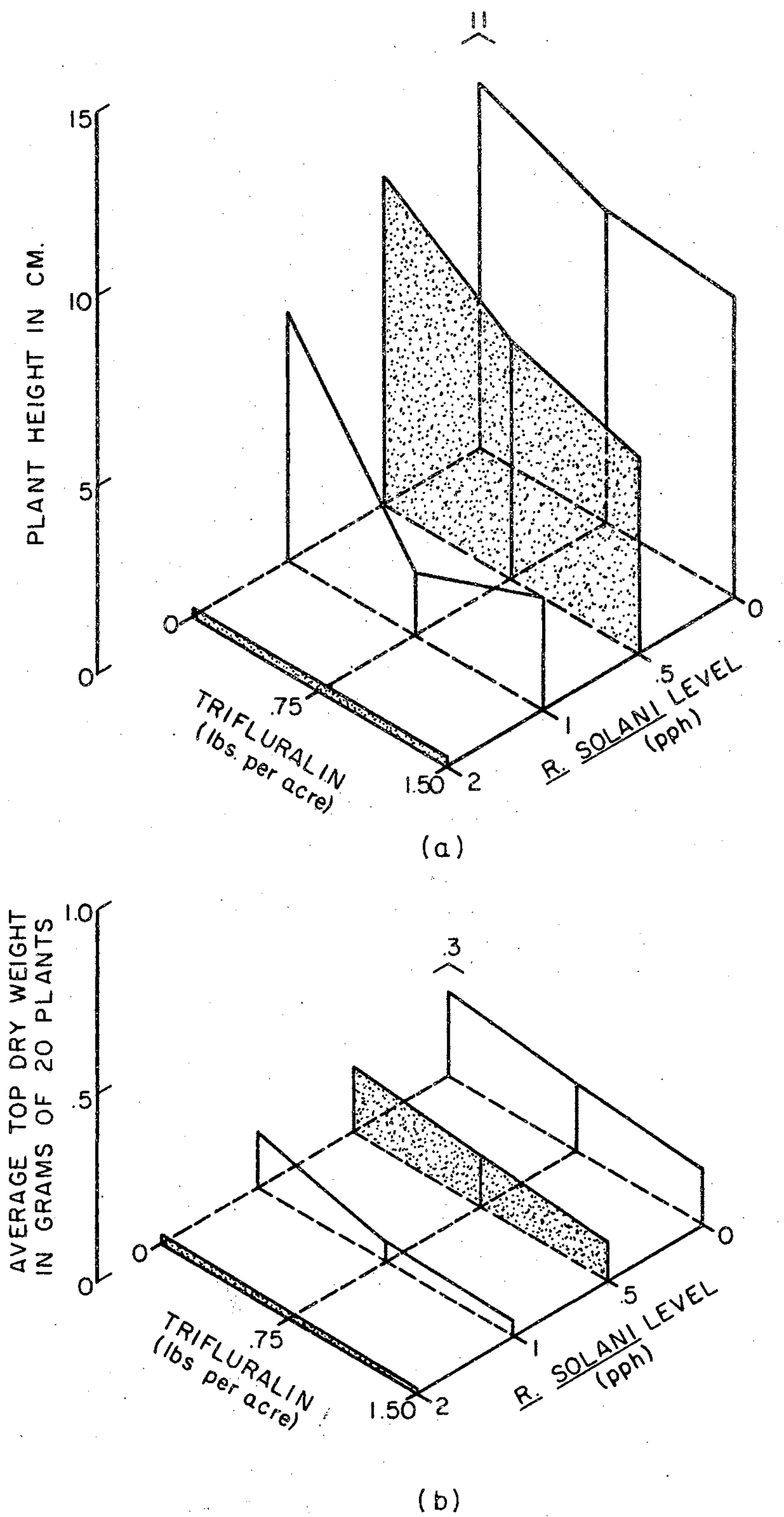


Fig. 2. The Effect of Trifluralin and R. solani on the Growth and Survival of cotton. Growth Chamber Study II.

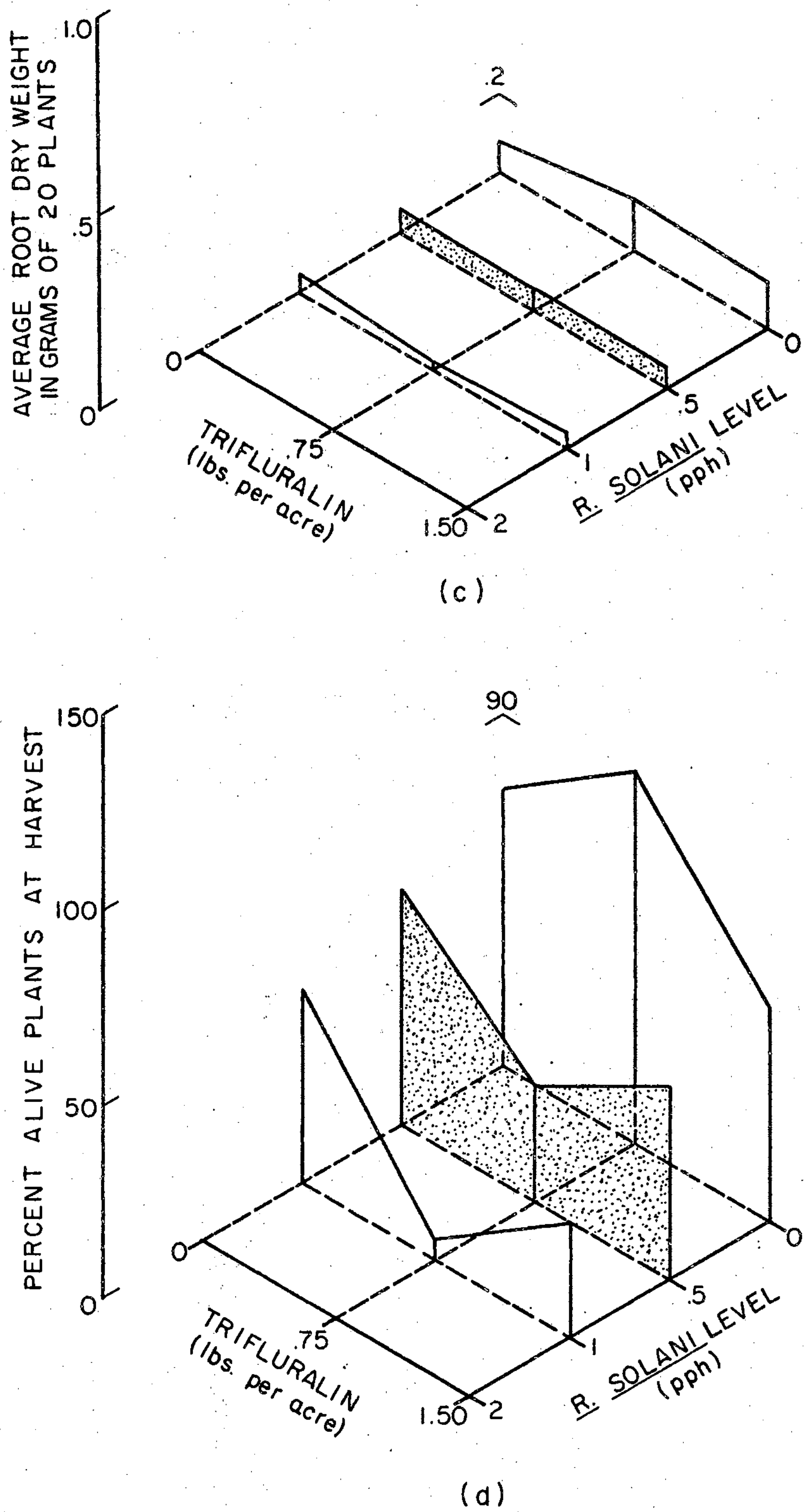


Fig. 2. The Effect of Trifluralin and R. solani on the Growth and Survival of Cotton. Growth Chamber Study II.

Experiment Number III

R. solani levels were reduced to .75 pph, .50 pph, and .25 pph in this study, while trifluralin rates remained at .75 and 1.50 lbs/A. *R. solani* again caused a reduction in the plant growth and the percentage alive at harvest (Figure 3). Trifluralin also caused a significant reduction in plant growth.

Figure 3-a shows that with an increase in trifluralin or the *R. solani* level, plant height was reduced. With the combination of trifluralin at either rates and *R. solani* at .25 pph, only a slight reduction in plant height was observed. With the application of trifluralin at .75 lbs/A and *R. solani* at the high rates a reduction equal in magnitude was observed with an increase in reduction over the .25 pph R. solani level. With the combination 1.50 lbs/A of trifluralin and .50 pph *R. solani* level, a highly significant interaction occurred. With this combination the plants were completely killed.

The various types of measurements in Figure 3 shows that the combination of trifluralin at 1.50 lbs/A and *R. solani* at .75 pph did not completely kill the cotton plants. It is possible that the herbicide was utilized by the increased amount of *R. solani* and was not available to place a stress on the plant thus leaving the plant in a more vigorous state to resist the organism. The other measurements each show the same type of results as the plant height data. In each there was a significant interaction existing with .50 pph *R. solani* and 1.50 lb/A of trifluralin.

Experiment Number IV

In this experiment prometryne at 1.5 and 3 lbs/A and *R. solani* at .25 pph, .50 pph and .75 pph was used. *R. solani* caused a significant

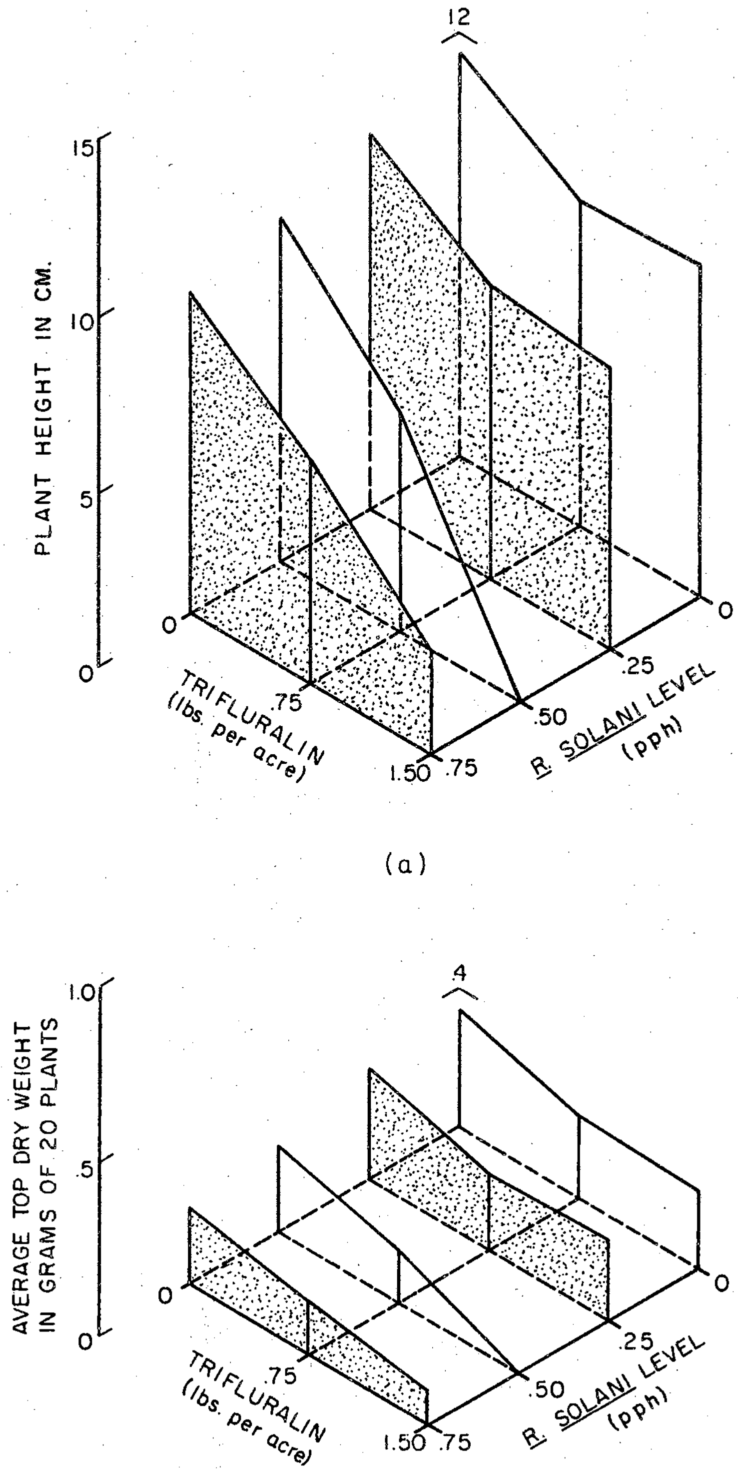
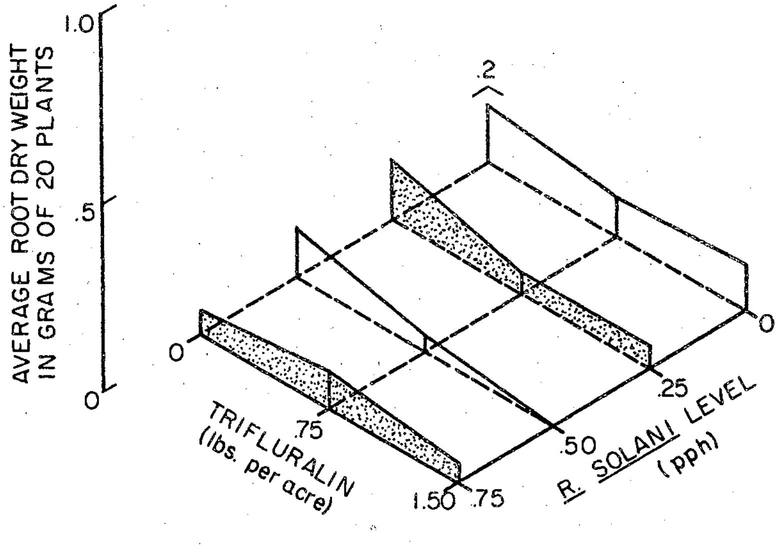


Fig. 3. The Effect of Trifluralin and R. solani on the Growth and Survival of Cotton. Growth Chamber Study III.



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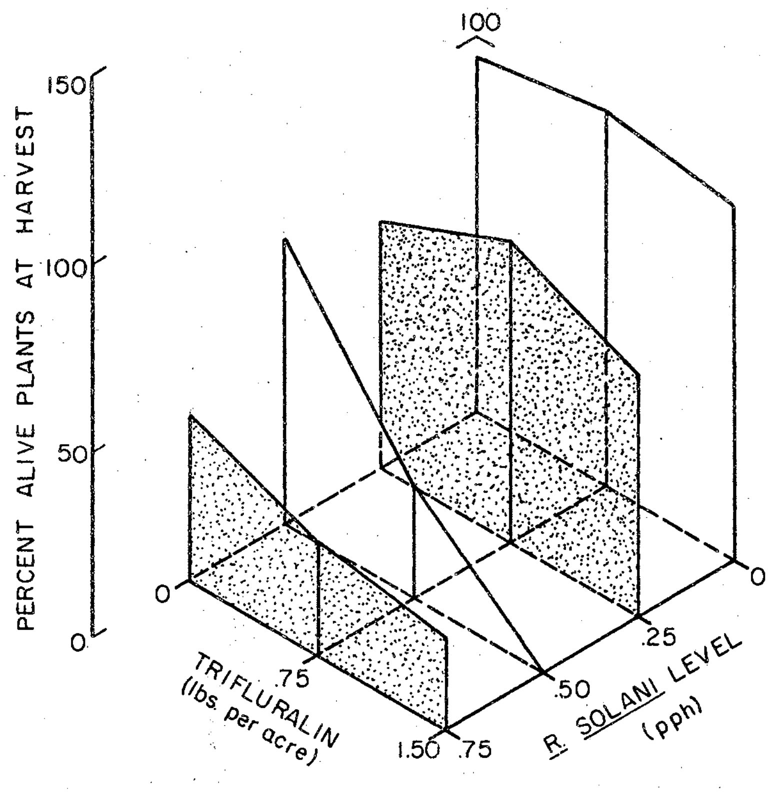

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Fig. 3. The Effect of Trifluralin and *R. solani* on the Growth and Survival of Cotton. Growth Chamber Study III.

reduction in all measurements except the mean disease rating which was significantly increased. Prometryne caused a significant reduction in plant height. The mean disease rating and plant top dry weight indicated a significant interaction between prometryne and _R. solani_ at the 5% and 10% level, respectively. Figure 4 shows that with the combination of prometryne at 3 lbs/A and _R. solani_ at .75 pph there was a reduction in plant height, top plant weight and percentage of live plants at harvest, while the mean disease rating was increased at this point. With the combination of prometryne at the 1.5 lb/A and _R. solani_ at the .50 level, there was an increase in the mean disease plants at harvest. Thus, it appears that with certain combinations of prometryne and _R. solani_ an interaction will occur, while at other points either the organism level was too high and the herbicide rate too low or the organism level was too low and the herbicide rate was too high to preduce an interaction.

Experiment Number V

In this study only one rate of _R. solani_ was used: .25 pph. All four herbicides were used: prometryne, fluometuron, trifluralin and SD11831 at rates of 1, 2, .75 and .75 lb/A, respectively. _R. solani_ caused a significant reduction in plant growth and an increase in the mean disease rating. SD11831 caused a reduction in plant height while the other herbicides had little effect. Although no significant interactions were recorded it is of interest to consider some of the data.

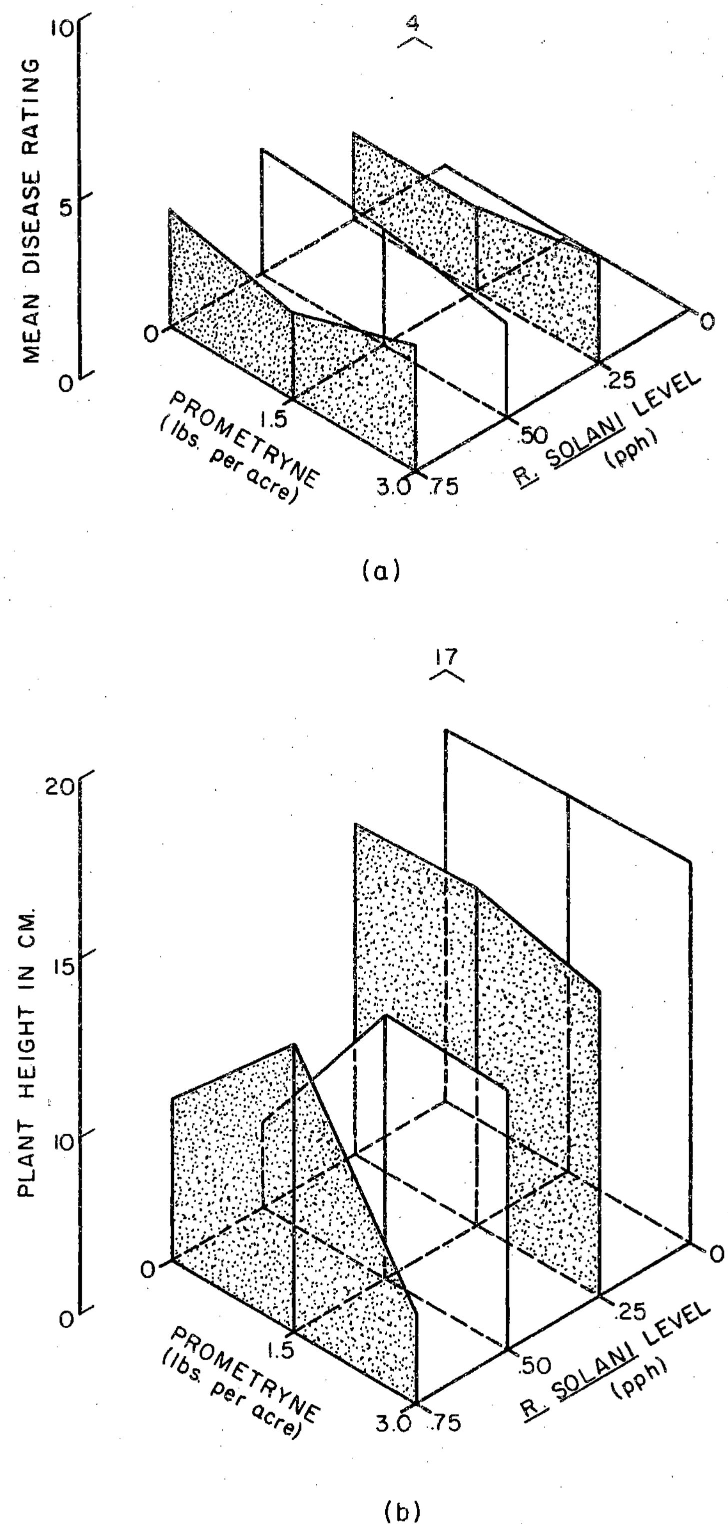


Fig. 4. The Effect of Prometryne and R. solani on the Growth and Survival of Cotton. Growth Chamber Study IV.

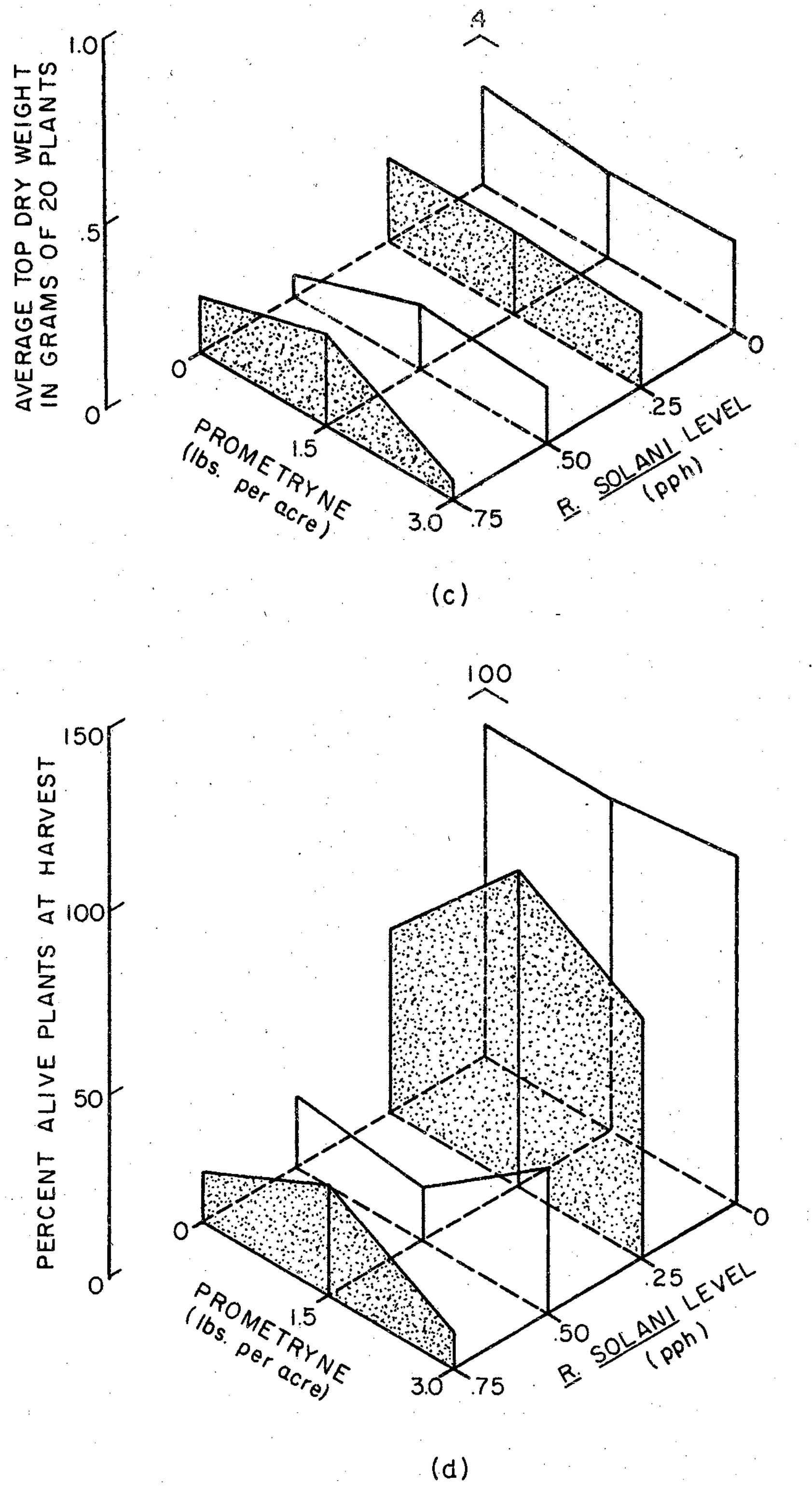


Fig. 4. The Effect of Prometryne and R. solani on the Growth and Survival of Cotton. Growth Chamber Study IV.

TABLE I

THE EFFECT OF FOUR HERBICIDES AND *R. SOLANI* ON THE GROWTH AND SURVIVAL OF SEEDLING COTTON. GROWTH CHAMBER STUDY V

Variable	*R. solani* Level (pph)	Herbicide and Rate (lb/A) Prometryne 1	Fluometuron 2	Trifluralin .75	SD 11831 .75	Check
Height (cm)	0	8.5	8.3	7.4	5.9	8.3
	.25	8.0	7.9	3.8	5.6	5.2
Percent Alive at Harvest	0	96.0	96.0	92.0	96.0	96.0
	.25	84.0	76.0	32.0	76.0	57.0

Table I shows little change in plant height when SD11831 and *R. solani* are in combination. An increase in plant height and percentage of plants alive at harvest was obtained when prometryne or fluometuron was combined with *R. solani* over the use of *R. solani* by itself. When trifluralin and *R. solani* were combined they produced a decrease in plant height and percentage of plants alive at harvest as compared with the use of *R. solani* by itself.

Experiment Number VI

R. solani was used at .25 pph and prometryne, fluometuron, SD11831 and trifluralin were used at the rates of 3, 2, .75 and .75 lb/A, respectively. There is no major difference in the results between experiments V and VI with the exception of a significant interaction between *R. solani* at .25 pph and prometryne at 3 lbs/A in Experiment Number VI (Table II). The interaction was observed for the mean disease rating, root dry weight and percent of plants alive at harvest. In Experiment Number V prometryne at 1 lb/A and *R. solani* at .25 pph did not show a significant interaction.

TABLE II

THE EFFECT OF FOUR HERBICIDES AND R. SOLANI ON THE GROWTH AND SURVIVAL OF SEEDLING COTTON. GROWTH CHAMBER STUDY VI

Variable	R. solani Level (pph)	Herbicide and Rate (lb/A) Prome-tryne 3	Fluome-turon 2	Triflu-ralin .75	SD 11831 .75	Check
Mean Disease Rating	0	0	0	0	0	0
	.25	1.2	1.0	1.2	.8	.6
Root Dry Weight (gm)	0	.08	.11	.08	.06	.11
	.25	.09	.09	.08	.05	.09
Percent Alive at Harvest	0	100.0	84.0	88.0	92.0	100.0
	.25	88.0	100.0	88.0	94.0	100.0

Experiment Number VII

In this study the herbicide rates were increased (Table III), but the R. solani rate was left at the .25 pph. With the use of the higher rates of the herbicides R. solani did not express a significant effect.

TABLE III

THE EFFECT OF FOUR HERBICIDES AND R. SOLANI ON THE GROWTH AND SURVIVAL OF SEEDLING COTTON. GROWTH CHAMBER STUDY VII

Variable	R. solani Level (pph)	Herbicide and Rate (lb/A) Prome-tryne 3.5	Fluome-turon 2.5	Triflu-ralin 1.25	SD 11831	Check
Height (cm)	0	8.4	7.9	6.3	4.8	8.1
	.25	8.4	8.6	6.6	4.2	8.5
Percent Alive at Harvest	0	92.0	92.0	96.0	100.0	88.0
	.25	80.0	84.0	92.0	80.0	84.0

Trifluralin and SD11831 caused a significant reduction in the plant height. No interactions occurred in this study. This study seems to indicate that any interaction that occurred was masked due to the increase of herbicide rates used.

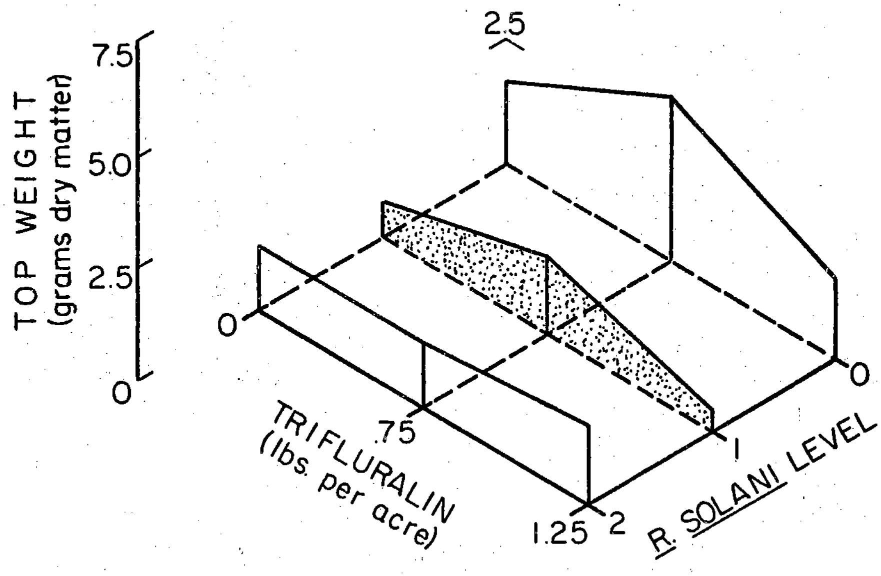
Field Studies

Field studies were conducted at Stillwater and Perkins to investigate the relation between R. solani and the four herbicides under field conditions. Statistical significance was set at the 5% level.

Mean disease ratings at Stillwater 18 days after planting indicated no significant change in degree of plant damage with an increase in the R. solani level or an increase in the rates of trifluralin, prometryne, fluometuron or SD11831. There was no significant interaction between the pathogen and the herbicides as affected disease ratings. There was no damage visually observed from the herbicides at the rates used in this study.

Oven dry plant weight were obtained 18 and 56 days after planting at Stillwater (Figure 5). Eighteen days after planting SD11831, prometryne and fluometuron had not caused a significant reduction in plant weight, but the pathogen had. Trifluralin caused a significant reduction in plant weight. There existed a significant interaction between R. solani at the low level and trifluralin at 1.25 lb/A. An interaction also existed between R. solani at the high level and SD11831 at 1.25 lb/A (Figure 5). Fifty-six days after planting there was no significant interaction between R. solani and any of the four herbicides when plant weight was obtained.

Final plant counts were made 55 days after planting at Stillwater. The four herbicides did not cause a significant reduction in the



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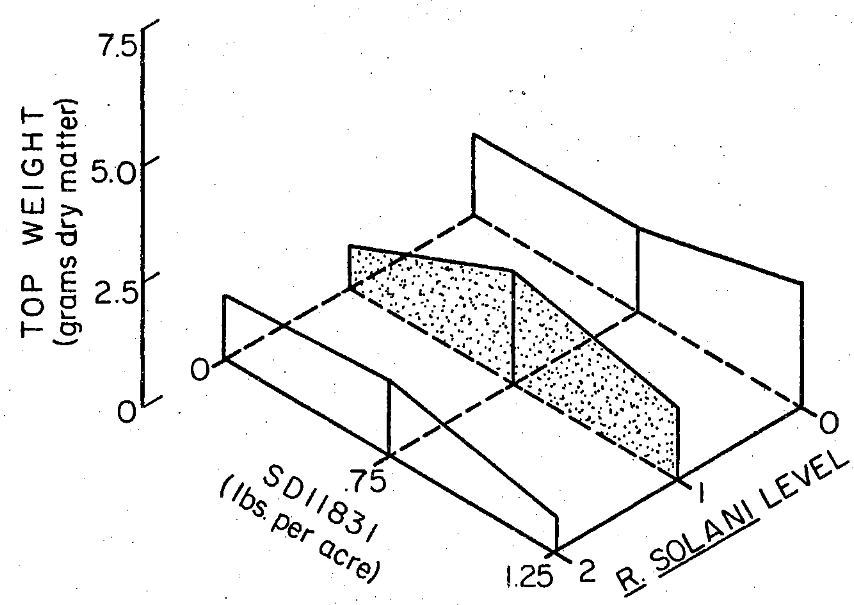

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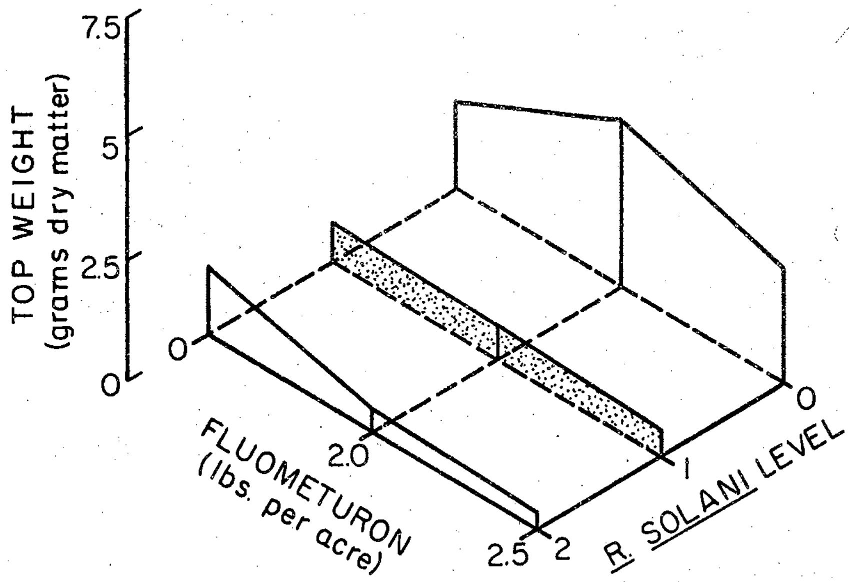
Fig. 5. The Effect of R. solani and Four Herbicides on Plant Weight 18 Days After Planting at Stillwater, 1966.



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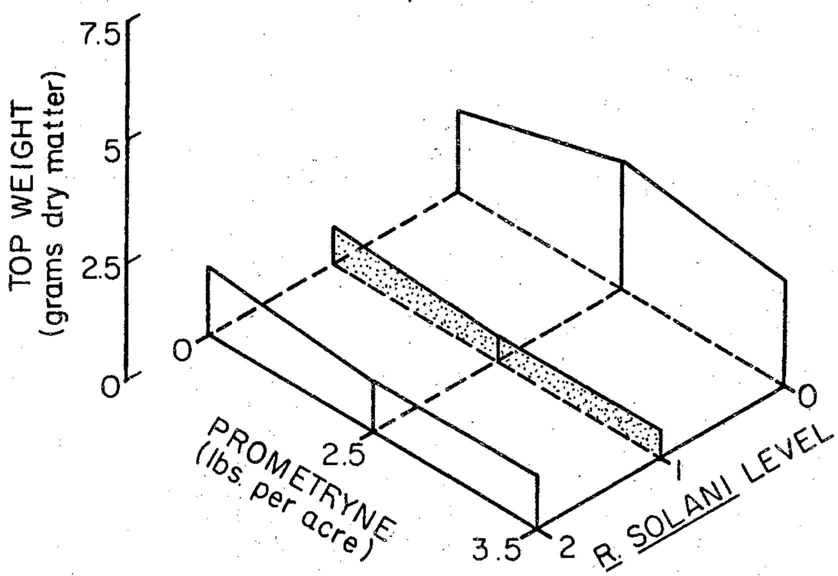


(d)

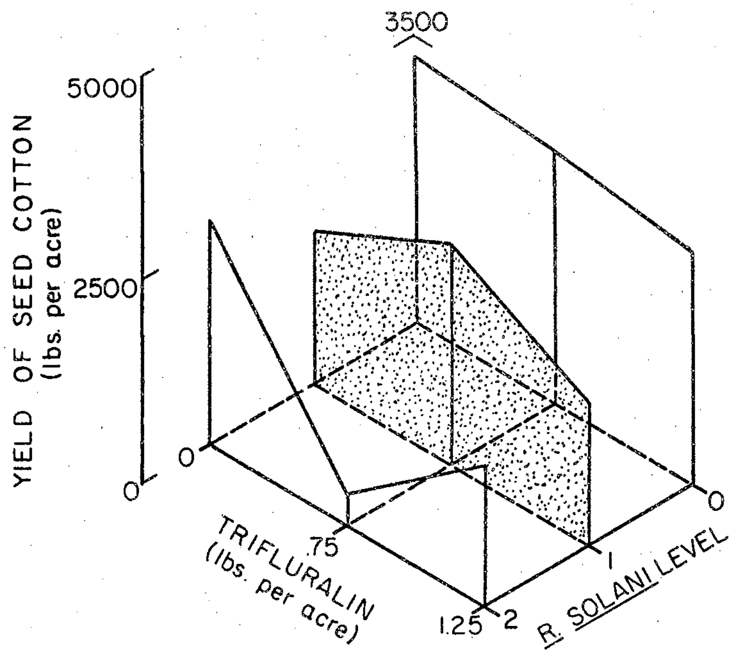
Fig. 5. The Effect of R. solani and Four Herbicides on Plant Weight 18 Days After Planting at Stillwater, 1966.

number of plants, while *R. solani* did. There existed no significant pathogen herbicide interaction.

Prometryne, fluometuron, SD11831 or trifluralin had no significant effect on yields (Figure 6). *R. solani* caused a significant reduction in the seed cotton yield. When *R. solani* was used in combination with fluometuron or SD11831 no significant interaction occurred. When trifluralin or prometryne was combined with *R. solani*, they approached the 10% significant level, but were not significant.

A mean disease rating taken 23 days after planting at Perkins showed significant pathogen damage with an increase in the inoculum level. There was no significant increase in visual injury with an increase in the level of any of the four herbicides. No significant mean disease rating interaction resulted from any organism-herbicide combination.

Herbicide damage on the cotton was observed 23 days after planting at Perkins (Figure 7). There was no visual herbicide damage with trifluralin or SD11831, but some damage was observed with fluometuron and prometryne. The prometryne damage was not significant (see Figure 7-B). Prometryne damage on the seedlings was in the form of leaf chlorosis and marginal burning of the leaves. Fluometuron damage was significant. From Figure (7-A) we can observe that with an increase in *R. solani* we can obtain a decrease in herbicide damage at the 2 and 2.5 lb/A of fluometuron. It appears that the *R. solani* was utilizing the fluometuron or the fluometuron was acting as a fungicide and being tied up with *R. solani*. A similar effect was noted in Growth Chamber Study Number V. Fluometuron damage on the seedlings appeared in the form of leaf necrosis.



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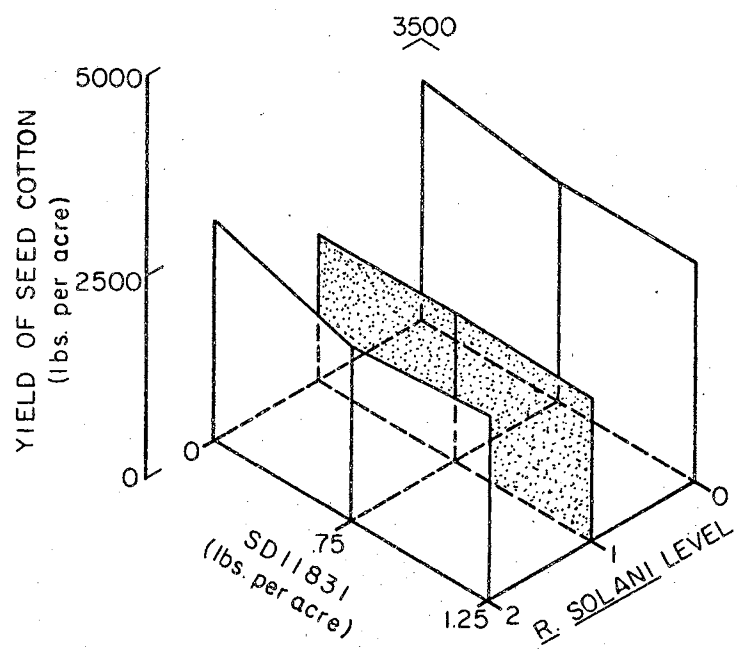

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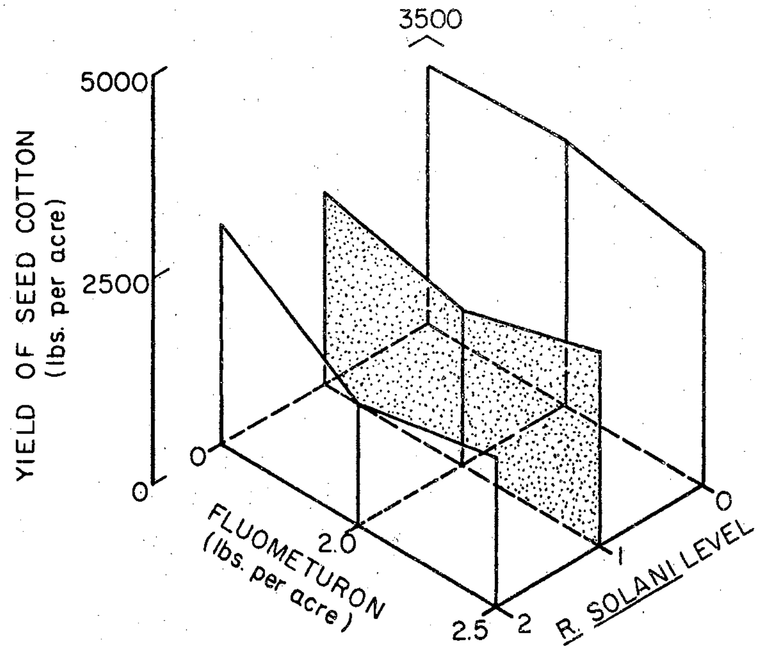
Fig. 6. The Effect of *R. solani* and Four Herbicides on Seed Cotton Yield 176 Days After Planting at Stillwater, 1966.



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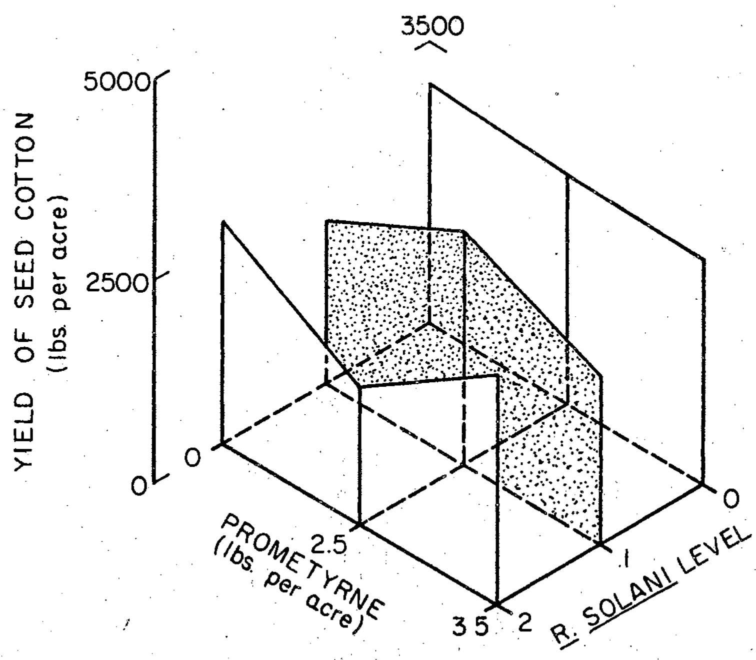

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Fig. 6. The Effect of *R. solani* and Four Herbicides on Seed Cotton Yield 176 Days After Planting at Stillwater, 1966.

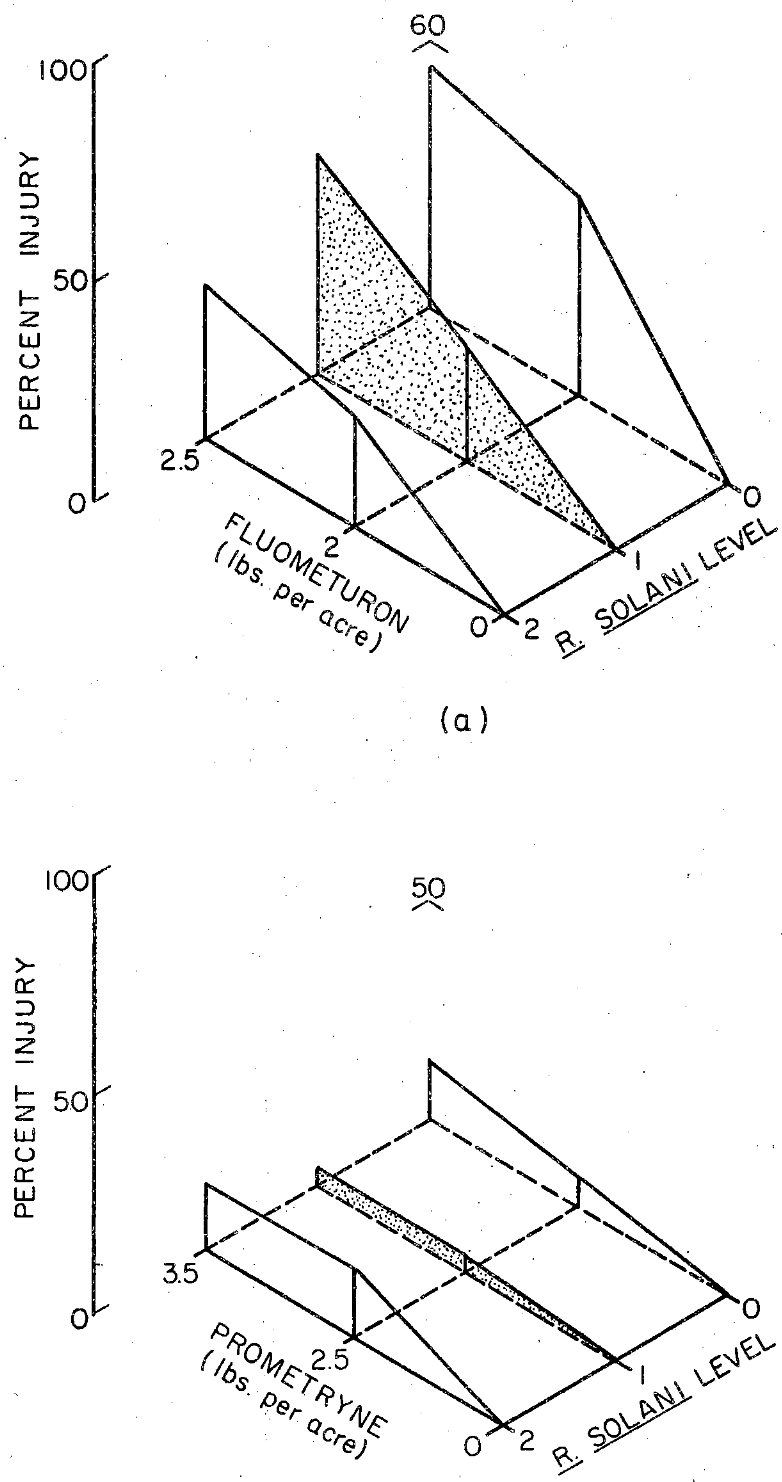


Fig. 7. Visual Damage to Cotton Plants Caused by Fluometuron or Prometryne with *R. solani* at Perkins, 1966.

Oven dry plant weights were obtained 23 and 41 days after planting. Twenty-three days after planting both SD11831 and trifluralin caused a significant reduction in plant weight, while prometryne caused only a slight reduction that was not significant. Fluometuron did not cause a significant reduction in plant weight from the 2 to the 2.5 lb/A rate, but there was a significant reduction from the non-treated to the treated material. *R. solani* caused a significant reduction in plant weight at the 5% level when used with SD11831, trifluralin or prometryne. When *R. solani* was used with fluometuron there was no difference in the levels of the organism. A possible interaction existed between the pathogen and prometryne, but it was not significant. There was not a significant interaction between *R. solani* and trifluraling, SD11831 or fluometuron. Forty-one days after planting there was no significant reduction in plant growth caused by any herbicide. *R. solani* likewise had no effect on the plant growth. There existed no interaction between *R. solani* and trifluralin, fluometuron and prometryne but the combination of SD11831 and the pathogen did produce a significant interaction (Figure 8-a).

Plant height was measured at Perkins 45, 55 and 75 days after planting and showed that *R. solani* did not effect the plant height. Fluometuron and trifluralin significantly reduced the plant height at all dates. *R. solani* at the high rate and trifluralin at 1.25 lb/A showed a very strong trend toward producing an interaction at 45 and 55 days after planting, but was not significant.

Plant counts were made 9, 13, 22 and 34 days after planting at Perkins. Trifluralin significantly reduced the number of plants on all four dates, but SD11831 and fluometuron did not. Nine days after

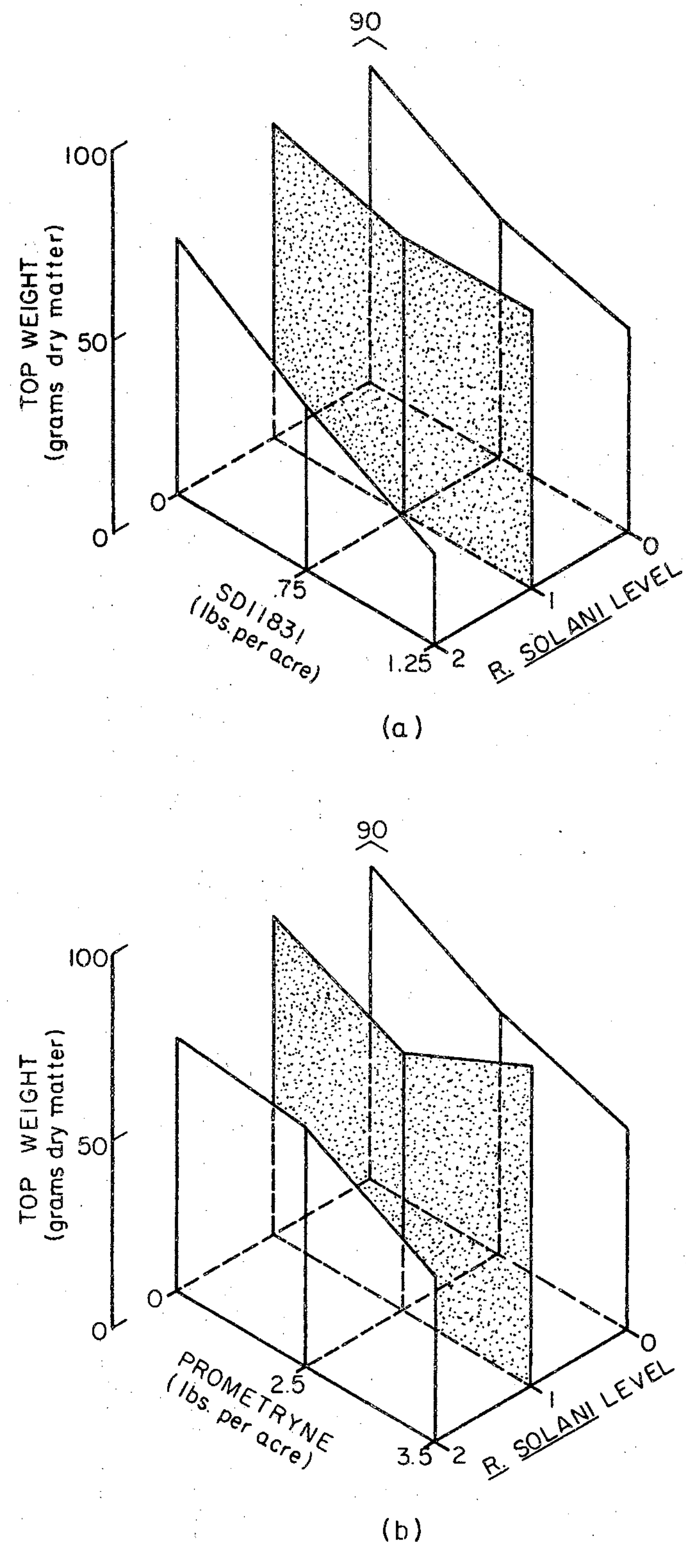


Fig. 8. The Effect of SD11831, Prometryne and <u>R. solani</u> on Plant Weight 41 Days After Planting at Perkins, 1966.

planting _R. solani_ had caused no significant reduction in stand, but at 13, 22 and 34 days after planting _R. solani_ stand reduction was significant at the 5% level. From the count data no significant interactions were recorded between _R. solani_ and SD11831, prometryne, fluometuron or trifluralin. Although the statistics indicated no interactions, it is of interest to consider the data taken 34 days after planting in graph form (see Figure 9). The main point of interest is that at the high level of _R. solani_ and the high level of all the herbicides there was a substantial reduction in the number of plants over either the zero or low rate of herbicide or the zero or low level of _R. solani_.

Final plant counts were made 55 days after planting at Perkins. Trifluralin reduced the stand significantly while prometryne, SD11831 and fluometuron did not reduce the stand significantly. _R. solani_ reduced the stand significantly. Statistically, there was no interaction between _R. solani_ and any of the four herbicides used. However, Figure 10-B shows a reduction in the number of plants when the high level of _R. solani_ and trifluralin are used in combination. While the zero or low herbicide rate or the zero or low level of _R. solani_ alone or in combination does not give the same magnitude in reduction.

Yield data was obtained 154 days after planting at Perkins. Due to a late planting date and an early killing frost date, the yield was reduced considerably. The yield data indicated that SD11831, fluometuron, prometryne or trifluralin did not significantly reduce the seed cotton yield (see Figure 11). The effect of _R. solani_ was not significant in reducing the seed cotton yield. Yields were decreased at the 2.5 lb/A of prometryne with an increase in _R. solani_ while at the

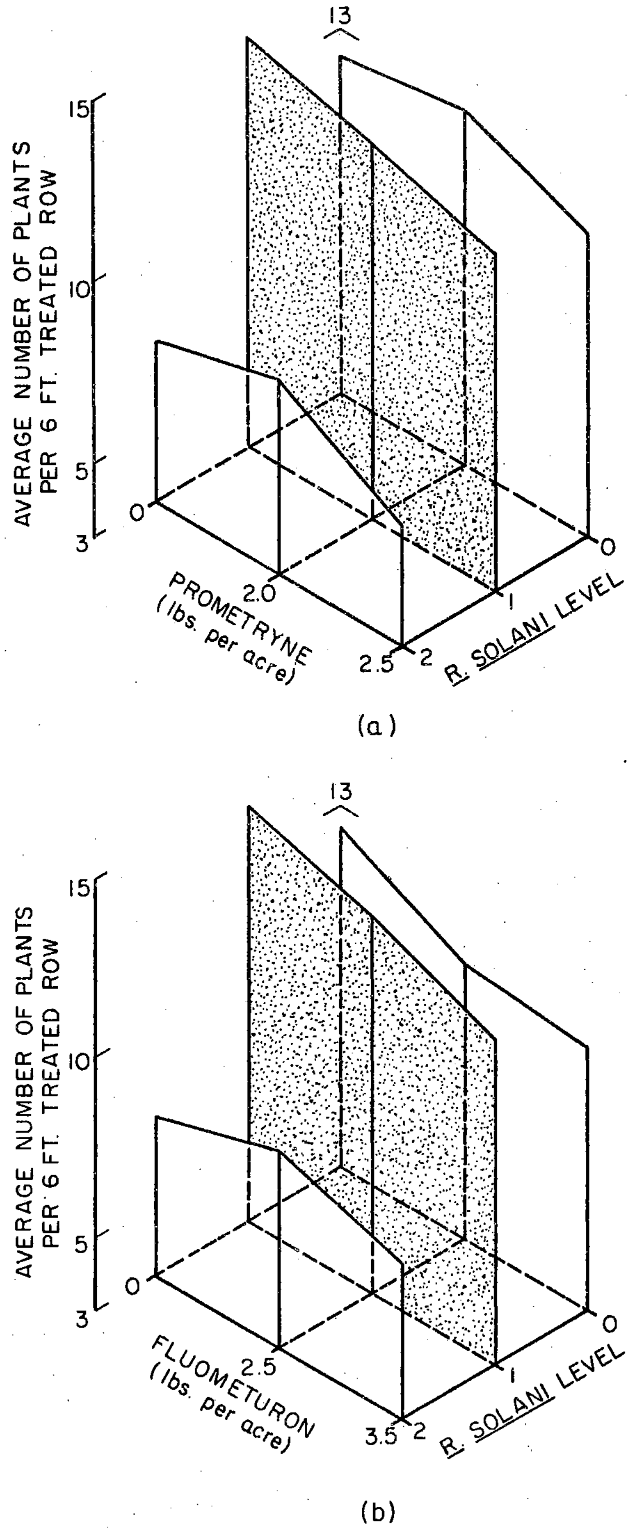


Fig. 9. The Effect of R. solani and Four Herbicides on the Plant Population 34 Days After Planting at Perkins, 1966.

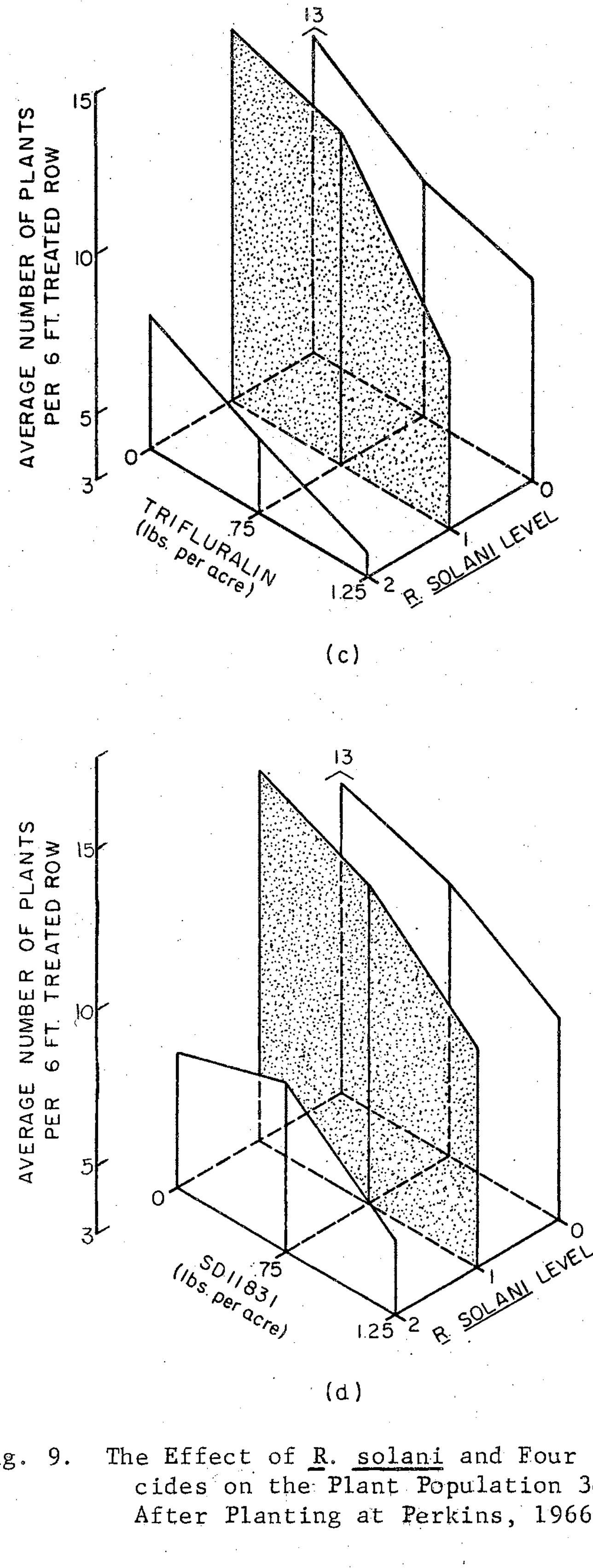
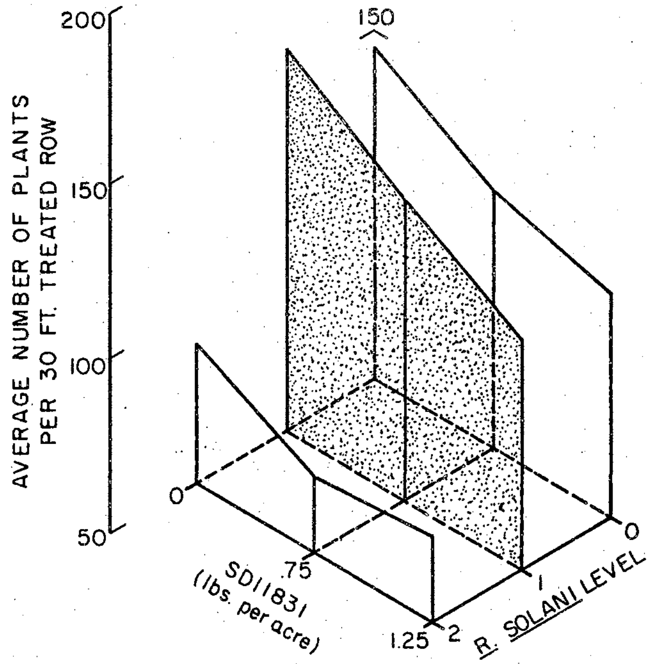


Fig. 9. The Effect of _R. solani_ and Four Herbicides on the Plant Population 34 Days After Planting at Perkins, 1966.



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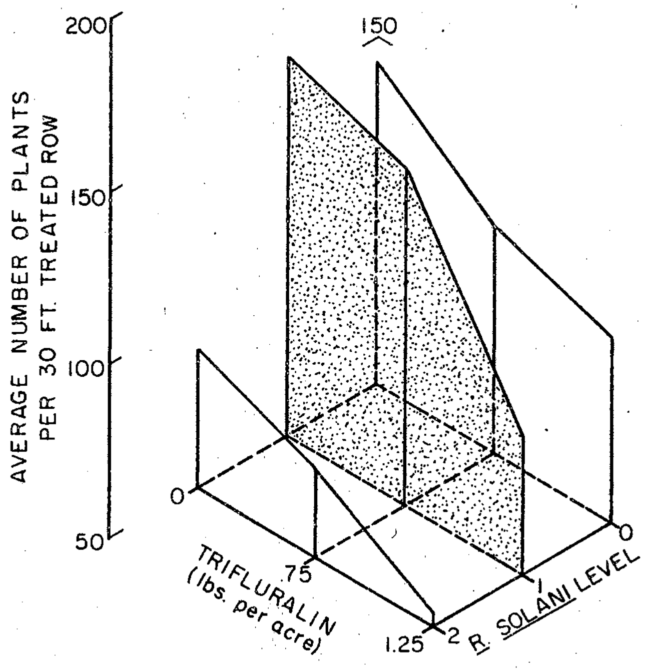
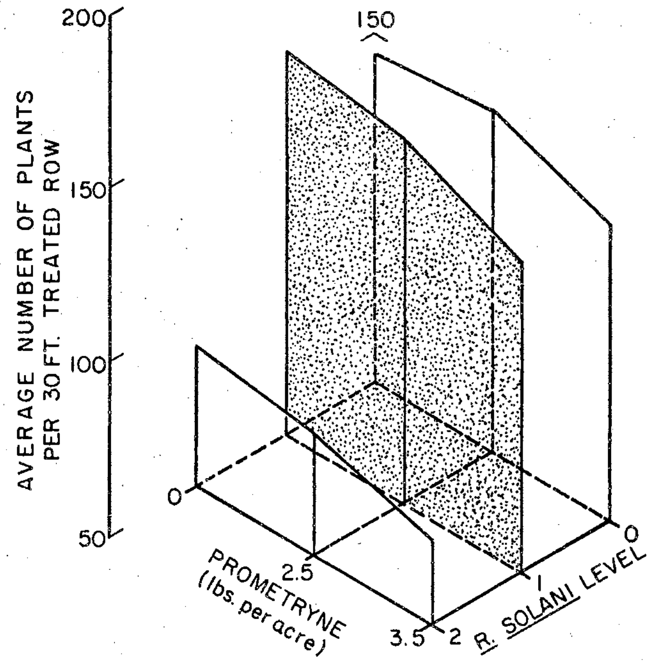


(b)

Fig. 10. The Effect of R. solani and Four Herbicides on the Plant Population 55 Days After Planting at Perkins, 1966.



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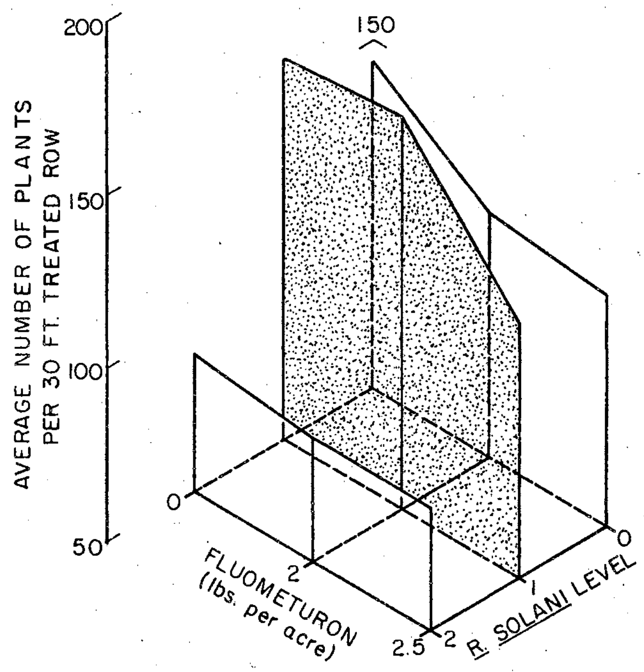


(d)

Fig. 10. The Effect of R. solani and Four Herbicides on the Plant Population 55 Days After Planting at Perkins, 1966.

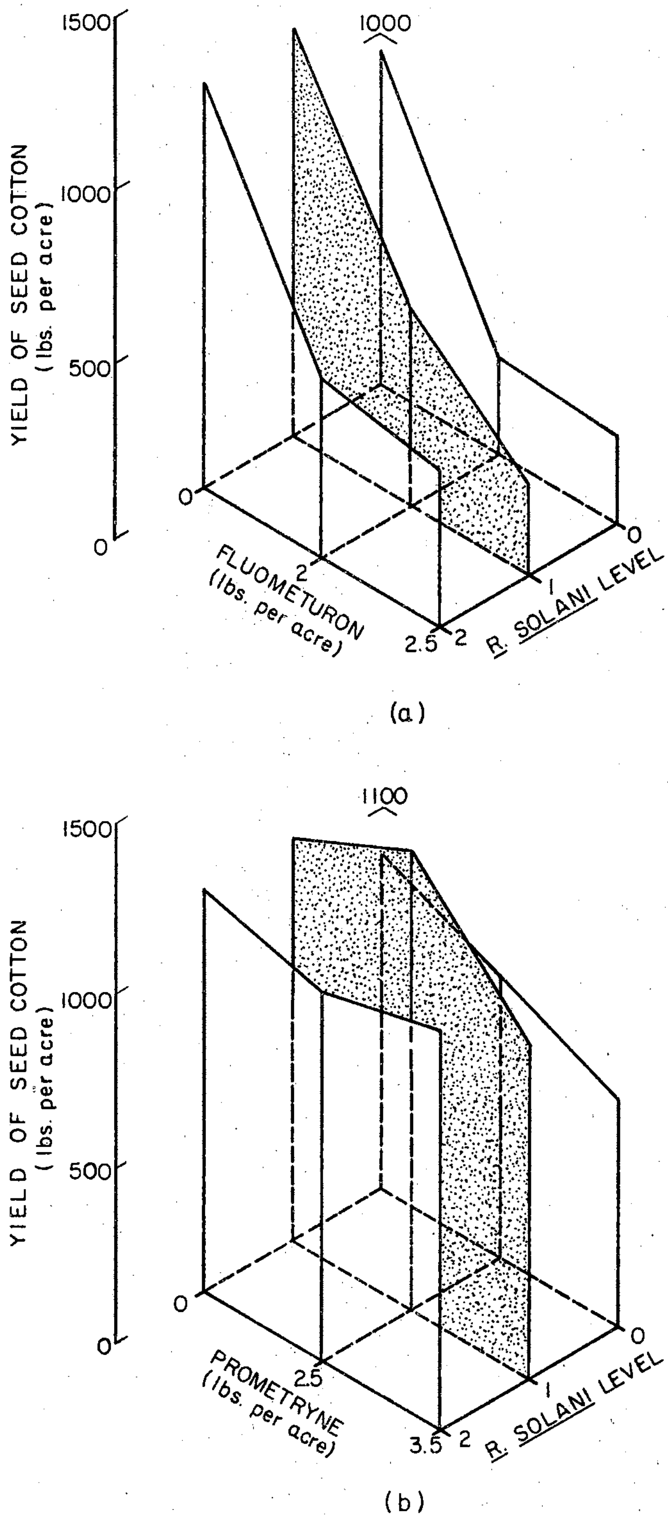
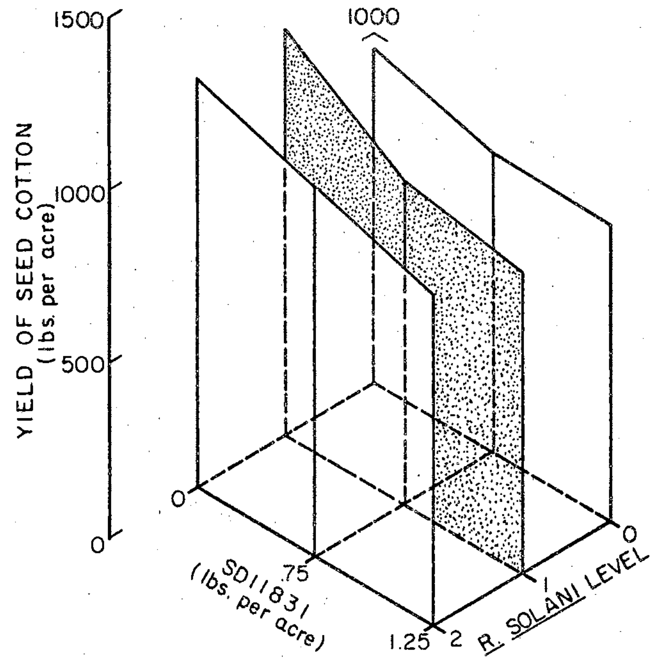


Fig. 11. The Effect of *R. solani* and Four Herbicides on Seed Cotton Yield 154 Days After Planting at Perkins, 1966.



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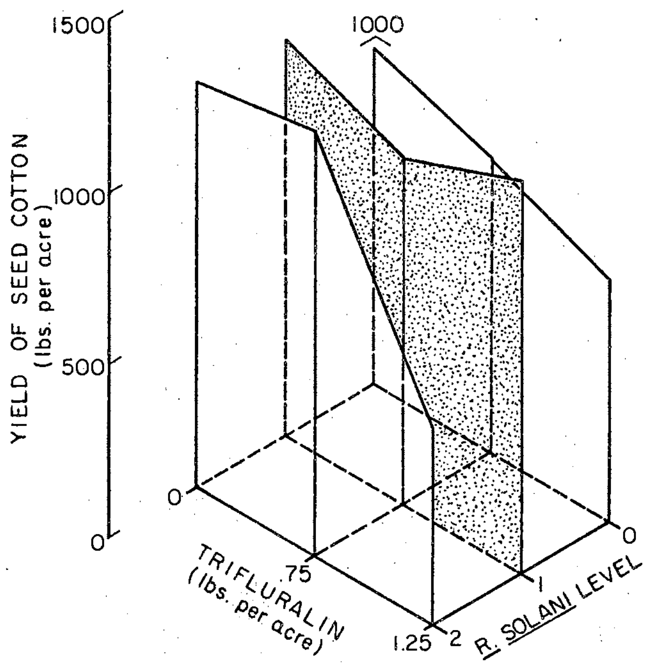

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Fig. 11. The Effect of R. solani and Four Herbicides on Seed Cotton Yield 154 Days After Planting at Perkins, 1966.

3.5 lb/A of prometryne the yields were increased with an increase in R. solani (Figure 9-b). When R. solani was combined with fluometuron, prometryne or SD11831, no significant interaction occurred. When R. solani and trifluralin were combined a significant interaction occurred (Figure 11-d). The yield was reduced when the high rates of trifluralin and R. solani were combined.

Since the postulation of a possible interaction between R. solani and a herbicide (37,68) it has become apparent that a pathogen-herbicide interaction does exist. Some of the early work (1) indicated that there was not an interaction between R. solani and trifluralin. Since then studies conducted by Standifer (65), Pinckard (84) and Roncadori (56) show that a pathogen-herbicide interaction may exist between R. solani and trifluralin.

In this study it is very apparent that pathogen-herbicide interactions do exist under growth chamber and field conditions. However, early growth chamber studies showed that only under certain conditions does such an interaction occur. It was found that high levels of herbicide or pathogen could cause interactions that may occur to be masked. Thus, with certain combinations of R. solani and trifluralin or prometryne in the growth chamber an interaction could occur. Under field conditions an interaction was found to occur with R. solani and trifluralin or SD11831. In most cases the pathogen-herbicide interaction occurred when the high level of the herbicide was used. In both growth chamber and field studies an interaction between R. solani and fluometuron was found to be absent. The data seems to show an antagonistic effect of fluometuron on R. solani in both growth chamber and field studies. Such an effect was also noted with prometryne in in the growth chamber. In producing this antagonistic effect either the *R. solani* was utilizing the herbicide or the herbicide was acting as a fungicide. The exact mechanism was not determined. The data in this study points out the fact that a pathogen-herbicide interaction will occur with a number of herbicides that are quite different in their chemical structure. Since in this study we looked at only four herbicides it is felt that other herbicides need to be screened for the possibility of a pathogen-herbicide interaction.

Since *R. solani* is only one of a group of pathogens that make up the seedling disease complex it is quite possible that there exist interactions between other seedling pathogens and herbicides.

SUMMARY

Growth chamber and field studies were conducted to investigate the possibility of an interaction between a herbicide and a seedling disease organism *Rhizoctonia solani*. The herbicides used were SD11831, trifluralin, fluometuron, and prometryne.

From preliminary greenhouse studies, it was found that a 0-4 ranking system was suitable for rating the effect of *R. solani* on cotton seedlings.

In general the growth chamber studies showed that the pathogenic effect of *R. solani* on cotton seedlings was highly significant with all characteristics studied. In most instances the herbicides produced a significant effect on all characteristics studied at either the 5% or 10% level. Significant interactions were observed for certain characteristics studied between *R. solani* and the herbicides at certain levels of each. In Experiment Number I and II either the herbicide or the pathogen level was too high to detect any interactions that were present. An interaction between *R. solani* and trifluralin was measured for all characteristics studied in Experiment Number III. The interaction occurred with the combination of trifluralin at 1.50 lb/A and *R. solani* at .50 pph. In Experiment Number IV a significant interaction occurred between prometryne and *R. solani* for the mean disease rating and plant top dry weight. The interaction occurred when *R. solani* at .75 pph and prometryne at 3 lb/A were combined or when *R. solani* at .50 pph and prometryne at 1.5 lb/A were combined. An

interaction also occurred between *R. solani* at .25 pph and prometryne at 3 lb/A in Experiment Number VI. The interaction was detected for the mean disease rating, root dry weight and percentage of plants alive at harvest data.

In Experiment Number V there were no interactions but it was noted that prometryne and fluometuron produced an antagonistic effect on *R. solani*. This antagonistic effect was also found to exist in Experiment Number VI when fluometuron and *R. solani* were combined.

In general, under field conditions *R. solani* exhibited a significant effect on all characteristics studied at the 5% level. Injury from *R. solani* was more highly significant when used with certain herbicides. Significant herbicide effects were observed. Herbicide significance varied with the type of data and time of data collection. Significant interactions between *R. solani* at the low level with trifluralin at 1.25 lb/A and SD11831 at 1.25 lb/A with *R. solani* at the high level were noted. The interaction caused a reduction in plant weight.

At Perkins a plant weight reduction interaction existed between *R. solani* at the high level and SD11831 at 1.25 lb/A for plant weight 41 days after planting. The yield data indicated a significant interaction between *R. solani* at the high level and trifluralin at 1.25 lb/A. The interaction caused a reduction in the pounds of seed cotton produced per acre.

At Perkins the visual herbicide damage rating indicated that fluometuron produced an antagonistic effect on *R. solani*. With an increase in the fluometuron rate the antagonistic effect of *R. solani* increased.

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APPENDIX

TABLE IV

MEAN RESPONSES OF *R. SOLANI* AND FOUR COTTON HERBICIDES
CLIMATE AND ENVIRONMENTAL RESEARCH LABORATORY, 1966

Experiment Number: I

Variable	Herbicide	Rate (lb/A)	*R. solani* Levels (pph)[1] 0	2	4	8
Mean Disease Rating	Trifluralin	1.00	.5	3.30	4.0	4.0
	Trifluralin	2.00	.4	3.20	4.0	4.0
	Check		1.2	3.40	4.0	4.0
Height	Trifluralin	1.00	8.6	6.00	0.0	0.0
	Trifluralin	2.00	6.9	5.10	0.0	0.0
	Check		11.20	7.30	0.0	0.0
Top Dry Weight	Trifluralin	1.00	.17	.12	0.0	0.0
	Trifluralin	2.00	.16	.08	0.0	0.0
	Check		.24	.17	0.0	0.0
Root Dry Weight	Trifluralin	1.00	.07	.02	0.0	0.0
	Trifluralin	2.00	.06	.01	0.0	0.0
	Check		.12	.48	0.0	0.0
Percent Alive at Harvest	Trifluralin	1.00	90.00	60.00	0.0	0.0
	Trifluralin	2.00	80.00	25.00	0.0	0.0
	Check		85.00	40.00	0.0	0.0

Experiment Number: II

			R. solani Levels (pph) 0	.5	1	2
Mean Disease Rating	Trifluralin	.75	.8	3.1	2.7	4.0
	Trifluralin	1.50	.2	3.1	3.5	3.7
	Check		.1	2.5	2.7	4.0

Variable	Herbicide	Rate (lb/A)	*R. solani* Levels (pph) 0	.5	1	2
Height	Trifluralin	.75	8.1	6.2	1.7	0.0
	Trifluralin	1.50	8.0	5.2	3.0	0.0
	Check		9.8	8.6	6.7	0.0
Top Dry Weight	Trifluralin	.75	.17	.13	.03	0.0
	Trifluralin	1.50	.16	.10	.05	0.0
	Check		.22	.19	.17	0.0
Root Dry Weight	Trifluralin	.75	.12	.06	.06	0.0
	Trifluralin	1.50	.10	.05	.007	0.0
	Check		.09	.08	.06	0.0
Percent Alive at Harvest	Trifluralin	.75	95.00	30.00	5.00	0.0
	Trifluralin	1.50	65.00	50.00	30.00	0.0
	Check		70.00	60.00	50.00	0.0

Experiment Number: III

			R. solani Levels (pph) 0	.25	.50	.75
Mean Disease Rating	Trifluralin	.75	0.0	2.50	3.0	3.20
	Trifluralin	1.50	0.0	2.20	0.0	3.20
	Check		0.0	2.00	2.4	2.70
Height	Trifluralin	.75	9.1	9.30	6.3	6.70
	Trifluralin	1.50	9.5	9.00	0.0	3.10
	Check		11.5	10.90	9.9	9.10
Top Dry Weight	Trifluralin	.75	.21	.21	.16	.16
	Trifluralin	1.50	.21	.22	0.0	.10
	Check		.33	.32	.24	.22
Root Dry Weight	Trifluralin	.75	.10	.67	.57	.10
	Trifluralin	1.50	.10	.82	0.0	.05
	Check		.13	.17	.13	.07
Percent Alive at Harvest	Trifluralin	.75	100.00	80.00	30.00	30.00
	Trifluralin	1.50	95.00	65.00	0.0	25.00
	Check		85.00	65.00	80.00	45.00

Experiment Number: IV

Variable	Herbicide	Rate	*R. solani* Levels (pph) 0	.25	.50	.75
Mean Disease Rating	Prometryne	1.50	0.0	2.40	3.20	2.60
	Prometryne	3.00	0.0	3.00	2.70	3.60
	Check		0.0	2.30	3.80	3.20
Height	Prometryne	1.50	10.4	9.6	7.60	8.00
	Prometryne	3.00	10.8	8.50	7.30	2.50
	Check		10.2	9.30	2.20	4.50
Top Dry Weight	Prometryne	1.50	.23	.22	.19	.27
	Prometryne	3.00	.24	.20	.18	.05
	Check		.26	.23	.06	.13
Root Dry Weight	Prometryne	1.50	.10	.10	.11	.12
	Prometryne	3.00	.09	.10	.08	.03
	Check		.10	.10	.01	.05
Percent Alive at Harvest	Prometryne	1.50	90.00	85.00	15.00	30.00
	Prometryne	3.00	95.00	65.00	40.00	10.00
	Check		90.00	50.00	20.00	15.00

Experiment Number: V

Variable	*R. solani* Levels (pph)	Herbicide and Rate (lb/A) Prometryne 1	Fluomeuron 2	Trifluralin .75	SD11831 .75	Check
Mean Disease Rating	.25	1.7	1.8	3.20	2.60	2.3
	0	0	0	0	0	0
Height	.25	8.0	7.9	3.8	5.6	5.2
	0	8.5	8.3	7.4	5.9	8.3
Top Dry Weight	.25	.18	.18	.13	.17	.13
	0	.22	.19	.21	.15	.21
Root Dry Weight	.25	.09	.09	.06	.11	.07
	0	.13	.11	.06	.04	.08
Percent Alive at Harvest	.25	84.00	76.00	32.00	87.00	57.00
	0	96.00	96.00	92.00	96.00	96.00

Experiment Number: VI

Variable	*R. solani* Levels (pph)	Prometryne 3	Fluometuron 2	Trifluralin .75	SD11831 .75	Check
Mean Disease Rating	.25	1.2	1.0	1.2	.8	.6
	0	0	0	0	0	0
Height	.25	9.0	9.3	7.8	6.7	9.4
	0	9.2	8.7	7.5	6.4	9.2
Top Dry Weight	.25	.24	.27	.22	.19	.27
	0	.23	.26	.22	.20	.25
Root Dry Weight	.25	.09	.09	.08	.05	.09
	0	.08	.11	.08	.06	.11
Percent Alive at Harvest	.25	88.00	100.00	88.00	94.00	100.00
	0	100.00	84.00	88.00	92.00	100.00

Experiment Number: VII

		Prometryne 3.5	Fluometuron 2.5	Trifluralin 1.25	SD11831 1.25	Check
Mean Disease Rating	.25	1.9	1.7	1.3	1.0	1.6
	0	0	0	0	.2	0
Height	.25	8.4	8.6	6.6	4.2	8.5
	0	8.4	7.9	6.3	4.8	8.1
Top Dry Weight	.25	.22	.23	.18	.12	.21
	0	.20	.22	.18	.12	.22
Root Dry Weight	.25	.10	.09	.07	.03	.10
	0	.10	.11	.08	.04	.12
Percent Alive at Harvest	.25	80.00	84.00	92.00	80.00	84.00
	0	92.00	92.00	96.00	100.00	88.00

[1] *R. solani* levels indicate the following: .25 parts per hundred (pph), .50 pph, .75 pph, 1.00 pph, 2.00 pph, 4.00 pph, 8.00 pph and 0 = no organism.

TABLE V

MEAN RESPONSES OF R. SOLANI AND FOUR COTTON HERBICIDES
PERKINS FIELD DATA, 1966

		R. solani Levels[2]								
		0	1	2	0	1	2	0	1	2
Herbicide	Rate (lb/A)	Mean Disease Rating			Plant Weight (23 Days)			Plant Weight (41 Days)		
Check		.9	1.0	2.5	8.2	10.1	4.1	82.7	83.8	69.0
Trifluralin	.75	.8	1.4	2.3	4.6	6.3	1.9	58.5	85.9	59.9
	1.25	.9	1.2	1.9	2.6	3.6	2.0	56.7	49.3	54.3
Prometryne	2.50	1.2	.8	2.0	6.9	6.2	4.0	62.0	67.4	64.4
	3.50	.8	1.2	2.2	7.4	5.9	1.9	53.0	85.8	46.9
SD11831	.75	1.0	1.1	1.9	6.6	9.2	2.4	61.8	71.1	41.1
	1.25	1.3	1.7	2.2	3.8	4.8	1.7	53.7	75.4	22.6
Fluometuron	2.00	1.0	1.0	2.1	2.9	2.6	3.2	27.2	30.8	18.4
	2.50	1.1	1.3	1.7	3.4	2.8	3.0	12.5	25.5	36.9
		Plant Height (45 Days)			Plant Height (55 Days)			Plant Height (74 Days)		
Check		23.5	24.5	22.2	30.2	30.3	30.3	35.5	34.9	33.6
Trifluralin	.75	19.7	22.8	20.0	25.9	30.5	26.8	31.4	34.9	32.2
	1.25	19.0	18.1	17.5	26.8	27.5	23.5	30.6	30.5	32.3
Prometryne	2.50	22.3	20.9	22.0	29.1	28.2	29.7	33.5	35.0	35.6
	3.50	21.4	22.2	20.3	29.1	29.4	26.8	34.6	34.3	32.9
SD11831	.75	22.7	22.4	20.1	29.0	30.3	27.4	34.7	34.3	33.3
	1.25	21.1	22.2	20.1	27.9	30.0	28.6	33.6	33.8	32.9
Fluometuron	2.00	16.5	17.6	15.7	23.9	26.5	24.4	31.4	32.3	32.7
	2.50	12.9	13.0	14.7	19.2	21.3	20.3	26.0	27.9	28.1

[2] R. solani Levels indicates the following: 0 = no organism, 1 = R. solani 1.5 inches from the row, 2 = R. solani 30 inches from the row.

Herbicide	Rate (lb/A)	Plant Counts (9 Days)			Plant Counts (13 Days)			Plant Counts (22 Days)		
R. solani Levels		0	1	2	0	1	2	0	1	2
Check		10.3	13.2	13.9	10.2	17.5	9.6	12.6	15.7	9.8
Trifluralin	.75	8.2	14.7	13.5	10.0	10.7	7.3	10.7	12.5	8.2
	1.25	8.1	7.2	6.6	9.6	4.4	4.2	9.9	9.3	6.1
Prometryne	2.50	11.4	11.2	9.5	10.1	10.9	7.0	13.0	16.9	8.9
	3.50	13.4	13.2	12.4	9.5	11.4	6.9	12.4	14.4	6.0
SD11831	.75	8.8	10.0	10.9	8.5	10.4	7.7	9.5	11.6	8.8
	1.25	9.4	9.7	12.2	8.8	8.2	6.9	11.0	10.2	7.6
Fluometuron	2.00	8.0	11.4	13.8	8.6	12.7	9.2	10.5	15.9	7.3
	2.50	12.7	12.8	13.4	12.8	11.8	6.5	12.6	13.4	8.6

Herbicide	Rate (lb/A)	Plant Counts (34 Days)			Plant Counts (55 Days)			Yield (154 Days)		
Check		12.7	14.7	7.2	142	160	90	980	1165	1176
Trifluralin	.75	10.3	13.3	5.2	117	149	74	825	1011	1228
	1.25	9.1	8.3	3.7	103	90	53	701	1166	567
Prometryne	2.50	11.9	13.1	8.7	149	156	84	794	1217	1083
	3.50	11.8	12.3	6.3	137	140	74	650	959	1166
SD11831	.75	11.4	13.2	8.4	122	134	70	876	918	1083
	1.25	9.2	9.9	5.3	111	113	75	846	856	949
Fluometuron	2.00	10.7	13.6	8.6	119	162	84	288	547	505
	2.50	10.2	12.0	7.5	117	123	83	247	258	433

TABLE VI

MEAN RESPONSES OF *R. SOLANI* AND FOUR COTTON HERBICIDES
STILLWATER FIELD DATA, 1966

		R. solani Levels								
		0	1	2	0	1	2	0	1	2
Herbicide	Rate (lb/A)	Mean Disease Rating			Plant Weight (18 Days)			Plant Weight (56 Days)		
Check		1.6	2.3	2.0	1.9	.9	1.2	92.0	69.5	23.7
Trifluralin	.75	1.7	2.5	2.3	3.2	1.6	1.2	132.5	61.5	32.7
	1.25	1.8	2.3	2.4	1.9	.3	1.7	113.5	16.0	68.6
Prometryne	2.50	1.3	2.3	2.3	2.7	1.0	.3	72.7	43.2	22.8
	3.50	1.3	2.1	2.1	2.1	1.1	.4	116.4	55.0	57.6
SD11831	.75	2.3	1.7	2.1	1.8	2.4	1.5	114.0	81.2	25.9
	1.25	1.7	1.3	1.0	2.7	1.4	.7	108.0	47.9	63.5
Fluometuron	2.00	1.6	1.5	6.5	3.4	.4	.7	109.7	42.5	36.8
	2.50	1.4	2.0	1.7	2.3	.3	.6	91.7	24.6	38.6

Herbicide	Rate (lb/A)	Plant Counts (49 Days)			Yields (176 Days)		
Check		168	97	91	3146	1973	2850
Trifluralin	.75	162	63	2	3250	2695	400
	1.25	150	89	76	2952	1792	1662
Prometryne	2.50	238	76	31	2979	2992	1728
	3.50	149	65	55	2992	2141	2953
SD11831	.75	156	77	43	2888	1960	2179
	1.25	206	80	39	2901	1844	2334
Fluometuron	2.00	232	18	23	3417	1934	1522
	2.50	173	20	21	2992	2450	1882

TABLE VII

STATISTICAL ANALYSIS OF GROWTH CHAMBER DATA
CLIMATE AND ENVIRONMENTAL RESEARCH LABORATORY, 1966

Experiment Number: I
Herbicide: Trifluralin
Rate: 1 and 2 pounds per acre
Organism: R. solani
Rate: 2pph, 4pph, and 8pph

Factors Analyzed

Variable	Interaction F	.05	.10	Organism F	.05	.10	Herbicide F	.05	.10
Mean Disease Rating	.54			83.26	**		.80		
Height	.59			33.53	**		1.48		
Top Dry Weight	1.07			39.55	**		3.07		*

Experiment Number: II
Herbicide: Trifluralin
Rate: .75 and 1.50 pounds per acre
Organism: R. solani
Rate: .5pph, 1pph, and 2pph

Factors Analyzed

Variable	Interaction F	.05	.10	Organism F	.05	.10	Herbicide F	.05	.10
Mean Disease Rating	.75			81.77	**		3.47	**	
Height	.99			18.15	**		2.77		*
Top Dry Weight	1.32			15.76	**		4.48	**	
Root Dry Weight	2.05			24.50	**		.51		
Percent Alive at Harvest	1.17			10.53	**		.60		

Experiment Number: III
Herbicide: Trifluralin
Rate: .75 and 1.50 pounds per acre
Organism: _R. solani_
Rate: .25pph, .50pph, and .75pph

	Factors Analyzed								
	Interaction			Organism			Herbicide		
Variable	F	.05	.10	F	.05	.10	F	.05	.10
Mean Disease Rating	1.48			33.45	**		1.74	**	
Height	3.87	**		8.66	**		12.44	**	
Top Dry Weight	3.29	**		7.02	**		16.96	**	
Root Dry Weight	29.86	**		45.31	**		126.30	**	
Percent Alive at Harvest	2.67	**		12.09	**		1.91		

Experiment Number: IV
Herbicide: Prometryne
Rate: 1.50 and 3.00 pounds per acre
Organism: _R. solani_
Rate: .25pph, .50pph, and .75pph

	Factors Analyzed								
	Interaction			Organism			Herbicide		
Variable	F	.05	.10	F	.05	.10	F	.05	.10
Mean Disease Rating	2.64	**		91.31	**		1.40		
Height	1.69			6.70	**		2.66		*
Top Dry Weight	2.15		*	3.72	**		2.30		
Root Dry Weight	1.90			1.68			3.66	**	
Percent Alive at Harvest	1.27			30.02	**		1.15		

Experiment Number: V
Herbicide: Prometryne; Fluometuron; Trifluralin; SD11831
Rate: 1; 2; .75; .75 pounds per acre
Organism: R. solani
Rate: .25pph, .50pph, and .75pph

	Factors Analyzed								
	Interaction			Organism			Herbicide		
Variable	F	.05	.10	F	.05	.10	F	.05	.10
Mean Disease Rating	1.68			129.42	**		1.67		
Height	1.52			7.20	**		3.73	**	
Top Dry Weight	1.22			5.65	**		.69		
Root Dry Weight	.98			.04			.95		
Percent Alive at Harvest	1.59			19.32	**		2.14		

Experiment Number: VI
Herbicide: Prometryne; Fluometuron; Trifluralin; SD11831
Rate: 3; 2; .75; .75 pounds per acre
Organism: R. solani
Rate: .25pph

	Factors Analyzed								
	Interaction			Organism			Herbicide		
Variable	F	.05	.10	F	.05	.10	F	.05	.10
Mean Disease Rating	2.81	**		181.28	**		2.81	**	
Height	.59			1.61			35.40	**	
Top Dry Weight	1.05			.01			11.30	**	
Root Dry Weight	4.10	**		10.09	**		31.62	**	
Percent Alive at Harvest	2.64	**		1.26			1.46		

Experiment Number: VII
Herbicide: Prometryne; Fluometuron; Trifluralin; SD11831
Rate: 3.5; 2.5; 1.25; 1.25 pounds per acre
Organism: _R. solani_
Rate: .25pph

	Factors Analyzed								
	Interaction			Organism			Herbicide		
Variable	F	.05	.10	F	.05	.10	F	.05	.10
Mean Disease Rating	1.91			.12			.92		
Height	1.29			.67			76.23	**	
Top Dry Weight	.69			.27			36.33	**	
Root Dry Weight	.33			1.98			14.62	**	
Percent Alive at Harvest	.30			.31			.30		

TABLE VIII

STATISTICAL ANALYSIS OF FIELD DATA
PERKINS, OKLAHOMA 1966

Type of Data	Days After Planting	Herbicide	Organism F	Organism .05	Organism .10	Herbicide F	Herbicide .05	Herbicide .10	Interaction F	Interaction .05	Interaction .10
Mean Disease Rating	23	Fluometuron	3.52		*				.54		
		Prometryne	20.89	**		.38			1.95		
		SD11831	6.46	**		3.07		*	.24		
		Trifluralin	6.47	**					.18		
Herbicide Damage	23	Fluometuron	4.30	**		7.92	**		.85		
		Prometryne	3.84	**		.14			.88		
		SD11831									
		Trifluralin									
Plant Weight	23	Fluometuron	.06			.12			.09		
		Prometryne	6.01	**		.41			.57		
		SD11831	5.48	**		4.52	**		.75		
		Trifluralin	3.53	**		2.70			.89		
Plant Height	45	Fluometuron				6.72	**		.82		
		Prometryne							1.36		
		SD11831	2.77			.54			.38		
		Trifluralin	1.78			12.43	**		2.40		
Plant Height	55	Fluometuron	1.09			12.51	**		.58		
		Prometryne							1.78		
		SD11831	1.51						.40		
		Trifluralin	4.52	**		2.83		*	1.60		
Plant Height	74	Fluometuron	1.02			21.36	**		.09		
		Prometryne							2.45		
		SD11831	.97			.96					
		Trifluralin	1.29			3.61		*	2.36		
Plant Counts 30 Feet	9	Fluometuron	2.15			2.21			1.36		
		Prometryne				2.82		*			
		SD11831	.86								
		Trifluralin	1.15			9.86	**		2.38		
Plant Counts 30 Feet	13	Fluometuron	3.24		*				2.09		
		Prometryne	2.99		*						
		SD11831	.70								
		Trifluralin	3.51	**		6.82	**		1.86		

Type of Data	Days After Planting	Herbicide	Organism F	.05	.10	Herbicide F	.05	.10	Interaction F	.05	.01
Plant Counts	22	Fluometuron	15.97	**					2.14		
		Prometryne	20.94	**					.45		
		SD11831	1.64						.54		
		Trifluralin	4.21	**		3.22	**		.38		
Plant Counts 30 Feet	34	Fluometuron	7.86	**		1.19			.11		
		Prometryne	9.37	**		1.09			.42		
		SD11831	6.09	**		6.33	**		.08		
		Trifluralin	10.34	**		4.44	**		1.00		
Plant Counts 150 Feet	55	Fluometuron	9.12	**		1.47			1.21		
		Prometryne	16.39	**		1.23			.05		
		SD11831	7.48	**		.64			.43		
		Trifluralin	9.70	**		7.98	**		1.58		
Yield	154	Fluometuron	1.99			2.56			.86		
		Prometryne	4.59	**		.79			.69		
		SD11831	.59			.37			.06		
		Trifluralin	2.24			2.77			3.60	**	

TABLE IX

STATISTICAL ANALYSIS OF FIELD DATA
STILLWATER, OKLAHOMA 1966

Type of Data	Days After Planting	Herbicide	Organism F	.05	.10	Herbicide F	.05	.10	Interaction F	.05	.10
Mean Disease Rating	18	Fluometuron	.45			.70			.57		
		Prometryne	1.37			.07			.03		
		SD11831	.29			1.26			.15		
		Trifluralin	.59						.03		
Plant Weight	18	Fluometuron	15.90	**		1.40			.74		
		Prometryne	6.61	**		.12			.26		
		SD11831	5.14	**		1.33			4.40	**	
		Trifluralin	29.39	**		17.06	**		13.50	**	

Type of Data	Days After Planting	Herbicide	Factors Analyzed: Organism			Herbicide			Interaction		
			F	.05	.10	F	.05	.10	F	.05	.10
Plant Weight	56	Fluometuron	2.60			.18			.06		
		Prometryne	3.74	**		2.99			.30		
		SD11831	3.40		*	.01			.94		
		Trifluralin	7.27	**		.20			1.51		
Plant Counts 160 Feet	49	Fluometuron	32.04	**		.83			.84		
		Prometryne	12.69	**		.94			1.62		
		SD11831	9.41	**		.36			.38		
		Trifluralin	4.45	**		.80			.58		
Yield	176	Fluometuron	2.81		*	.08			.30		
		Prometryne	.82			.09			2.09		
		SD11831	1.32						.02		
		Trifluralin	7.25	**					2.09		

TABLE X

RAINFALL DATA - STILLWATER, OKLAHOMA
March 1 - November 15, 1966

Date	Inches	Date	Inches
March 12	.17	June 13	.29
April 12	.07	June 16	.14
April 14	.04	July 15	1.50
April 18	.19	July 20	.03
April 19	.01	July 21	1.87
April 22	.84	July 22	.07
April 23	.72	July 23	3.79
April 25	.04	July 29	.08
April 26	.08	Aug. 10	.25
April 29	.06	Aug. 11	.02
April 30	.12	Aug. 13	.02
May 1	.01	Aug. 19	2.53
May 9	.12	Aug. 23	.17
May 11	.10	Aug. 30	.20
May 12	.22	Sept. 2	.24
May 16	2.20	Sept. 4	.74
May 21	.56	Sept.16	.32
May 31	.27	Sept.27	.04
June 6	2.35	Oct. 17	.32
June 7	.86	Oct. 18	.08
June 9	.11	Nov. 10	.13

TABLE XI

RAINFALL DATA - PERKINS, OKLAHOMA
March 1 - November 15, 1966

Date	Inches	Date	Inches
March 17	.94	June 15	.10
March 17	.14	July 15	1.09
April 12	.07	July 21	2.00
April 18	.02	July 23	3.30
April 22	1.18	July 29	.10
April 23	.52	Aug. 10	.10
April 25	.05	Aug. 11	.10
April 30	.15	Aug. 13	.03
May 1	.07	Aug. 19	2.39
May 9	.09	Aug. 23	.23
May 11	.35	Aug. 31	.09
May 15	1.15	Sept. 3	.08
May 21	.53	Sept. 4	1.08
May 31	.14	Sept.16	.32
June 4	.23	Sept.27	.07
June 6	.36	Oct. 17	.39
June 7	2.44	Nov. 9	.05
June 8	.22	Nov. 10	.04

TABLE XII

MAXIMUM AND MINIMUM DAILY TEMPERATURES
Stillwater, Oklahoma - 1966

Date	May Max.	May Min.	June Max.	June Min.	July Max.	July Min.
1	57	43	83	61	97	67
2	71	34	87	63	93	68
3	78	39	87	57	96	68
4	79	42	86	67	99	71
5	84	47	90	69	100	71
6	86	47	88	64	99	75
7	87	54	81	65	98	75
8	86	49	92	72	97	75
9	86	47	89	55	100	76
10	60	44	72	55	100	76
11	83	48	93	72	102	75
12	82	46	96	68	102	80
13	67	37	91	67	101	74
14	81	40	88	60	103	74
15	90	52	92	70	102	70
16	90	57	86	63	95	73
17	92	66	84	61	97	74
18	90	55	82	55	101	74
19	67	53	86	58	103	76
20	83	55	88	62	99	73
21	84	58	90	68	86	70
22	90	54	89	69	89	73
23	88	62	89	69	88	69
24	80	49	91	71	86	72
25	81	46	93	72	90	73
26	81	48	95	73	94	74
27	83	54	94	72	93	75
28	88	56	96	71	92	76
29	90	58	96	66	97	75
30	89	59	98	64	94	74
31	82	62			94	72
Aug.	82	50	89	65	96	73

TABLE XIII

MAXIMUM AND MINIMUM DAILY TEMPERATURE
Perkins, Oklahoma - 1966

Date	May		June		July	
	Max.	Min.	Max.	Min.	Max.	Min.
1	79	59	97	65	92	73
2	82	65	95	66	87	72
3	85	64	94	66	83	61
4	85	64	94	70	83	62
5	85	68	92	69	85	62
6	88	62	96	71	83	67
7	75	59	96	68	96	68
8	77	67	95	71	91	64
9	88	54	94	73	92	64
10	72	52	97	72	82	62
11	80	58	98	72	80	64
12	89	72	101	73	82	65
13	88	65	100	71	84	67
14	84	58	100	72	87	71
15	80	68	100	75	92	72
16	90	62	103	66	96	71
17	78	60	86	72	97	72
18	78	65	90	72	92	63
19	81	58	86	72	82	68
20	84	60	101	72	85	70
21	86	59	86	68	84	61
22	86	62	77	70	84	62
23	88	63	96	66	73	60
24	88	67	80	68	63	57
25	90	71	82	71	75	52
26	92	70	81	72	78	56
27	93	66	82	73	79	58
28	92	66	90	74	79	62
29	94	65	91	71	80	64
30	95	64	86	72	85	68
31			89	71	80	65
Aug.	85	63	92	70	84	65

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