EFFECTS OF SURFACE WHEAT RESIDUE LEVELS ON THE DISSEMINATION PATTERN OF TAN SPOT IN HARD RED WINTER WHEAT IN OKLAHOMA

By

TET JONG CHANG

Bachelor of Science in Agriculture

Oklahoma State University

Stillwater, Oklahoma

1985

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the degree of
MASTER OF SCIENCE
May, 1987

EFFECTS OF SURFACE WHEAT RESIDUE LEVELS ON THE DISSEMINATION PATTERN OF TAN SPOT IN HARD RED WINTER WHEAT IN OKLAHOMA

Thesis Approved:

Eugene S. Krenzer Jr.
Thesis Adviser

Britt J. Carver

Robert M. Hunger

Francis L. Gough

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

I wish to express my sincere gratitude to all persons who have assisted me in the development of this thesis, and to all who helped me through my graduate program at Oklahoma State University.

Foremost, I wish to express my deepest appreciation to Dr. Eugene G. Krenzer for his time, constructive criticism, direction, and friendship throughout the course of this study.

I also wish to thank Dr. Francis J. Gough, Dr. Robert M. Hunger, and Dr. Brett F. Carver for serving on the graduate committee and their valuable assistance throughout the course of this study. Grateful acknowledgment is also extended to Dr. James H. Stiegler for his assistance during the initial development of this study.

Special thanks are expressed to Dr. Ronald W. McNew for his assistance in the statistical analysis of this study, and to Mr. James E. Williams for providing us the land used in this study.

I also wish to thank Mrs. Maria Garcia, our secretary, and Mr. Mark Hodges, project Senior Agriculturist, for their

assistance and friendship through my graduate program.

Finally, a special thanks, and my deepest appreciation go to my parents and my family for their moral encouragement and constant support of my educational program.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

Interest in no-till tillage systems has been on the increase worldwide during the last two decades as a farming practice to better control soil erosion, and enable water and energy conservation. The basic principle of no-till was to leave a certain amount of crop residue on the soil surface right after crop harvest as opposed to the traditional practice of incorporating crop residue with a turning plow. Wheat (Triticum aestivum L.) is one of the crops which has been cultivated under a no-till tillage system in many parts of the world. Diseases that are associated with residue generally have increased in recent years in areas that are cultivated under a no-till tillage system.

One such disease becoming widespread in major wheat production areas is tan spot, a leaf spotting disease caused by the fungus Pyrenophora tritici-repentis (synonyms, anamorph, epitaph). It has a sexual stage that overwinters on the surface of wheat residue. During the fall and spring both sexual and asexual spores are released which subsequently cause widespread infection. According to

research in other parts of North America, tan spot can be a devastating disease when environmental conditions were favorable for disease development.

During the last ten years, tan spot has become a serious disease in no-till and continuous wheat fields in Oklahoma. At the present time, information on the epidemiology of tan spot on hard red winter wheat is limited. For example, the relationship between levels of residue on the soil surface and the severity and prevalence of tan spot has not been well established. Also it is unclear whether tan spot from one field will be able to spread to another field some distance away.

This study was designed to: (1) determine when ascospores and conidia of P. tritici-repentis are present during a winter wheat growing season, (2) determine the pattern of spread of tan spot from an initial focus point, and (3) determine whether different amounts of infected wheat residue on the soil surface affect the severity of tan spot infection.

CHAPTER II

PREVIOUS WORK AND LITERATURE REVIEW

During the past two decades, interest in no-till and conservation tillage systems has increased due to the scarcity and increased cost of fossil fuels, periodic world food shortages, and the concern over soil erosion, Phillips et al. (1980), and Wittmuss et al. (1975). The United States Conservation Tillage Information Center defines conservation tillage or planting system as a system that retains 30 percent or more residue cover on the soil surface after planting. Boosalis and Doupnik (1976) reported that reduced tillage systems have been established in many areas of the world and will become increasingly important in other areas where soil moisture conservation and erosion control are critical for crop production. The United States Department of Agriculture projected in 1974 that 62 million hectares or 45 percent of the total U.S. cropland will be under the no-tillage system by the year 2000 (U.S. Department of Agriculture 1975).

Summer et al. (1981) stated that "although much progress has been made in refining and in improving

conservation tillage systems for specific crops and environments, many more aspects need further improvement. These include more efficient planting machinery, establishing the necessary control levels of weeds, diseases, and pests associated with crop residues, crop row spacing, and breeding varieties adapted to the new environment." Traditionally, farmers bury plant residues to destroy pathogens from year to year, Drayton (1929). By plowing under plant residues, diseases are often kept under control. With recent increases in cropland being cultivated under some form of conservation tillage, numerous diseases have reportedly been on the increase. One of the new diseases associated with reduced tillage systems in wheat (Triticum aestivum L.) is tan spot (Pyrenophora tritici-repentis).

Since wheat is the leading income-producing crop in the Southern Great Plains, a new wheat disease represent a major concern. Tan spot of wheat has been increasingly important in the Great Plains during the last 15 to 20 years. There has been considerable research done on the epidemiology of tan spot in spring wheat, but little research has been conducted on hard red winter wheat. Yet nearly all of the wheat produced in the Southern Great Plains is hard red winter wheat.

Rees et al. (1982) observed that an early, severe epidemic of tan spot results in the retardation of crop

development up to flowering. According to Rees and Platz (1983) severe tan spot caused delayed or reduced tillering. They observed that diseased plants were much smaller in size than healthy plants. They found that severe tan spot affected tiller production, tiller size, and leaf area index. With crop development being retarded first by early disease infestation and then by delayed flowering, a reduction in grain-filling period ranging from 11 to 22 % was observed. This resulted in a reduction in grain yield. Rees and Platz (1983) estimated that about 75% of the yield loss caused by tan spot was a consequence of severe tan spot after jointing.

A severe epidemic of tan spot can cause substantial losses. In Kenya, losses up to 75 percent were attributed to tan spot, Duff (1954). In one Michigan field, Andrews and Klomparens (1952) attributed a reduction in yield to severe tan spot infection from 35 bushels per acre in one year to 18 the following year. In North Dakota, Hosford and Busch (1974) showed an average increase in yield of 11.2 % by controlling tan spot on the flag leaf with two applications of fungicide. In Montana, Sharp et al. (1976) detected losses of up to 19.7 % in kernel weight in small plots artificially inoculated with P. tritici-repentis. In Kansas, Sim and Willis (1982) estimated an average annual loss of $200 * 10^6$ kg of grain over the 1979-1983 seasons. In South Dakota, Buchenau et al. (1977) estimated that under

stubble-mulch practices tan spot can destroy 30 percent or more of the crop. They also showed that a reduction in tan spot by fungicide application resulted in yield gains as high as 38.8 percent. Rees et al. (1981) estimated a potential loss in grain yield per tiller of around 26 percent. Tan spot control on the flag leaf with 3 applications of Mancozeb was related to yield increases of 10-14% in Oklahoma, Williams and Gough (1979).

Hosford (1982A) listed the synonyms of tan spot as yellow spot, yellow leaf blotch, leaf blotch, wheat leaf blight, and eye spot. He also listed the different scientific and common names used by different researchers to designate this fungal pathogen. Among others it has been called Pyrenophora trichostoma(Fr.) Fckl., asexual state - Helminthosporium tritici-repentis(Died). To avoid confusion, Pyrenophora tritici-repentis will be used as the name for the pathogen that causes tan spot of wheat. This name was used by a number of researchers familiar with this pathogen, e.g. Platt et al. (1977), Rees and Platz (1979, 1980), Morrall and Howard (1975), and Platt and Morrall (1980).

Krupinsky (1982) reported "the isolation of P. tritici-repentis from wheat (T. aestivum), Russian Wildrye (Elymus junceus, Fisch.), Altai Wildrye (E. angustus, Trin.), Mammoth Wildrye (E. giganteus, Vahl), Tetraploid crested Wheatgrass (A. desertorum (link), Schult.), Intermediate

Wheatgrass (A. intermedium (host), Beauv.), and Western Wheatgrass (A. smithii, Rydb.)." He also reported that barley (Hordeum vulgare), oats (Avena sativa), and rye (Secale cereale) are other cereal host that can be infected by P. tritici-repentis. Any one of these cereals can serve as an alternate host during the off-season and providing a source of inoculum during the growing season of the wheat.

The pathogen overwinters in sexual fruiting structures called pseudothecia. According to Rees and Platz (1980), P. tritici-repentis is capable of producing abundant pseudothecia on infected stubble. Pseudothecia initials develop on infested wheat stubble on or above the soil surface soon after harvest, Conners (1940). Later in the year, larger pseudothecia develop on the surface of wheat straw left on or above the soil surface, Doupnik and Boosalis (1980), Hosford (1971A, 1976), Howard and Morrall (1975), and Morrall and Howard (1975). Pseudothecia are small, about the size of a pin head, black in color, and erumpent. Hosford (1971A) reported that in North Dakota mature pseudothecia develop in wheat stubble during the spring and summer, suggesting a time and moisture effect. Odvody et al. (1982) determined that the maturation of pseudothecia was temperature-dependent and proceeds at low temperature (15-18 ^{o}C). Hosford (1976) reported that weathering straw left on the soil surface was capable of producing spores throughout three consecutive growing

seasons.

There are two types of spores produced by P. tritici-repentis: ascospores (sexual spores) and conidia (asexual spores). Ascospores are produced in mature pseudothecia in transparent asci. The number of ascospores produced from a single pseudothecia is not known, but there are eight ascospores within a single ascus. Pseudothecia also produce conidia on setae on their surfaces, Hosford (1972). By incubation under moist conditions in the laboratory, Rees and Platz (1980) were able to produce conidia around the top of pseudothecia. Even though this is rare in the field, conidia are known to be produced at the tip of dark aerial hyphae, setae or conidiophore arising from the surface of pseudothecia. Most conidia produced in the field are produced in old leaf lesions, Hosford (1972, 1976). In addition to ascospores and conidia, dark aerial hypha are also capable of germination and infection. All three types of propagules can be present at the same time throughout a single growing season.

Optimal conidiation occurred with a 12 h light-12 h dark photoperiod at 21 ^{o}C, Platt et al. (1977). Platt and Morrall (1980) reported that light intensity of over 200 Wm^{-2} inhibit conidiation. They attributed the rare occurrence of conidiation in the upper part of the canopy to the intense insolation. Platt and Morrall (1980) reported that these data were consistent with the observation that

conidia were usually found on dead and senescent leaves, which were frequently lower in the canopy where the reduced light intensity may be conducive to conidiation.

Hosford and Busch (1974) reported that ascospores were forcibly ejected only a short distance and ejection occurs mainly in the moist still air of night. Therefore ascospores generally travel short distance to cause disease, while conidia and aerial hyphae can travel over a longer distance. Hosford (1976) believed that conidia and dark aerial hyphae can be blown as far as 50 miles while ascospores can only travel at most several meters.

Ascospores can function either as primary or secondary inoculum. Hosford (1972) reported that ascospores from overwintering wheat stubble can function exclusively as primary inoculum in Canada, as a major form of primary inoculum in North Dakota, and may be an important secondary inoculum in North Africa. However, Conners (1940, 1967) argued that the first wave of infection was caused by ascospores released from pseudothecia. Since conidia can be present during the early part of the growing season, there were contradicting reports on the role of conidia as a primary inoculum. Rees and Platz (1980) feel that conidia were not as important as ascospores as primary inoculum. They believe that conidia produced during a growing season only promote the rapid development of an epidemic. In contrast, Shaner (1981) reported that although conidia of

P. tritici-repentis were rare in the field, they have the potential to act as primary inoculum. However, he agrees that conidia may not be as important as ascospores in this respect.

Rees and Platz (1980) suggested that epidemics of yellow spot were initiated by ascospores and possibly conidia of P. tritici-repentis produced on infected weathering stubble. They contend that spores from outside the wheat field were not important as initial inoculum. As the season progresses, large numbers of conidia may be produced when environmental conditions were favorable, resulting in the rapid development of an epidemic. At this time, with larger numbers of conidia being produced on the crop compared to ascospores on the stubble, infected stubble will decrease in importance as a source of inoculum. Rees and Platz (1980) believe that "ascospores developing at ground level beneath the crop canopy have a relatively poor chance of reaching green tissues towards the top of the canopy." Shaner (1981) noticed that large numbers of conidia were not airborne until after lesions appear on the upper two leaves of the wheat plant. Attempts have been made through spore trapping to determine the type of spores that might be present over a wheat field during an entire wheat growing season.

One attempt was made in Oklahoma to trap propagules of P. tritici-repentis by Dr. Francis Gough (personal

communication), but it was unsuccessful even though lesions appeared on the leaves of the surrounding wheat plants. This was not a unique situation, as Morrall and Howard (1975) were never able to trap ascospores in great number even though there were numerous ascospores in the air over native prairie in Saskachewan, Canada. Of the spores that were successfully trapped, the number of conidia greatly exceeded the number of ascospores. However, the peak trapping of ascospores occurred before that of the conidia during the two years that the study was conducted. Early in the season during August of 1977, Rees and Platz (1980), using a 7-day volumetric spore trap (Burkard Manufacturing Co. Ltd, England), were unable to detect on a single traverse of spore trap tapes any spores of P. tritici-repentis even though tan spot on wheat was observed on the 24th of that month. They suggested the poor detection threshold of the spore trap as compared to that of susceptible plants was the reason for this observation. Later in the year, Rees and Platz (1980) were successful in trapping conidia over winter wheat from late winter through harvest time. During the peak spore trapping period (late spring) they were able to trap as many as 1500 spores/m^3 of air per day.

According to Willis (1984) "tan spots first show as small, 1/8 inch diameter lens or diamond shaped spots on leaves. A yellow border or halo soon develops around the

tan center. In young, actively growing leaves these spots remain about the same size. Then as leaves mature and begin to decline the spots expand to irregular shapes but the darker center where the infection started is usually still obvious and the yellow halo becomes less prominent. Severely affected leaves die prematurely and fungus spores are produced on these dying leaves. Lower leaves are infected first and with proper conditions infection progresses up to the flag leaves."

Hosford (1971A) described the appearance of spots on wheat leaves caused by P. tritici-repentis as a light brown leaf spot with distinct yellow borders. Williams and Gough (1979) described the appearance of the lesion as "large tan to light brown blotches surrounded by distinct yellow borders." Platz et al. (1977) describe the typical symptoms of tan spot as "chlorotic and later gray leaf tips or chlorotic to necrotic leaf spots often preceding the formation of coalesced streaks." Wiese (1977) described young tan spot lesions as tan-brown flecks which later expand into lens-shaped, tan blotches up to 12 mm in length.

The reduction of wheat yield due to tan spot was most pronounced under wet conditions, Hosford (1971B). Hosford (1976) stated that the spores of P. trichostoma must be on wet foliage for several to many hours to cause leaf spotting. In fact, wheat varietal resistance to tan spot was related to the length of the post inoculation wet

period, Hosford (1982B). According to Rees and Platz (1983), the severity of tan spot varies greatly between years and can differ markedly within a crop season, depending largely on the occurrence of wet weather. If rain follows crop emergence, the disease may be severe in young plants. Should dry weather conditions then occur, further development of yellow spot was restricted. Rees and Platz (1980) found that wet periods were required for the production and release of ascospores and conidia. In fact, they had to apply sprinkler irrigation to enhance infection when natural rainfall was not adequate.

Among factors contributing to increased yellow spot in the 1970's in Northern Australia, Rees and Platz (1979) point to the retention or partial incorporation of stubble in lieu of burning as the primary reason. Hosford (1971A) observed that tan spot was prominent in fields under continuous wheat. He attributed the tan spot epidemic of 1969 in North Dakota partially to an increase in wheat stubble on the ground. He was able to correlate tan spot severity on spring wheat at the three-leaf stage with the abundance of pseudothecia on adjacent stubble. Also, Rees et al. (1981) were able to correlate increases in tan spot with increased surface retention of wheat residue.

There was a need to determine whether fields under conservation tillage practices can act as a source of inoculum within a wheat producing area. This was in light

of a report by Hosford in 1976 that fields distant from those with wheat stubble are as severely infested with tan spot as fields containing the infected stubble.

Since most of the research has been done on hard red spring wheat, the objectives of this study were: 1) to determine when spores were present over a field of hard red winter wheat, 2) to determine the pattern of disease spread from initial foci in a field, and 3) to determine if different levels of infected wheat stubble on the soil surface affect tan spot severity through a growing season.

CHAPTER III

MATERIALS AND METHODS

This study was conducted in two field tests during the 1985-86 wheat growing season. Field one was located on the north end of a 43 hectare (106 acre) field, 5 km north of Stillwater, Oklahoma. Field two was located in the middle of a 15 hectare (37 acre) field, approximately 1 km north of the first field. The soil-type in field one was a fine, mixed, thermic udertic Paleustolls while the soil-type in field two was a clayey-skeletal, montmorillonitic, frigid xerollic Haplargids.

Both fields were grazed out the previous cropping season (1984-85) due to cheat (Bromus japonica) infestation. As a result, both fields were considered free of wheat residue on the soil surface. Both fields were inspected before and after planting to ensure that no residue was on the soil surface.

Cultural practices for field one included discing on May 14, 1985, chisel plowing on May 22, 1985, and field cultivating on July 16 and September 7, 1985. Fertilizer addition included broadcast application of 28 kg/ha 18-46-0

on September 7, 1985 and 89 kg/ha N as anhydrous ammonia applied on September 7, 1985. However, no nitrogen was applied at planting time. Glean at a rate of 35 gm/ha was applied on November 6, 1985 for weed control.

Cultural practices for field two included discing on May 18 and May 26, 1985, chisel plowing on June 18, 1985, and field cultivating on June 16, August 24, and November 1, 1985. Fertilizer addition included broadcast application of 28 kg/ha 18-46-0 on September 7, 1985 and 89 kg/ha N as anhydrous ammonia applied on September 7, 1985. Glean at a rate of 23 gm/ha was applied on January 21, 1986 for weed control.

In field one, TAM W-101, a locally adapted hard red winter wheat cultivar, was planted at a rate of 70 kg/ha on September 20, 1985. Due to wet weather, field two was planted on November 1, 1985. Chisholm, another locally adapted hard red winter wheat cultivar, was planted in field two at a rate of 100 kg/ha.

Precipitation and temperature were monitored at the North Stillwater Agronomy Research Station located approximately 6 km from the fields.

Tan spot-infected residue was collected from a single wheat field at the North Stillwater Agronomy Research farm. Residue for field one was collected on September 20, 1985, and residue for field two was collected on October 22, 1985. Residue for field one (which had escaped fall rain)

was taken directly from the source field, weighed, and applied to the field on the same day. Residue for field two was collected approximately a week before the sowing date, air-dried and weighed. Great care was taken to ensure that the residue was not kept indoors for too long as the development of pseudothecia was known to be influenced by temperature and moisture, Odvody et al. (1982), and Rees and Platz (1980).

Four rates of residue were used: 0, 500, 1000, and 3000 kg/ha. The 3000 kg/ha rate was equivalent to the amount left on the soil surface from a 30 to 35 bushel wheat yield. As soon as the wheat had been sowned, four plot focus 80 meters apart were measured at each field (Figure 1, Appendix B). Residue rates were assigned to these plots at random. With the exception of the 0 kg/ha rate plot, a 3-m diameter circle was measured at each plot focus. Residue, which had previously been determined as the equivalent of the different rates, was distributed evenly over the entire 3-m diameter circle. As soon as this was done, chicken wire was used to cover the residue to keep residue in the 3-m circle.

Within each plot focus, 4 concentric circles (1, 3, 6, and 15 meters in radius from the plot focus) were established. Six equally spaced rays, dissecting these concentric circles were later established. These rays were later numbered in such a manner that ray 1 pointed south

with rays 2, 3, 4, 5, and 6 arranged in a clockwise manner. This arrangements were consistent in all 4 plots in both field one and two. Sampling points were established at each intersection between the circles and rays. A total of 24 sampling points were established for each plot. Flags were used to mark the location of each sampling point.

Soon after crop emergence, two plants (subsamples) were identified at random at each sampling point and labelled with white plastic tags. A total of 12 plants (subsamples) were labelled in each concentric circle. More plants were not used for disease rating due to the time required to evaluate each plant and the large number of leaves that would need to be rated would have exceeded the available resources. These tagged plants were consistently used for disease ratings through the 1985-86 growing season.

Disease ratings were conducted using a modified version of the disease scale for septoria leaf blight developed by James (1971). In addition to the four levels of disease (1, 5, 25, and 50 percentage leaf area covered by disease) proposed by James, seven more levels of percentage leaf area covered by disease were added. The modified key that was used in this study to evaluate disease through the growing season had the following levels: 0.1, 0.2, 0.3, 0.4, 0.5, 1, 5, 10, 20, 25, and 50 percent leaf area covered by disease. The first 5 levels were determined by actual lesion counts. The presence of 1 lesion per leaf represented 0.1 percent,

the presence of 2 lesions per leaf represented 0.2 percent, etc. The presence of 5 to 10 lesions per leaf represented a 1.0 percent disease level. The remaining levels were relative to each other in terms of the leaf area covered with disease.

Disease ratings were made throughout the 1985-86 wheat growing season. The 0 kg/ha rate plot was always the first plot to be rated to ensure that infected residue or spores from other plots were not transported in.

Disease ratings were measured on no more than 3 leaves per plant at a single time. To be consistent when taking disease ratings, a system was devised to track the leaf from which disease ratings were scored. Using this system, the youngest, fully expanded leaf was labelled leaf one, the next leaf down was labelled leaf two, and the next leaf down from leaf two was labelled leaf three. No disease ratings were performed on leaves that were not fully expanded. A tape recorder was used to record data onto cassette, which was later taken into the office for transfer to micro-computer diskettes. This method shortened the length of time needed to record data in the field.

Disease ratings were made twice (11/09/85 and 12/28/85) during the fall in field one. Ratings were stopped when plant growth ceased due to low temperature. Due to the late sowing date in field two, no fall ratings were taken. During the spring, disease ratings were resumed in fields

one and two. In field one disease ratings were conducted on 3/06/86, 3/20/86, 4/07/86, 4/15/86, 4/22/86, 4/29/86, and 5/06/85. In field two disease ratings were conducted on 4/22/86, 4/29/86, and 5/16/86.

Air sampling was conducted to monitor the presence of P. tritici-repentis spores from the seedling to soft dough stages of wheat growth. A Collin's-Kramer trap was used for this purpose. The trap was constructed of a vacuum pump and a metal pot containing a revolving drum. Removable transparent tape was placed on the drum with the adhesive side towards the drum. A thin film of petroleum jelly (vaseline) was applied onto the non-adhesive surface of the tape. The vacuum pump was used to draw samples of air through an orifice on the metal pot and over the vaseline. Spores in the air samples were then retained on the vaseline. In addition to being an inert medium for fungal germination, the petroleum jelly (vaseline) also protected spores from desiccation between sampling periods. A timer was used to control the time and duration of sampling. The trap was set to operate for 1 minute every hour. Spore trapping was conducted in field one by the 3000 kg/ha rate plot. The trap was placed within the 3 meter diameter circle containing the wheat residue. A metal rod, driven into the ground, was used to support the trap. During the fall of 1985, the trap was placed so that the orifice on the side of the metal pot was approximately 20 centimeters above

the residue. In 1986, the orifice was kept level with the top of the crop canopy. Spore trapping was conducted in the fall of 1985 between October 15 and December 30. Spore trapping resumed on February 1, 1986 and continued until April 30, 1986. The availability of two drums allowed continuous sampling. Once a week, the drum and tape were removed and taken into the laboratory. In the laboratory, tape was removed from the drum and mounted onto microscope slides. Under the microscope, slides were examined for the presence or absence of P. tritici-repentis spores. Identification of spores of P. tritici-repentis was done with the aid of photographs published by other researchers working with P. tritici-repentis.

Due to the early planting date in field one, there was an enormous quantity of top growth by late fall. Cattle were allowed to graze field one between January 20, and February 20, 1986. When the cattle were taken out, all top growth from the previous fall had been grazed off. Therefore, all disease ratings recorded during the 1986 were on newly produced leaves in the spring. Field two was not grazed.

Statistical analysis was performed on a within-circle basis. The standard error (SE) of the sample mean was calculated for the 12 subsamples in each circle. Then using the sample mean of the 12 subsamples and the standard error (SE) of sample mean, a 95% confidence interval ($CI_{95\%}$) was

determined using the following formula:

$$CI_{0.95} = \overline{X} \pm (t_{0.05,11} * \text{SE of } \overline{X})$$

A value of 2.0 was used for $t_{0.05,11}$. A significant difference between two means was determined when both 95% confidence intervals were not overlapping.

CHAPTER IV

RESULTS AND DISCUSSION

Monthly precipitation totals and the corresponding 91-year monthly average are shown in Table I, Appendix A. The level of precipitation between September 1985 and May 1986 was well below the average. Even though September, October, and November 1985 received precipitation less than expected for that period of time, cold and misty weather was common and environmental conditions were ideal for tan spot development. Thus, there was a high level of tan spot infection detected on 11/09/85 and 12/28/85 in field one.

Since the presence of free moisture was necessary for the release and germination of fungal spores, dry weather during the first few months of 1986 substantially influenced the epidemiology of tan spot during grain development. For an epidemic to develop there must be ample supply of spores. Since spore production was dependent upon environmental factors such as precipitation. A short supply of free moisture, would limit the production of asexual spores such as conidia, which were responsible for long distance disease infection. Without conidia in large

numbers, Shaner (1981) believed that tan spot epidemic would not be possible. The low precipitation level during the 1985/86 wheat growing season relative to the 91-year average represented one of the most important links missing for the development of a tan spot epidemic in 1985-86.

Tables II-VI, Appendix A, show the monthly minimum and maximum temperature for September, October, November, and December 1985, and January 1986, respectively. According to Odvody et al. (1982) pseudothecia maturation was temperature dependent and proceeds between 15°C and 18°C. The minimum temperature from September 21, 1985 to January 31, 1986 averaged below 18°C. Therefore temperature conditions during the fall and winter of 1985/86 were sufficiently low to allow for maturation of pseudothecia.

Tapes collected from the spore trap were taken into the laboratory and examined under the microscope on a weekly basis. Debris and spores of other fungi were observed on the tape which indicated that the spore trap was functioning. No P. tritici-repentis spores were identified from any of the spore trap tapes even when tan spot lesions were found on plants in the vicinity of the spore trap. This could be due to the poor detection threshold of the Collin's-Kramer trap. Later during the spring of 1986, the inability to trap spores may have been caused by the lack of spores in the air as there were very few diseased plants in the area where the spore trapping was carried out.

Mature ascospores were first observed in pseudothecia collected from the vicinity of the spore trap during the week of November 23, 1985. Since it was obvious that ascospores were being released from pseudothecia beginning as early as November 1985, one would expect the spore trap to be trapping spores soon after that time. But no spores were observed on tapes collected during November or the months thereafter. The ineffectiveness of the Collin's-Kramer trap to collect spores of P. tritici-repentis could be attributed to the trap's poor detection threshold as suggested by Rees and Platz (1980).

In field one disease ratings were conducted on November 9 (Figures 2-4, Appendix B) and December 28 (Figures 5-7, Appendix B) in 1985. On both dates, no level of disease significantly different from 0 % was found on any plants in the 0 kg/ha rate plots. Also, no significant level of disease was found on any plants in the 6-m and 15-m circles in the 500 (December 28, 1985), 1000 (November 9, and December 28, 1985), and 3000 (December 28, 1985) kg/ha rate plots.

On November 9, 1985 (Figures 2-4, Appendix B), in field one, disease ratings were obtained at the 0 and 1000 kg/ha residue rate plots. In each case three leaves per plant were evaluated for tan spot lesions.

In the 1000 kg/ha rate plot (Figures 2-4, Appendix B), no significant level of disease was found on leaf one of any

plants evaluated. However, a level of disease significantly different from 0 % was found on leaf two and three in the 1-m and 3-m circles of the 1000 kg/ha rate plot. On both leaf two and three, significantly more disease was found at the 1-m circle than at the 3-m circle.

On November 9, 1985 (Figures 2-4, Appendix B), the disease observed was generally confined to the lower leaves and probably initiated by ascospores since ascospores travel only a short distance. If conidia were present, tan spot disease should have been observed throughout the entire field. Since no disease was found at the 0 kg/ha rate plot where no tan spot-infected residue was present, the spores responsible for initiating leaf lesions were probably ascospores and not conidia.

On December 28, 1985, in field one (Figures 5-7, Appendix B), disease ratings were obtained at the 0, 500, 1000, and 3000 kg/ha residue rate plots. Here, as before, three leaves per plant were evaluated for tan spot lesions. In the 500, 1000, and 3000 kg/ha rate plots, the level of disease on leaf one was not significantly different from 0 % regardless of the distance from plot foci.

In the 500 kg/ha rate plot on December 28, 1985, the level of disease on leaf two (Figure 6, Appendix B) was not significantly different from 0 % regardless of the distance from plot foci. However, leaf three (Figure 7, Appendix B) on plants in the 1-m and 3-m circles had disease levels

significantly different from 0 %. However, the level of disease on plants in the 1-m circle was not significant different from that of plants in the 3-m circle.

In the 1000 kg/ha rate plot, leaf two (Figure 6, Appendix B) at the 1-m circle had a higher level of disease than leaf two at the 3-m circle. A significant level of disease on leaf three (Figure 7, Appendix B) was found at the 1-m and 3-m circles. Here, leaf three at the 1-m circle showed a significantly higher level of disease than leaf three at the 3-m circle.

In the 3000 kg/ha rate plot, a significant level of disease was found on leaf two (Figure 6, Appendix B) and three (Figure 7, Appendix B) at the 1-m and 3-m circles. The level of disease on leaf two was not significantly different between the 1-m and 3-m circles. However, leaf three (Figure 7, Appendix B) at the 1-m circle had significantly more disease than leaf three in the 3-m circle.

On December 28, 1985 (Figures 5-7, Appendix B), leaf one was generally free of disease regardless of residue rate. Since tan spot was found only on the lower leaves, it was probably initiated by ascospores and not conidia. Conidia, if present, may not be in large numbers. Residue rates had an obvious influence on the level of disease being detected. The level of disease found on leaf three was much higher in the higher residue rates, i.e., 3000 kg/ha rate >

1000 kg/ha rate > 500 kg/ha rate. Since there may be more pseudothecia producing ascospores at the higher residue rates, a correspondingly higher level of disease might be expected at the higher residue rates.

On April 22 and 29, 1986, in field two (Figures 8-12, Appendix B) disease ratings were obtained on the 0, 500, 1000, and 3000 kg/ha rate plots. Three leaves per plant were evaluated on April 22 (Figures 8-10, Appendix B), and two leaves per plant were evaluated on April 29 (Figures 11, Appendix B). No level of disease significantly different from 0 % was found on any plants in the 0 kg/ha rate plots on both April 22 and 29, 1986 (Figures 8-12, Appendix B). Also no significant level of disease was found on any plants in the 6-m and 15-m circles. On both April 22 (Figure 8, Appendix B) and 29, 1986 (Figure 11, Appendix B), no significant level of disease was observed on leaf one in all 4 residue rates at field two.

In the 500 kg/ha rate plot, leaf two on April 22, 1986 (Figure 9, Appendix B) did not have a significant level of disease, while leaf two (Figure 12, Appendix B) on April 29, 1986, and leaf three (Figure 10, Appendix B), on April 22, 1986 had significantly more disease at the 1-m circle than at the 3-m circle.

In the 1000 kg/ha rate plot, leaf two on April 22, 1986 (Figure 9, Appendix B) and on April 29, 1986 (Figure 12, Appendix B), and leaf three on April 22, 1986 (Figure 10,

Appendix B) had more disease in the 1-m circle than the 3-m circle.

In the 3000 kg/ha rate plot, more disease was found on leaf two and three at the 1-m than at the 3-m circle on both April 22, 1986 (Figure 9 and 10, Appendix B) and April 29, 1986 (Figure 12, Appendix B).

There were many similarities in disease level and dissemination pattern between field one on November 9 and December 29, 1985 and field two on April 22 and 29, 1986. As in field one on November 9 and December 29, 1985, disease levels found in field two on April 22 and 29, 1986 were probably caused by ascospores released from mature pseudothecia on the residue. Evidence that supports this include i) diseased plants were found only within the area where residue was present and distance from the residue significantly influenced disease incidence, ii) the disease was confined only to the lower leaves which is characteristic of disease initiated by ascospores since ascospores are ejected only a short distance, and iii) the wheat field as a whole remained free of disease.

In field one between March and May, 1986, no level of disease significantly different form 0 % was found on any plants. This lack of disease could be due to i) the removal of disease leaves from fall infection by grazing cattle, ii) the lack of inoculum from residue resulting from the hooves of cattle pushing the residue into the soil, iii) the lack

of free moisture necessary for spore release and infection, and iv) the lack of conidia to cause infection. Any one of these factors alone might not have a significant effect on the epidemiology of P. tritici-repentis, but the occurrence of all four factors at the same time probably led to little or no tan spot disease.

In field two, during May, 1986, tan spot disease did not spread significantly upwards from the lower leaves to infect the upper leaves. As a consequence, no significant level of disease different from 0 % was observed. Even though the absence of disease in the second field closely resembled that of the first field, some factors contributing to this absence of disease were different. In field two low precipitation coupled with late sowing of wheat and a lack of conidia could have contributed to the lack of disease. Late planting did not allow disease development during the fall while the lack of moisture retarded disease development in the spring.

Had environmental conditions been more conducive to an epidemic of tan spot, i.e., a higher level of precipitation or more diseased plants from the previous fall, etc., different results may have been observed.

CHAPTER V

CONCLUSIONS

No spores were successfully trapped during the entire wheat growing season of 1985-86 in field one. This may have resulted from the lack of spores as evidenced by the lack of disease in field one during the spring. When there was a substantial amount of disease present, such as the case during early winter in field one, there was an obvious residue rate effect on the level of tan spot leaf infection. In field one during the fall and in field two during early spring, disease severity was greatest on the lower leaves in the 3000 kg/ha rate plot while the 0 kg/ha rate plot was free of tan spot leaf lesions. The order of infection level as affected by residue rate was: 3000 > 1000 > 500 > 0 kg/ha rate. Not a single plant in the 0 kg/ha rate plot showed a level of disease significantly different from zero. Therefore, areas with no residue on the soil surface were free of tan spot.

Tan spot infection on the lower leaves must have been caused by ascospores. Conidia were not a significant source of inoculum during the 1985-86 wheat growing season. The

observation that infections were limited to only the area where residue was placed strongly indicates that ascospores were responsible. The inverse relationship between the level of infection and the distance away from the infected wheat residue suggest that infection was caused by an inoculum that did not have the potential to travel very far. Our data indicate that the maximum distance that this inoculum traveled is 1.5 meters.

No doubt the dry weather during the 1985-86 wheat growing season played an important role in preventing the development and subsequent spread of tan spot. Had there been more precipitation during the same period, the outcome of the study may have been different.

Since the effect of residue level on tan spot development is dependent on the amount of precipitation, it may be difficult to tell if the next cropping season will be a good or bad year for tan spot disease. If it is wet, more than likely tan spot will be severe, but if it is dry, there is every reason to suggest that tan spot will not be a problem.

LITERATURE CITED

Andrews, E., and W. Klomparens. 1952. Yellow spot of winter wheat in Michigan in 1951. Plant Dis. Rep. 36:10-11.

Boosalis, M. G., and B. Doupnik, Jr. 1976. Management of crop disease in reduced tillage systems. Entomol. Soc. Am. Bull. 22:300-302.

Buchenau, G. W., J. D. Smolik, and D. E. Miller. 1977. Effect of tillage practices on diseases of spring wheat at redfield in 1976. Progress Report 1977. Agric. Exp. Stn. South Dakota State Univ. 2 p.

Conners, I. L. 1940. Yellow leaf blotch. In 19th Annu. Rep. Can. Plant Dis. Surv. pp. 12-14.

Conners, I. L. 1967. An annotated index of plant diseases in Canada. Can. Dep. Agric. Publ. No. 1251.

Doupnik, B., Jr. and M. G. Boosalis. 1980. Ecofallow - A reduced tillage system - Plant disease. Plant Dis. 64:31-35.

Drayton, F. L. 1929. Bulb growing in holland and its relation to disease control. Scientific Agriculture. 9:225-228.

Duff, A. D. S. 1954. A new disease of wheat in Kenya caused by a species of Pyrenophora. East Afri. Agric. J. 19:225-228.

Hosford, R. M., Jr. 1971A. A form of Pyrenophora trichostoma pathogenic to wheat and other grasses. Phytopathology. 61:28-32.

Hosford, R. M., Jr. 1971B. Wheat leaf blight and blotch losses and control. N. Dakota Farm Res. 29:5-8.

Hosford, R. M., Jr. 1972. Propagules of Pyrenophora trichostoma. Phytopathology. 62:627-629.

Hosford, R. M., Jr. 1976. Fungal leaf spot diseases of wheat in North Dakota. North Dakota Agric. Exp. Stn. Bull. 500. Fargo, ND.

Hosford, R. M., Jr. 1982A. Tan spot - Developing knowledge 1902-1981. pp. 1-5. In tan spot and related diseases workshop. 14-15 July 1981. North Dakota State University. Fargo, ND.

Hosford, R. M., Jr. 1982B. Tan spot - Developing knowledge 1902-1981. pp. 11-13. In tan spot and related diseases workshop. 14-15 July 1981. North Dakota State University. Fargo, ND.

Hosford, R. M., Jr. and R. H. Busch. 1974. Losses in wheat caused by Pyrenophora trichostoma and Leptospharia f. sp. triticea. Phytopathology 64:184-187.

Howard, R. J. and R. A. A. Morrall. 1975. The epidemiology of leaf spot disease in a native prairie. I. The progression of disease with time. Can. J. Bot. 53:1040-1050.

James, W. C. 1971. An illustrated series of assessment keys for plant diseases, their preparation and usage. Can. Plant Dis. Surv. 51:39-65.

Krupinsky, J. M. 1982. Hosts of Pyrenophora trichostoma. In tan spot of wheat and related disease workshop. North Dakota Agr. Experimental Station Publication. pp. 25-27.

Morrall, R. A. A., and R. J. Howard. 1975. The epidemiology of leaf spot disease in a native prairie; II. Airborne spore populations of Pyrenophora tritici-repentis. Can. J. Bot. 52:2345-2353.

Odvody, G. N., M. G. Boosalis, and J. E. Watkins. 1982. Development of pseudothecia during progressive saprophytic colonization of wheat straw by Pyrenophora trichostoma. pp. 33-35. In tan spot and related diseases workshop. 14-15 July, 1981. North Dakota State University. Fargo, ND.

Phillips, R. E., R. L. Blevins, G. W. Thomas, W. W. Frye, and S. H. Phillips. 1980. No-tillage agriculture. Science 208:1108-13.

Platt, H. W., R. A. A. Morrall, and H. E. Gruen. 1977. The effects of substrate, temperature, and photoperiod on conidiation of Pyrenophora tritici-repentis. Can. J. Bot. 55:254-259.

Platt, H. W. and R. A. A. Morrall. 1980. Effects of light intensity and relative humidity on conidiation in Pyrenophora tritici-repentis. Can. J. Of Plant Pathology 2:53-57.

Rees, R. G. and G. J. Platz. 1979. The occurrence and control of tan spot of wheat in north-eastern Australia. Aust. J. Exp. Agric. Anim. Husb. 19:369-372.

Rees, R. G. and G. J. Platz. 1980. The epidemiology of yellow spot of wheat in southern Queensland. Aust. J. Agric. Res. 31:259-67.

Rees, R. G. and G. J. Platz. 1983. Effects of yellow spot on wheat: Comparison of epidemics at different stages of crop development. Aust. J. Agric. Res. 34:39-46.

Rees, R. G., R. J. Mayer, and G. J. Platz. 1981. Yield losses in wheat from yellow spot: A disease-loss relationship derived from single tillers. Aust. J. Agric. Res. 32:851-859.

Rees, R. G., G. J. Platz, and R. G. Mayer. 1982. Yield losses in wheat from yellow spot: Comparison of estimates derived from single tillers and plots. Aust. J. Agric. Res. 33:899-908.

Shaner, G. 1981. Effect of environment on fungal leaf blights of small grains. Ann. Rev. Phytopathology 19:273-296.

Sharp, E. L., B. K. Sally, and F. N. McNeal. 1976. Effect of Pyrenophora wheat leaf blight on the thousand kernel weight of 30 spring wheat cultivars. Plant Disease Reporter. Vol. 60, No. 2.

Sim, T., IV, and W. G. Willis. 1982. Kansas wheat disease losses. Kansas State Board of Agriculture, Topeka. 4pp.

Summer, D. R., B. Doupnik, Jr., and M. G. Boosalis. 1981. Effects of reduced tillage and multiple cropping on plant diseases. Ann. Rev. Phytopathology 19:167-187.

U.S. Department of Agriculture, Office of Planning and Evaluation, "Minimum tillage: A preliminary technology assessment." Part II of a report for the committee on Agriculture and Forestry, United States Senate, (Government Printing Office, Publ. No. 57-398, Washington, D.C., 1975).

Wiese, M. V. 1977. Compendium of wheat diseases. The American Phytopathological Society. St. Paul, Minnesota. 106 pp.

Williams, E., Jr. and F. J. Gough. 1979. Tan spot of wheat. Oklahoma State Univ. Extension Fact No. 7624.

Willis, W. G. 1984. Wheat diseases. Cooperative Extension Service. Manhattan, Kansas. 30 pp.

Wittmuss, H., L. Olson, and D. Lane. 1975. Energy requirements for conventional versus minimum tillage. J. Soil and Water Conserv. 30:72-75.

APPENDIX A

PRECIPITATION AND TEMPERATURE DATA

TABLE I

MONTHLY PRECIPITATION FOR STILLWATER FOR THE 1985/86 WHEAT CROP YEAR COMPARED WITH THE LONG-TERM AVERAGE

Month	Long-term* Ave	1985/86 Ave
	mm	
September	81	51
October	71	38
November	47	24
December	34	14
January	30	0
February	34	7
March	47	9
April	73	47
May	117	41

* Stillwater 91 Year Average

TABLE II

SEPTEMBER, 1985 MINIMUM AND MAXIMUM TEMERATURE DATA
STILLWATER, OKLAHOMA

DAY	MIN	MAX	DAY	MIN	MAX
	--- °C ---			--- °C ---	
1	21	37	16	21	26
2	22	39	17	20	27
3	20	35	18	20	32
4	21	36	19	21	32
5	23	41	20	21	32
6	24	37	21	11	32
7	23	35	22	17	18
8	23	36	23	13	28
9	23	38	24	8	18
10	21	38	25	10	22
11	20	34	26	6	20
12	21	31	27	8	16
13	22	32	28	16	25
14	14	26	29	9	24
15	18	25	30	3	9

TABLE III

OCTOBER, 1985 MINIMUM AND MAXIMUM TEMERATURE DATA
STILLWATER, OKLAHOMA

DAY	MIN	MAX	DAY	MIN	MAX
	--- °C ---			--- °C ---	
1	2	13	16	4	21
2	3	17	17	5	23
3	7	22	18	14	22
4	9	26	19	14	22
5	5	18	20	12	21
6	6	19	21	9	17
7	13	24	22	5	23
8	12	27	23	13	24
9	19	26	24	11	28
10	9	23	25	11	27
11	8	12	26	16	26
12	19	19	27	12	26
13	16	26	28	14	24
14	16	24	29	9	21
15	7	16	30	9	15
			31	4	14

TABLE IV

NOVEMBER, 1985 MINIMUM AND MAXIMUM TEMERATURE DATA
STILLWATER, OKLAHOMA

DAY	MIN	MAX	DAY	MIN	MAX
	--- °C ---			--- °C ---	
1	6	17	16	-1	8
2	-1	16	17	9	17
3	-1	16	18	20	20
4	2	18	19	6	23
5	6	22	20	-4	8
6	10	22	21	-3	5
7	-1	14	22	0	7
8	0	16	23	7	11
9	18	20	24	0	9
10	3	22	25	3	3
11	4	4	26	-1	21
12	4	10	27	-3	22
13	10	21	28	-2	1
14	6	21	29	-2	-2
15	4	8	30	0	2

TABLE V

DECEMBER, 1985 MINIMUM AND MAXIMUM TEMERATURE DATA
STILLWATER, OKLAHOMA

DAY	MIN	MAX	DAY	MIN	MAX
	--- °C ---			--- °C ---	
1	-11	0	16	-4	9
2	-13	-7	17	-4	8
3	-13	-4	18	-9	11
4	-4	4	19	-9	-4
5	-2	8	20	-6	7
6	-4	13	21	1	0
7	5	14	22	1	13
8	-4	12	23	-2	13
9	2	9	24	1	13
10	-2	11	25	-11	3
11	-4	1	26	8	3
12	-8	-5	27	-7	13
13	-14	-7	28	-8	9
14	-17	-7	29	-2	11
15	-9	4	30	-2	11
			31	1	15

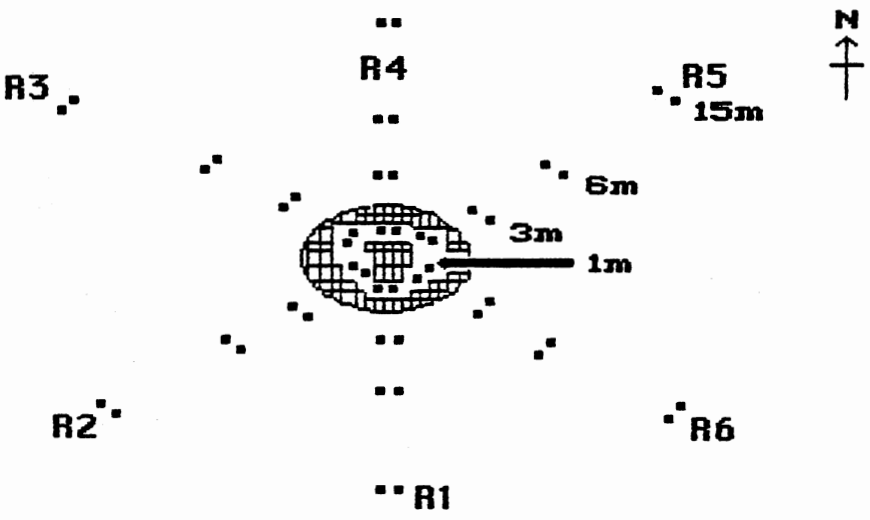
TABLE VI

JANUARY, 1986 MINIMUM AND MAXIMUM TEMERATURE DATA
STILLWATER, OKLAHOMA

DAY	MIN	MAX	DAY	MIN	MAX
	--- °C ---			--- °C ---	
1	-4	11	16	-6	18
2	0	14	17	-2	20
3	-4	13	18	6	14
4	-3	11	19	-2	12
5	-7	6	20	-2	17
6	1	8	21	-2	27
7	-8	9	22	-5	14
8	-12	1	23	-8	11
9	-11	-2	24	-7	11
10	-7	12	25	-2	14
11	-7	12	26	-2	12
12	1	20	27	-13	6
13	-7	14	28	-12	3
14	-6	16	29	0	22
15	-7	16	30	-4	12
			31	-1	18

APPENDIX B

DISEASE DATA



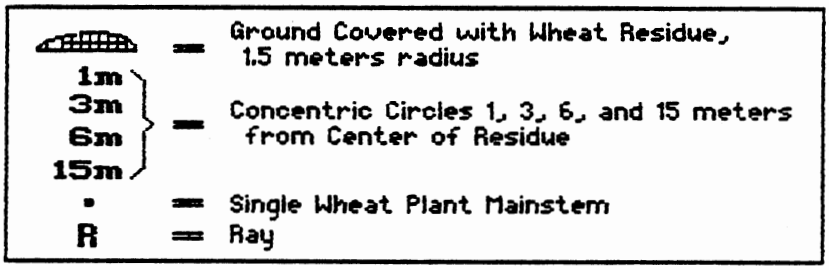


Figure 1. Sampling Scheme for Individual Residue Rate

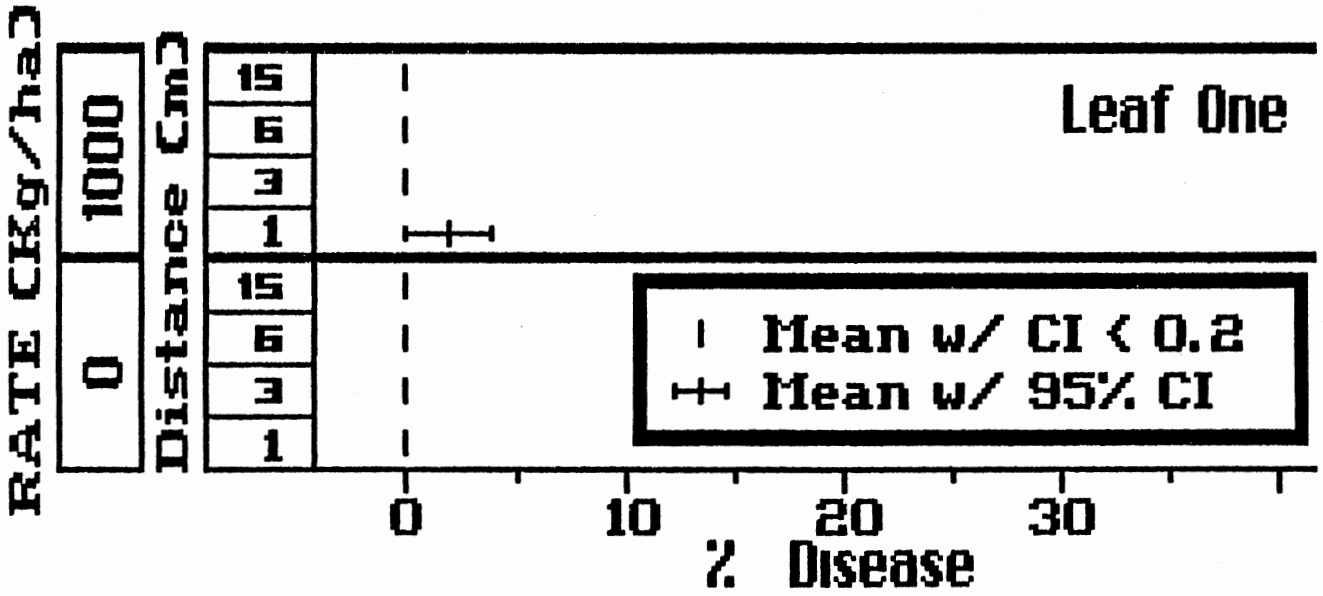


Figure 2. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf One on 11/09/85 in Field One

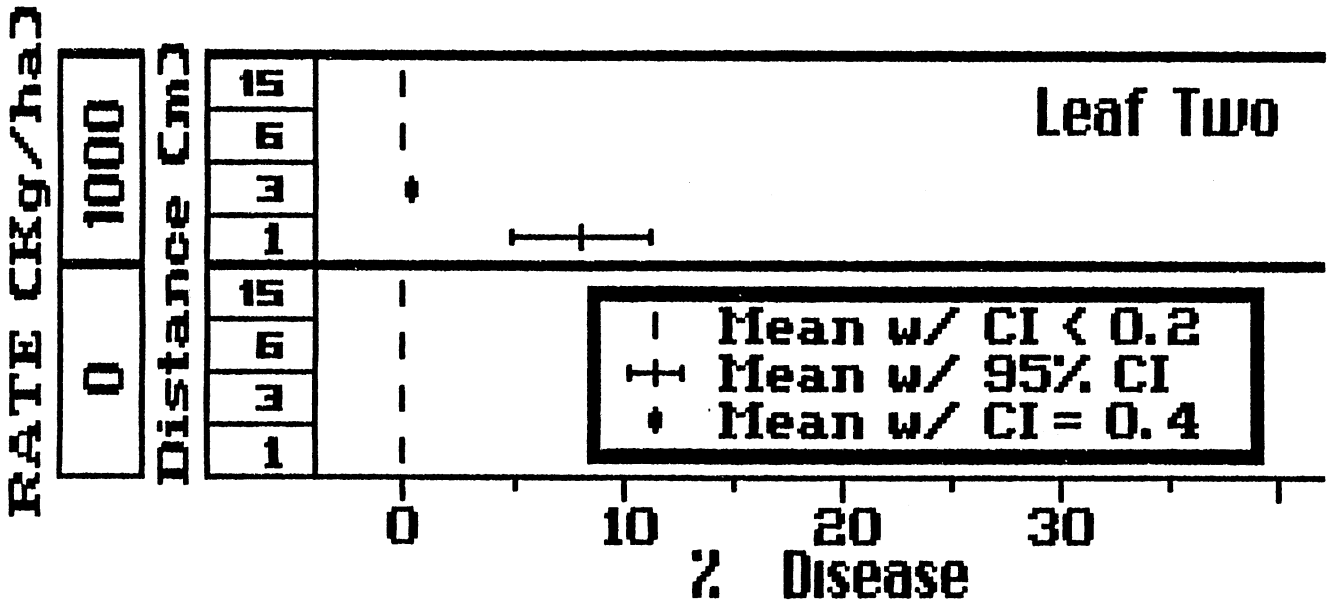


Figure 3. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf Two on 11/09/85 in Field One

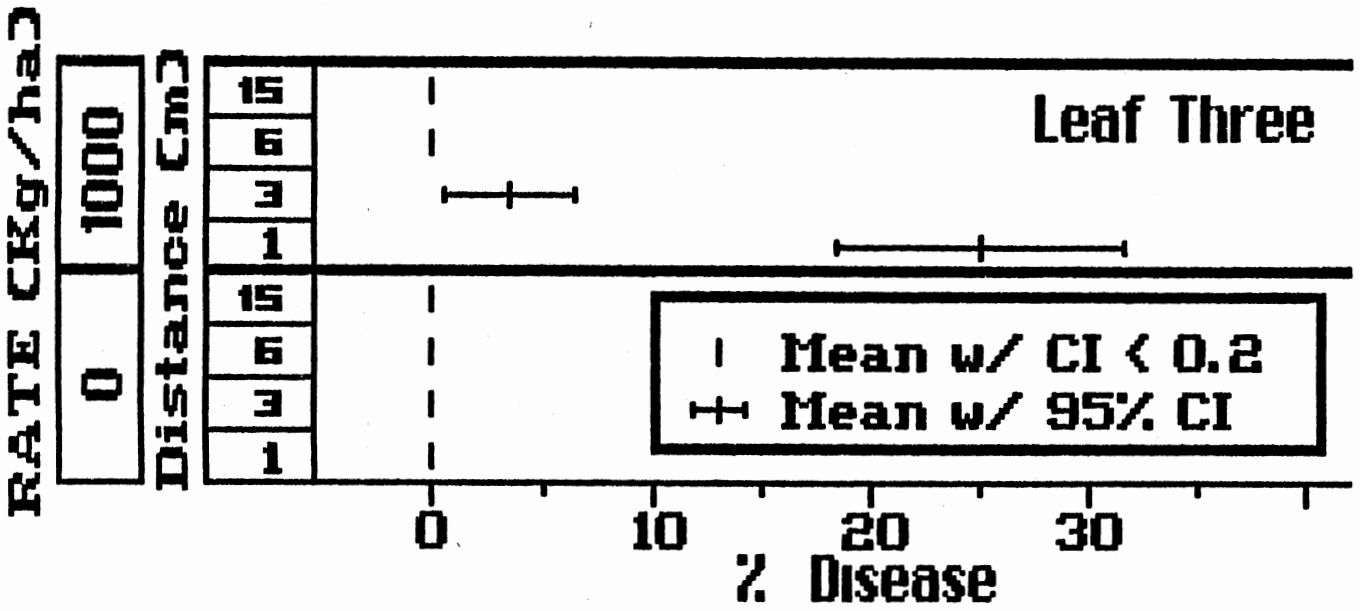


Figure 4. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf Three on 11/09/85 in Field One

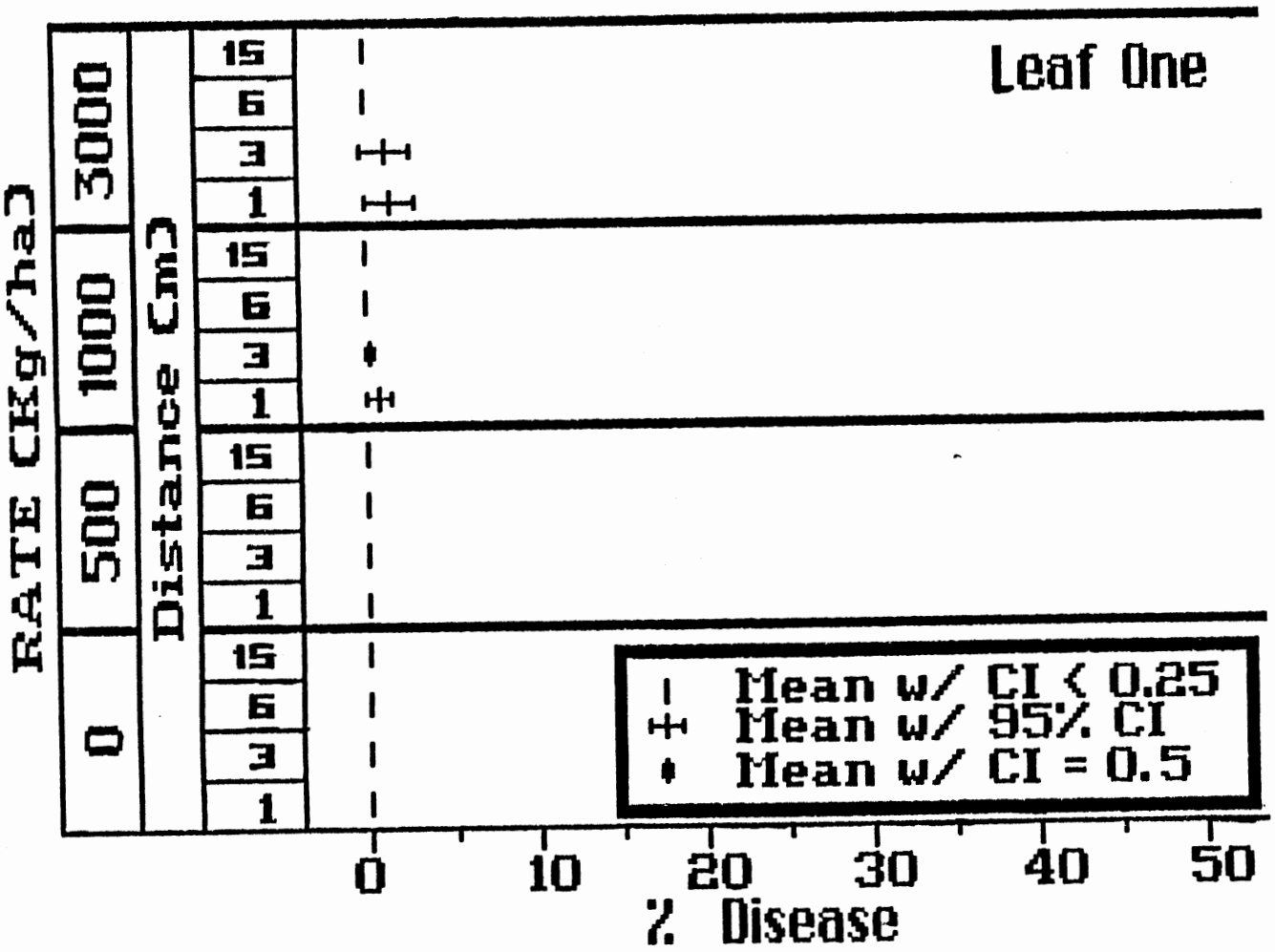


Figure 5. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf One on 12/28/85 in Field One

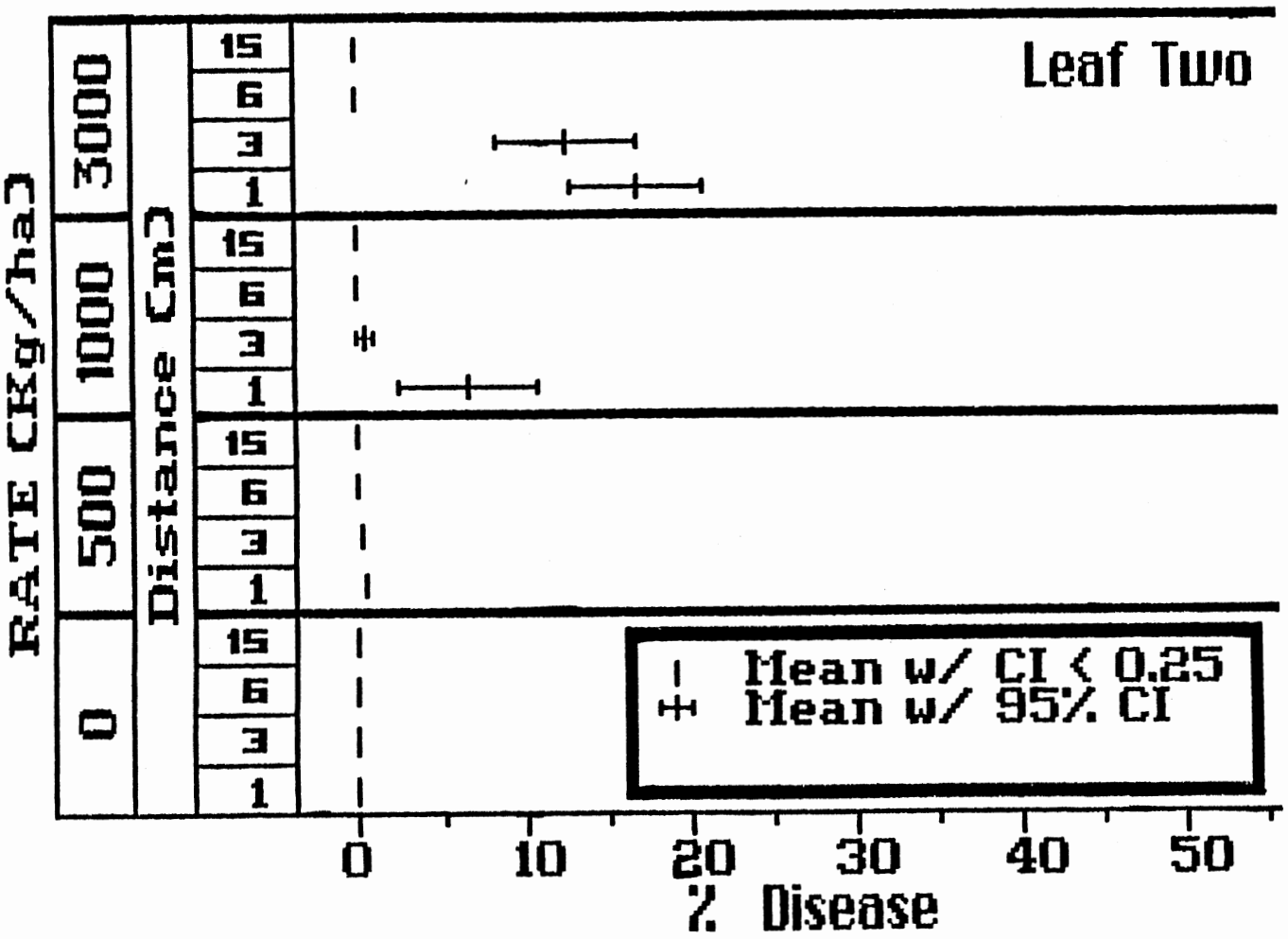


Figure 6. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf Two on 12/28/85 in Field One

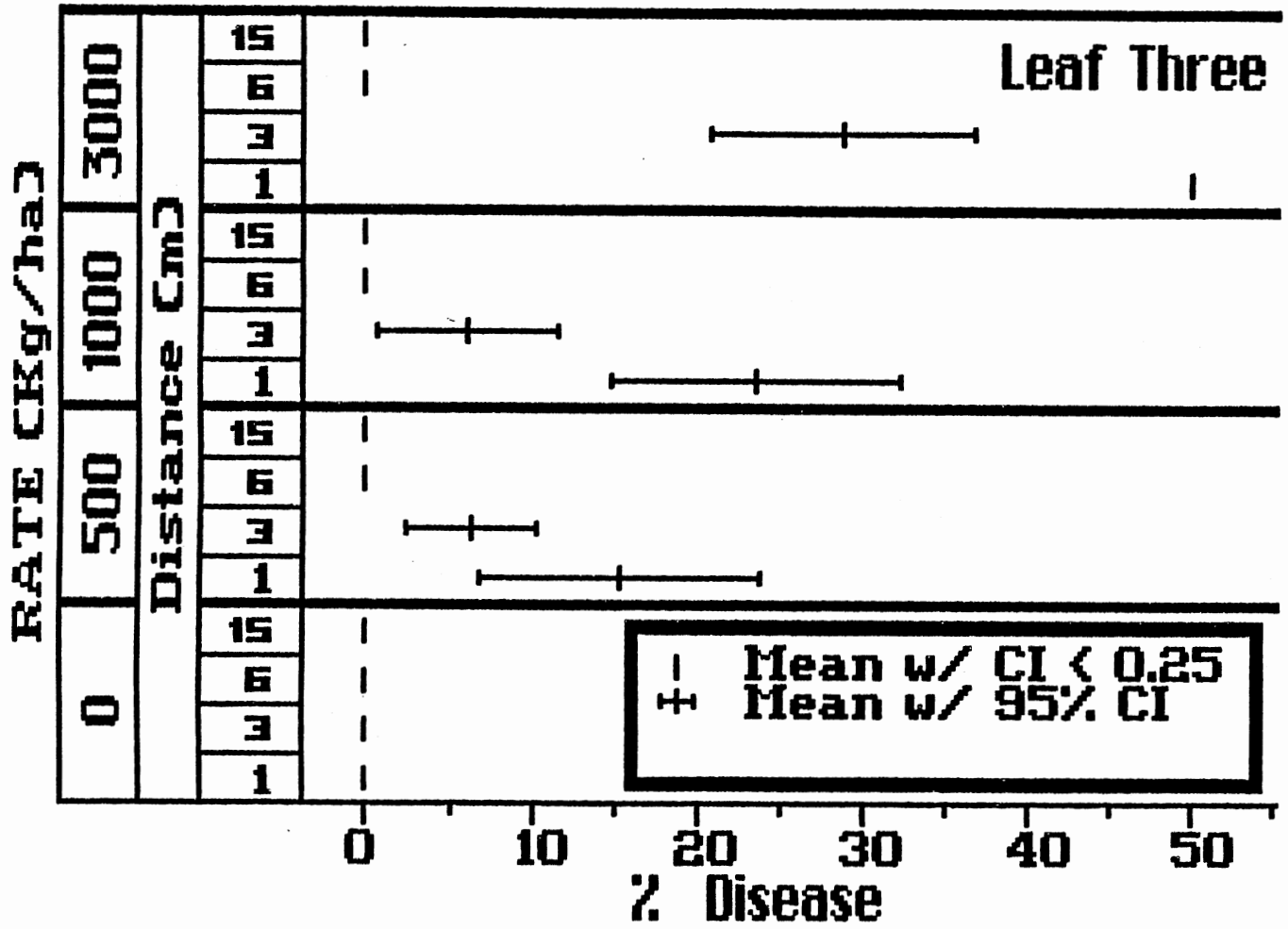


Figure 7. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf Three on 12/28/85 in Field One

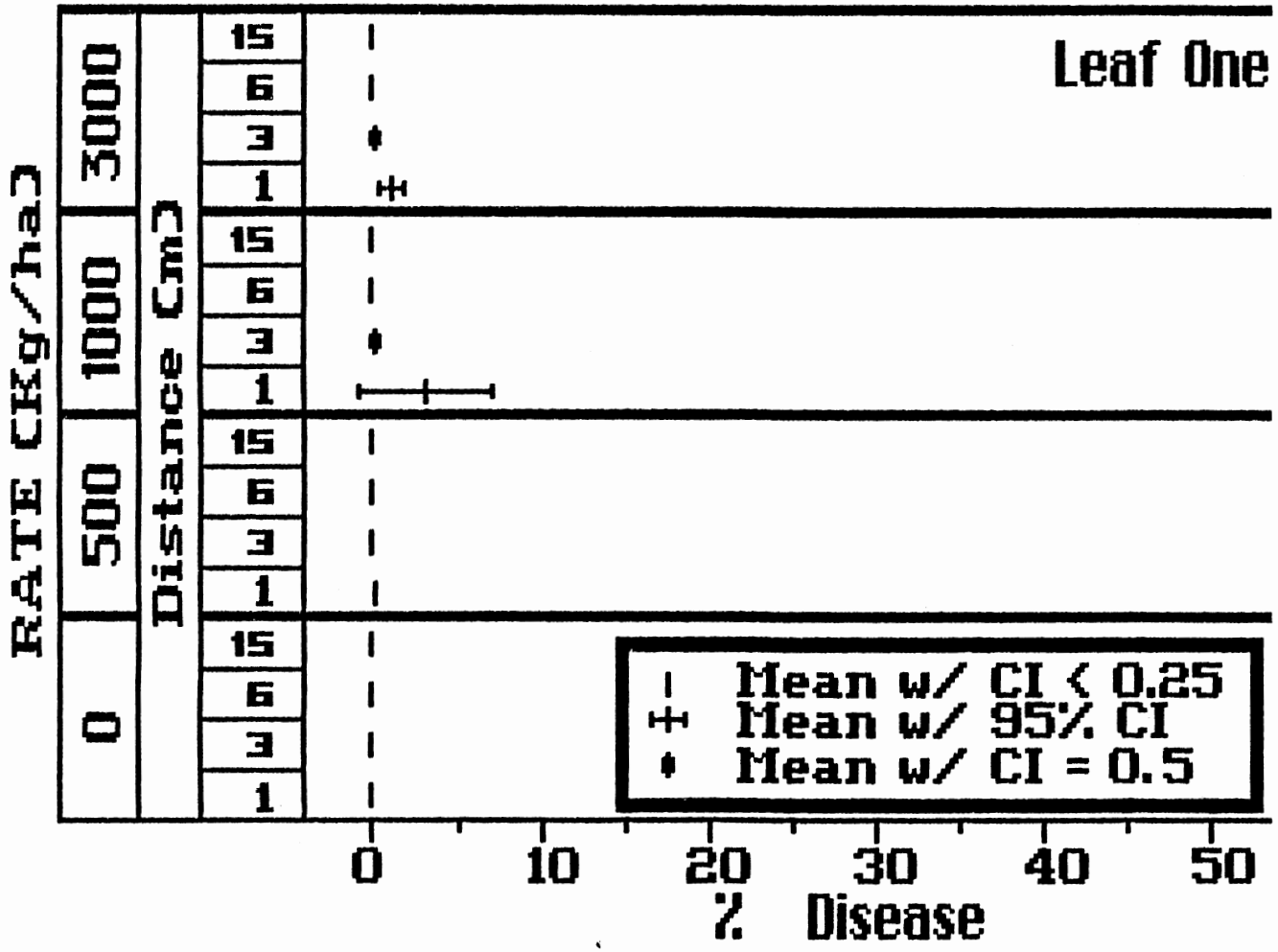


Figure 8. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf One on 4/22/86 in Field Two

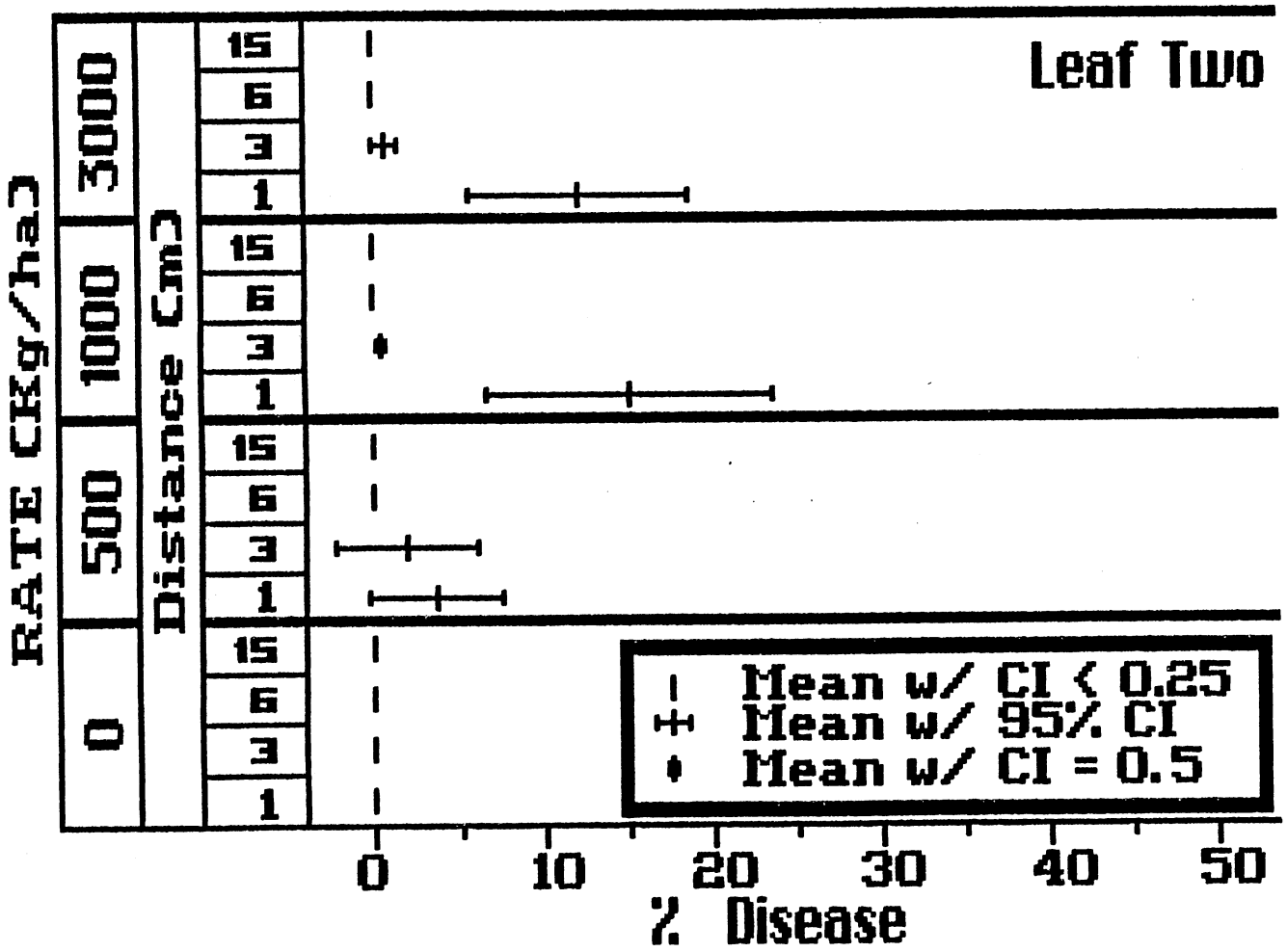


Figure 9. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf Two on 4/22/86 in Field Two

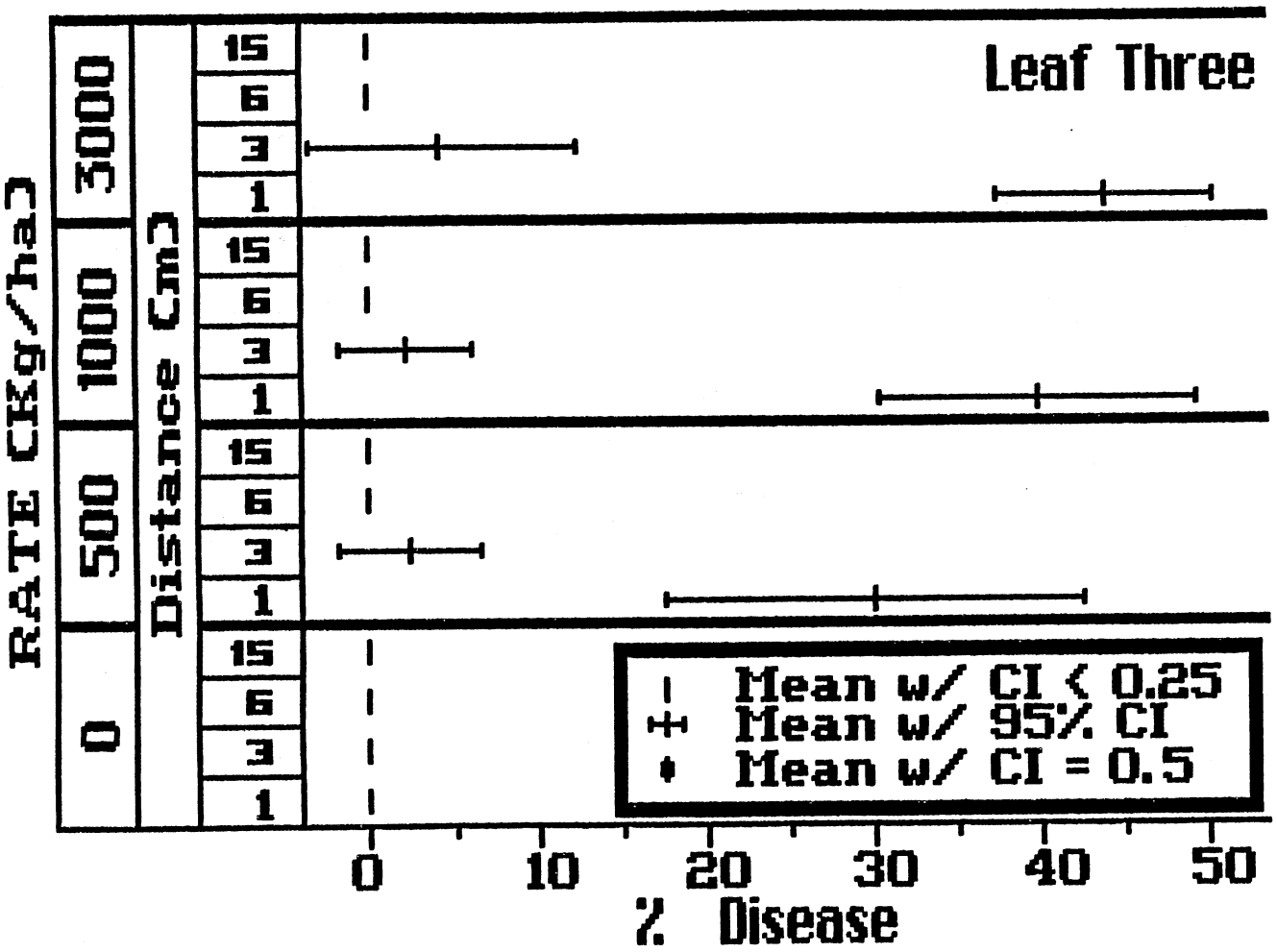


Figure 10. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf Three on 4/22/86 in Field Two

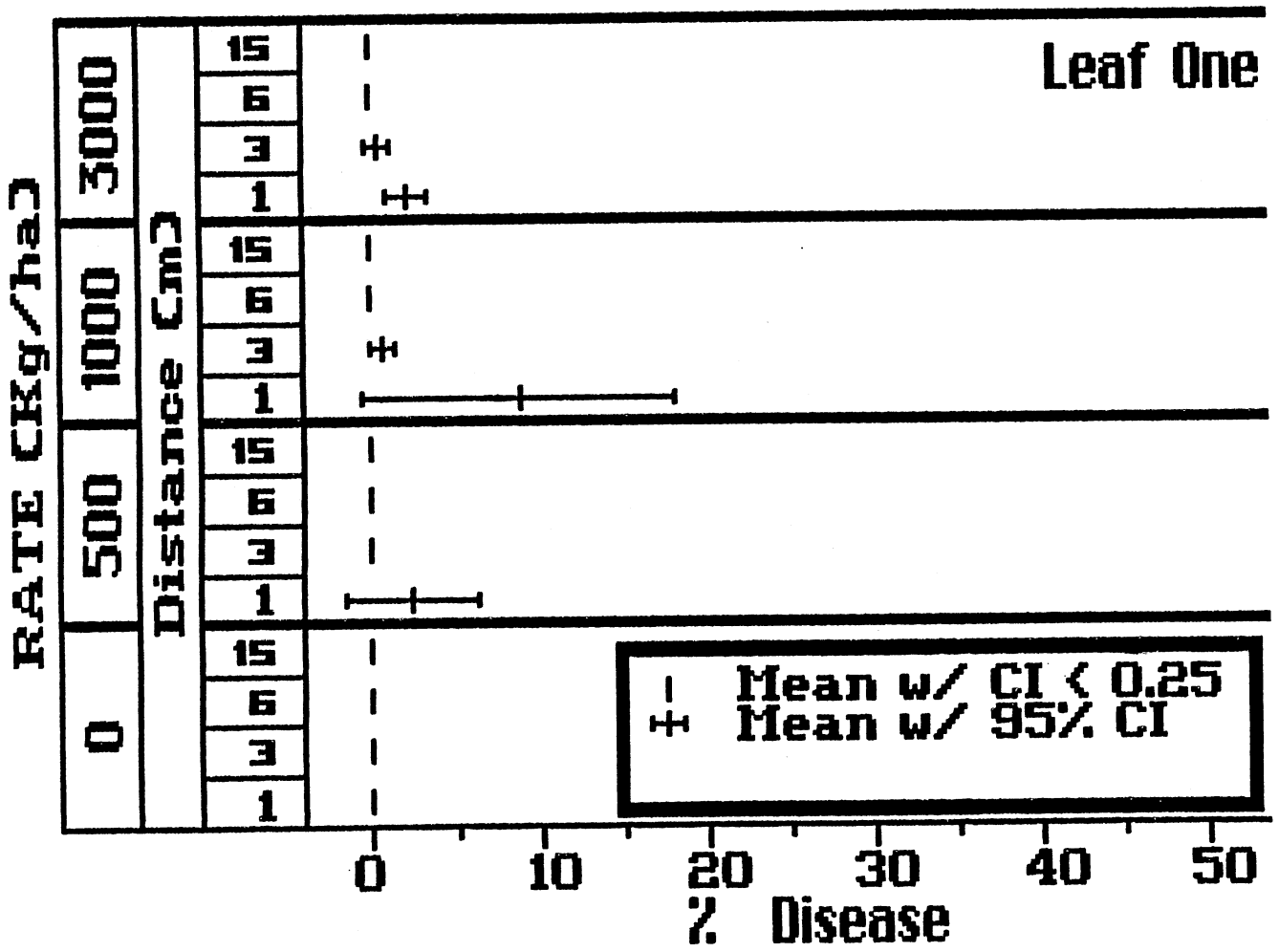


Figure 11. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf One on 4/29/86 in Field Two

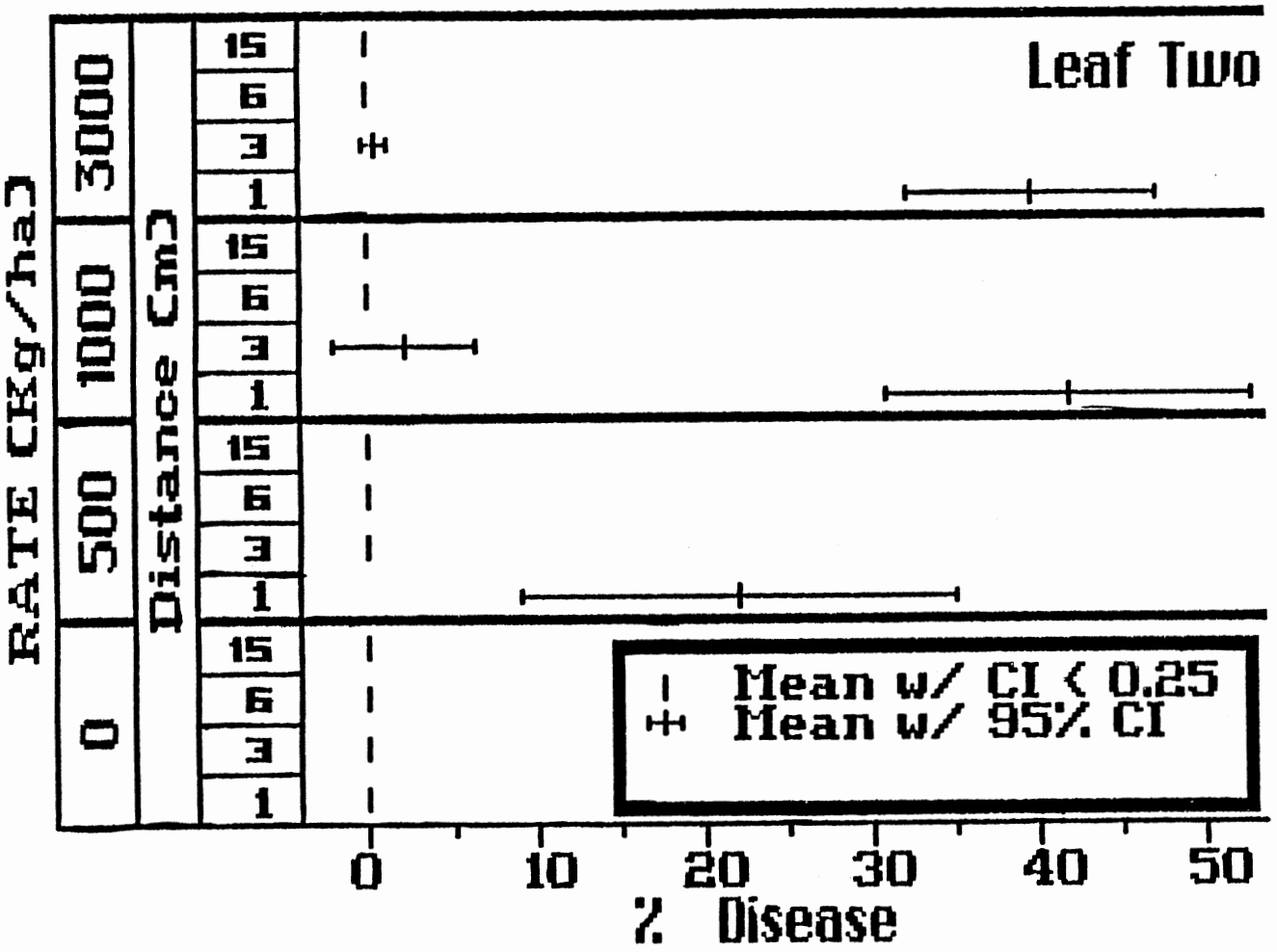


Figure 12. Effect of Residue Level and Distance from Residue on Tan Spot of Leaf Two on 4/29/86 in Field Two

VITA

TET JONG CHANG

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF SURFACE WHEAT RESIDUE LEVELS ON THE DISSEMINATION PATTERN OF TAN SPOT IN HARD RED WINTER WHEAT IN OKLAHOMA

Major field: Agronomy

Biographical:

Personal Data: Born in Kota Kinabalu, Sabah, Malaysia, May 15, 1960, the son of Mr. Chang Tshang Tshiang and Mrs. Tin Siang Lun.

Education: Graduated from Shan Tao High School, Kota Kinabalu, Sabah, in November, 1978: received Bachelor of Science Degree in Agronomy from Oklahoma State University in May, 1985: completed requirements for the Master of Science Degree at Oklahoma State University in May, 1987.

Professional Experience: Research Assistant, Department of Agronomy, Oklahoma State University, July, 1985 to May, 1987.

Member: American Society of Agronomy; Crop Science Society of America; Soil Science Society of America