INTERACTION OF LEAF RUST AND SPECKLED LEAF BLOTCH SEVERITY ON VARIOUS GROWTH PARAMETERS OF WINTER WHEAT

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CHAPTER I

INTRODUCTION

Leaf rust caused by Puccinia recondita Rob. ex. Desm. f. sp. tritici Eriks. has long been recognized as a common and destructive disease of winter wheat in the United States. Carleton (7) observed in 1898 that under certain conditions and in certain localities, considerable injury may follow if leaf rust develops much in advance of harvest. Since that time, nearly all research on the effects of the disease has considered only the grain crop (19).

Melchers (23) reported that the grain yield of a pure line winter wheat in Kansas called P.706 was reduced by 38 percent when the estimate of leaf rust infection was 100 percent. Johnston and Miller (20) reported reduction in average grain yields of 42 to 93 percent with susceptible cultivars. They also reported reduction of staw production and a rapid and severe root deterioration which was indicated by a marked loss in total root weight. Williams (40) concluded from his growth chamber tests that leaf rust infection reduced initial growth and regrowth after leaves were clipped to similate grazing, reduced tillering, retarded root development, and caused root deterioration.

Septoria leaf blotch or speckled leaf bloth (38) caused by Septoria tritici Rob. ex Desm. has sometimes been considered to be of minor importance, but serious epiphytotics develop whenever excessive rains occur during the growing season (29). The disease has been

reported worldwide in over 50 countries including the United States (31, 32). In Oklahoma, severely infected seedlings are killed prematurely or are predisposed to winter injury. Consequently, both winter grazing potential and grain yield are lowered (24). Wadsworth and Young (35) reported, in 1952, that 70 to 90 percent of the flag leaves were destroyed by the time of maturity. Gough and Smith (17) reported foliage losses of up to 80 percent of hard red winter wheat (rosette stage)in fields of North Central Oklahoma in the winter and spring of 1974-1975. In 1977, Gough and Merkle (16) reported that the leaf infection of young winter wheat plants caused a significant retardation of root development.

The fact that both pathogens mentioned above are apparently capable of causing the same type of damage to different parts of the wheat plant brought to mind the Yarwood theory (41) that plants infected by a particular pathogen may be predisposed to subsequent attack by another pathogen. Recent studies suggested that wheat or barley affected by leaf rust may be more susceptible to infection by Septoria species. Van Der Wal et al. (37) reported that wheat infected by P. recondita f. sp. triticina was more susceptible to attack by S. nondorum than non-infected plants. Shearer et al. (30) found that infection of barley by S. avenae f. sp. triticea was more severe when plants were previously infected with P. hordei. Chester (9) reported that at least under some condition S. tritici was able to destroy leaf rust infected wheat leaves faster than the rust could infect new ones. Thus, S. tritici reduced the level of wheat leaf rust infection. The studies reported here deal with experiments investigating the possible effects of wheat

leaf rust on subsequent infection by S. tritici and of the individual and combined effects of these pathogens on various growth parameters of winter wheat.

CHAPTER II

LITERATURE REVIEW

More than 400 million acres of the world's crop land are devoted to the production of wheat, the world's most important food crop. On the major part of the acreage, in the vast wheat areas of Russia, Poland, Argentina and the Great Plains of North American, and to a large extent in the wheat-producing areas of India, China and Australia, the most destructive disease of wheat is leaf rust (10). In English-speaking lands, the terms "leaf rust" or "orange leaf rust," first used by Carleton (7) in 1898, are preferred for this disease, although some present day British and European workers use the term "brown rust". Among farmers, "red rust" is a common name for the disease.

The past 60 years have been marked by a rising appreciation of the economic importance of wheat leaf rust, possibly because of increased research on the effect of leaf rust on wheat yields. All of this research inescapably led to the conclusion that leaf rust was a disease of serious economic importance; far more destructive than formerly had been believed. Following the earlier work of Carleton (7) and Melchers (23), Butler (4), in 1940, concluded from his sulpher dusting experiments that the loss from leaf rust in New York State during 1937 to 1939 varied from 20 to 25 percent (2 to 3 million bushels per year). Mains (22) in 1930, studied the effect of leaf rust on the yield of wheat and concluded that the wheat cultivars Mediterranean and Red Fife

moderately infected with leaf rust from tillering to maturity, were reduced in yield 63.3 and 57.2 percent, respectively. The Fulcaster cultivar heavily infected from tillering to maturity was reduced in grain yield 97.4 percent. A severe infection on Fulcaster from shooting (jointing) to maturity resulted in a 91.3 percent reduction in yield, while heavy rust beginning in the boot stage reduced the yield 54.3 percent. Heavy rust in the period from blossoming to maturity reduced yields 24.7 percent. With the cultivar Michigan Amber heavy rust from the boot stage reduced yields 37.2 percent and when 100 percent infection was produced at blossoming, the yield was reduced 27.2 to 33.5 percent. By dusting with sulpher to control rust as a basis for evaluating the effect of leaf rust on several cultivars, he reported that grain yield reduction could vary from 24 to 97 percent depending on the cultivar and the time of infection. Johnston and Miller (20) in 1934, reported losses of 55 percent on susceptible cultivars in Kansas and in Oklahoma. Chester (10) reported a leaf rust epiphytotic, in 1938, in commercial fields near Enid, Oklahoma, limited production to as little as three bushels per acre in fields that had given promise of 30 bushel yields earlier in the season.

Caldwell et al. (5) in Indiana, reported that with very susceptible cultivars, reduction in yield of grain associated with the heavy infection of leaf rust ranged from 14.8 to 28.4 percent. In most cultivars the losses were approximately proportional to the severity of the rust and the yield of staw and grain were affect alike. Approximately three-fourths of the grain loss caused by leaf rust resulted from a reduction in the number of kernels per head, and the remainder from a reduction in weight per kernel. They also reported that the percentage of

protein in the grain of susceptible cultivars of both hard and soft winter wheat was very significantly reduced by severe leaf rust infection. In contrast to the grain, the combined culms and leaves of the rusted plants contained higher percentages of total nitrogen. In fact, in most cases, greater quantities of total nitrogen per tiller were found in rusted plants than in those of the control plants.

In the same experiment, Caldwell et al. reported that the percentage of starch content of the mature grain varied inversely with the protein percentage, the lower-protein grain from rusted plants being higher in starch than was the grain from control plants. However, because of the reduced number and size of kernels, the total quantity of starch laid down per kernel and head was distinctly reduced by leaf rust. The culms and leaves of rusted plants at the nearly ripe stages contained lower percentages of both sucrose and reducing sugar then did the control plants. The percentages of phosphorus and total ash of the grain were not appreciably affected by leaf rust. Similar studies were conducted in Portugal, in 1939, by D'Olivera (13). He also indicated that leaf rust infected plants contained higher percentaged of nitrogen than rust-free plants, and that the longer the plants had been rusted the greater was this difference. He proposed that rusts were able to fix atmospheric nitrogen.

Weiss (30) studied the effect of rusts on plant water requirements by growing "Marquis" wheat in quartz sand culture supplied with various combinations of mineral nutrients. An artificial epiphytotic of leaf rust was induced in one series, of stem rust in a second series, and a third series was maintained free from infection. He reported that either leaf or stem rust infection resulted in lowered water economy of

the host, whether the dry matter of entire tops or of grain was considered. The actual quantity of water transpired was of significance in relation to infection only when the correlative production of dry matter was taken into account.

Johnston and Miller (20) reported that leaf rust could reduce the average grain yields of susceptible cultivars from 42 to 93 percent. They also reported that the yields of straw were significantly reduced by leaf rust infection, and that heavy rust infection on susceptible cultivars resulted in a rapid and severe deterioration of the roots. This was indicated by root discoloration, a decrease in the number of fibrous roots, and a marked loss in total root weight. Their studies indicated that leaf rust infections increased the water requirement of the susceptible cultivars from 31 to 104 percent based on total dry matter and on the length of the rust infection period.

Williams (40) studied the effects of leaf rust on nutrition and production of winter wheat forage by a aseries of growth chamber and field tests comparing infected and non-infected wheat. He reported that the forage production from plants infected with leaf rust was up tp 50 percent less than rust free plants. Leaf rust infection affected wheat plants in the following manner: reduced intitial growth and also reduced regrowth after a forage harvesting, reduced tillering, survival after forage harvesting, increased the water requirement, retarded root development, and cuased root deterioration.

The Septoria leaf blotch disease of wheat caused by S. tritici had been identified in over 50 countries around the world. Literature dealing with the geographic distribution, economic importance of the disease, and the biology of the pathogen was reviewed by Shipton et al.

(31) in 1971. In several regions of the United States, Central and South America, and in a number of European countries, Septoria leaf blotch can assume epidemic proportions and cause serious reductions in yield. It is, therefore, considered a major wheat disease in some countries.

According to Weber (38), Desmazieres first reported Septoria leaf blotch on wheat in 1842 in France and presented a complete description of the pathogen and the disease. The perfect stage of the organism was not identified until 1972 when Sanderson (25) reported that a Mycosphaerella sp. on wheat was the sexual stage of S. tritici. After studying and comparing the material of Mycosphaerella sp. from wheat with slides prepared by the Commonwealth Mycological Institute in Australia in 1976, Sanderson (26, 27) named the ascogenous state or sexual stage Mycosphaerella graminicola (Fuckel) Sanderson Comb. Nov. and indicated that this sexual stage was important in the epidemiology of Septoria leaf blotch of wheat. Brown et al. (3) indicated that the distribution of M. graminicola and the dissemination of ascospored was the primary factor in the epidemiology of speckled leaf blotch of wheat in Victoria. The pathogen was present on wheat stubble throughout the Victorian wheat belt and ascospores were discharged from stubble following periods of leaf wetness caused by rain or dew.

Septoria leaf blotch of wheat often assumes epidemic proportions, and has caused serious yield reduction. Shipton et al. (31) reported heavy losses in Argentina since 1939, and an epidemic occurred there in 1943-1944. In New Zealand and Australia, the disease has caused moderate or heavy losses for many years. Schiever and Fumagalli (28) in 1961 indicated that Septoria leaf blotch was the most important

disease on wheat in Guatemala. The disease has been severe in all wheat regions and at altitudes ranging up to 9,000 feet. All commercial wheat cultivars were susceptible to the disease which developed most severaly during the rainy season or even in the dry season under irrigation.

The disease also has been considered a major problem of wheat in the coastal regions of the Mediterranean Sea, and in the north and northeastern part of Africa where annual rainfall exceeds 700 mm. Stewart et al. (34) reported that an epiphytotic of the disease developed in Morocco, Tunisia and Turkey in 1968-1969. Severaly damaged fields of northern Morocco, which had a potential yield of 4,000 kg per ha, produced only 500 to 800 kg per ha. According to Eyal (14) and Eyal and Ziv (15) the disease has caused severe damage to wheat in Israel during the last 30 years and epiphytotics occurred after the introduction of high yielding, semi-dwarf Mexican cultivars which were particularly susceptible to S. tritici. Under epidemic situations, susceptible wheat cultivars showed losses in yield of up to 40.4 percent.

In the United States, the disease was first reported by Pammel in 1901 as cited by Weber (38), and since that time, it has been found in every wheat growing region of the country. Dickson (12) noted that the disease occurred consistently over a wide area of hard red and soft red winter wheat regions. According to Sprague (33), the disease was prevalent in the humid areas of Oregon, Washington, Northern California, and sometimes in the midwestern and eastern states. During 1957 and 1958, studies were made in Indiana by Caldwell and Narvaez (6), who found that yields in inoculated plots were 25.0 to 44.6 percent below

the sprayed checks. Early maturing cultivars were more severaly damaged than late maturing ones.

Wadsworth and Young (35) made a comprehensive survey of over 4,500 acres of wheat in north-central Oklahoma. They reported that speckled leaf blotch was the most severe disease, affecting all fields they examined. "Comanche" was the most severely affected cultivar while "Red Chief" appeared the most resistant. In 1941, Chester (8) noted that beginning the first of April and extending into mid-May Oklahoma was subject to an unusual period of wet weather when more than half of the days were cloudy or rainy with cool temperatures prevailing. These conditions resulted in a state-wide epiphytotic of specked leaf blotch, killing 40 to 60 percent of the entire complement of leaves.

According to Shaner and Finney (29), a severe epidemic occurred in Indiana in 1976 when there were 34 days of rain with no single period exceeding two days without rain and with minimum temperatures of about 7 C or lower. They believed that it may be possible to forecast a severe epidemic at the time flag leaves emerge by examining weather data from the previous 40 days.

Cooke and Jones (11) reported that Septoria leaf blotch of wheat caused reductions in 1,000-kernel wt. of 16.2 and 18.6 percent in the spring wheat cultivars "Flameks" and "Lickti II" respectively. In the winter wheat cultivers Leonardo and Leone losses in 1,000-kernel wt. amounted to 23.7 and 24.4 percent respectively. Atkins (1) noted that loss of grain yield caused by Septoria leaf blotch was over 4 million bushels in Texas in 1950.

According to Gough and Smith (17) Septoria leaf blotch caused severe foliage losses to hard red winter wheat in north central

Oklahoma during the winter and spring of 1974-1975. Plants in upgrazed fields and experimental plots lost up to 80 percent of their foliage during the rosette stage. In 1977, and Gough and Merkle (16) reported that inoculation of young winter wheat with S. tritici in greenhouse and growth chamber tests reduced root development (dry wt.), respectively, 52.6 and 31.4 percent in the cultivar Oasis, 53.3 and 42.5 percent in Tam W-101 and 61.1 and 41.9 percent in Improved Triumph. In the same tests foliage yields were reduced only 12.5 and 12.8 percent in Oasis, 17.8 and 16.4 percent in Tam W-101, and 24.5 and 29.4 percent in Improved-Triumph. Thus, reduced root mass caused by fall and winter infection may have a greater impact on grain yields than the loss of photosynthetically active leaf tissue in the spring.

Ziv and Eyal (43) determined loss in various yield components for five spring wheat cultivars affected by Septoria leaf blotch epidemics compared to fungicide protected plants. They found lateral tillers sustained greater yeidl reductions than did the central tillers.

In 1959, Yarwood (41) noted that plants which have been infected by a particular pathogen may be predisposed to subsequent attack by another pathogen. Several studies have recently suggested that wheat or barley affected by leaf rust may be more susceptible to infection by Septoria species. Van Der Wal et al. (37) recorded that the yield of wheat infected with both P. recondita and S. nodorum was reduced more than would be predicted from the additive effects of both pathogens when they occurred sparately. They reported that in their experiments they yield loss resulting from infection by S. nodorum was negligible, whereas that caused by P. recondita was more significant. In 1974, Van Der Wal and Cowan (36) found that the loss of head weight

due to rust was inconspicuous but that caused by S. nodorum was significant. In this situation the effect of inoculating with both pathogens again caused a greater loss than the sum of the effect of each pathogen separetely. In 1944, Chester (9) reported that low leaf rust incidence was associated with late winter temperatures that held the reproduction rate of P. triticina to such a low level that S. tritici, each lesion of which had a greater capacity for destroying wheat leaf tissue than lesions of leaf rust, was able to destroy rust infected leaves faster than the rust could advance with new infections. On the other hand, Hyde (18) studied the effect on wheat inoculated with P. recondita and and Leptosphaeria nodurum and concluded that, with respect to the criteria assessed, interaction between P. recondita and L. nodorum on wheat did not always occur. In 1974, Shearer et al. (30) found that barley leaves infected with P. hordei were more severely infected with S. avenae f. sp. tritici than when rust was absent.

CHAPTER III

MATERIALS AND METHODS

Three cultivars of winter wheat were used for these experiments made under controlled conditions in a greenhouse. The cultivars were Triumph 64 (CI 13679), Timpaw (CI 13014), and Chinofuz (CI 15350); abbreviated in this study TMP64, TPA, and CNF (2) respectively. Two pure cultures, 22 and 26, of the speckled leaf blotch fungus S. tritici and two pure races, designated 2AAG and 6B, of the leaf rust fungus P. recondita were used.

TPA has the leaf rust resistance gene Lr24, and is resistant to P. recondita culture 6B (42). TPA also is resistant to S. tritici but is susceptible to P. recondita culture 2AAG. CNF has an identified gene or genes for resistance to culture 2AAG of P. recondita but is susceptible to cultures 6B and S. tritici. TMP64 has no known resistance to either of the two organisms.

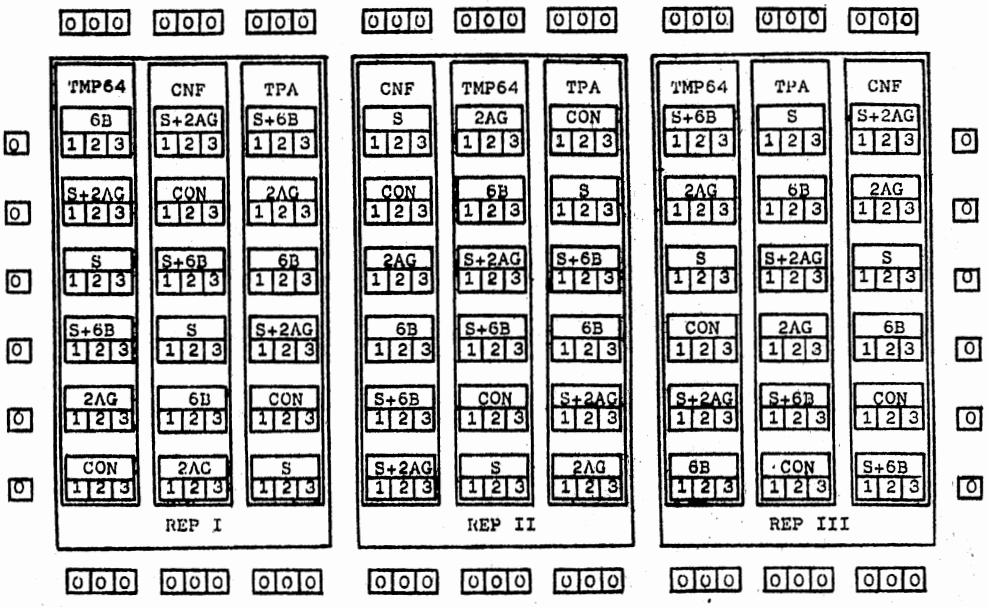
Two experiments were made: the first involved inoculating plants in the seedling stage and harvesting their leaves and roots in the seedling to tillering stage; and the second involved inoculating the plants both before and after vernalization and harvesting them at maturity.

The first experiment, concerned with the individual and combined effects of leaf blotch and leaf rust on immature wheat plants, was arranged in a split plot design with three replications. Within each

replication, five Arasan treated seeds of each cultivar (main plot) were sown in six 15 cm clay pots containing a 1:1:1 mixture of sand, peat moss and clay loam soil, and thinned after emergence to three plants per pot. The pots and soil were steam sterilized twice prior to planting at 200 C and at a pressure of 1,055 g/cm for three hours with an interval of two days between each sterilization. Six treatments served as sub-plots as follows:

1. Non-inoculated (control).
2. Inoculated with S. tritici only.
3. Inoculated with S. tritici and P. recondita race 2 AAG simultanously.
4. Inoculated with S. tritici and P. recondita race 6B simultanously.
5. Inoculated with P. recondita race 2AAG only.
6. Inoculated with P. recondita race 6B only.

Both main plots and sub-plots were randomized and were arranged in the design shown in Figure 1. The entire experiment was surrounded with a border row of pots of plants. The inoculation treatments were applied 35 days after emergence. The preparation of inoculum and procedures of inoculation were as follows: the leaf rust cultures of P. recondita races 6B and 2AAG were previously purified isolates of the fungus, collected from a universally susceptible cultivar with a cyclone separator-type spore collector, which had been stored in liquid nitrogen refrigeratore in glass tubes (21). The initial inoculum of these cultures was removed from storage, treated with warm water at 47 C for five minutes, diluted with mineral oil and sprayed on the 35-days old wheat seedling with a venturi type micro-sprayer. These inoculated plants then were sprayed with water and a surfactant Tween 20



Legend:

TMP64, CNF and TPA are cultivars representing main plots. S, 6B and 2AG are isolates of S. tritici and P. recondita respectively representing sub-plot treatments. The numbers 1, 2 and 3 are designations of the three pots of plants used for each treatment on each cultivar within each replication.

Figure 1. Experimental Design Used in the First Experiment to Measure the Effects of Septoria tritici and Puccinia recondita Alone and In Combination on the Growth of Seedling Wheat Plants

(polysorbate), and placed in a moist chamber at 20 C for 12 hours.

Inoculum of S. tritici was produced by growing the cultures in a liquid medium (4 g. malt extract, 0.2 g. of yeast extract, 100 ppm streptomycin sulphate before autoclaving, and 1,000 ml of water) for 10 to 14 days. Cultures 22 and 26 were mixed and strained through a double layer of cheese cloth, then 0.5 g of Knox gelatin dissolved in 20 ml of warm water was added directly to 100 ml of the medium. The concentration of spores and hyphal fragments were counted by means of a hemacytometer and adjusted to approximately nine million per ml by adding sterilized distilled led water. Inoculations were made three times on three consecutive days by spraying the inoculum on to plants with a De Vilbiss atomizer at a pressure of 352 g/cm^2. Both inoculated and uninoculated plants were covered with an opaque polyethylene film supported by a frame and kept moist by a time clock-controlled fine mist blower (Golden Egg Herrmidifier, Model 500 ER) for a period of about 72 hours at 20 C. All tested plants were removed and kept in the greenhouse at 20-25 C. Measurements were made in the following manner.

Infected leaves were harvested 30 days after inoculation, dried in a 60 C hot air oven over night, then weighed. Regrowth of leaves was measured two weeks later in the same manner. After obtaining leaf data, the pots containing soil and plants were soaked in water for one hour to facilitate removal of roots and soil from the pots. The root mat below the crown of each plant was washed gently in water over a fine-mesh screen to remove soil particles. The roots were then pressed between paper towel to remove the exogenous water and the volume of each root mass was measured in ml by water displacement. After volume measurements were obtained, the root masses were dried over night in a

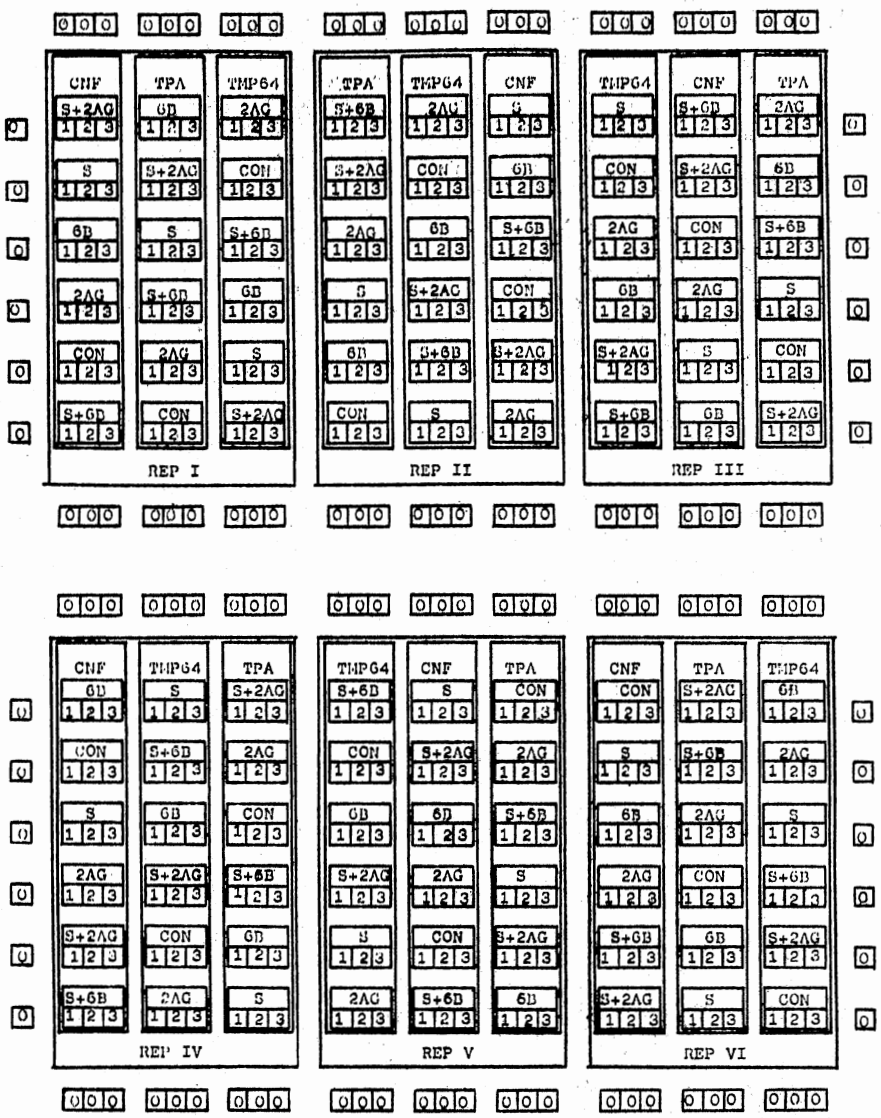
90 C hot air oven, and then weighed.

All data were summarized and analyzed, using the means of each variable, and then interactions between the effects of the different treatments were calculated.

The second experiment was concerned with the individual and combined effects of leaf blotch and leaf rust on mature wheat plants. It involved inoculating the plants after vernalization and harvesting them at maturity. The experiment was arranged in a split plot design with six replications. Three wheat cultivars, the same as those used in the seedling experiment, served as main plots and six inoculation treatments served as sub-plots. Within each replication, foundation seed of each wheat cultivar were sown in 18 sterilized 15 cm pots (1 plant/pot). The experiment design is shown in Figure 2. Six inoculation treatments were applied as follows:

1. Non-inoculated (control).
2. Inoculated with S. tritici only.
3. Inoculated with S. tritici and P. recondita culture 2AAG.
4. Inoculated with S. tritici and P. recondita culture 6B.
5. Inoculated with P. recondita culture 2AAG only.
6. Inoculated with P. recondita culture 6B only.

Soil mixtures were prepared and treated in the same manner as in experiment 1. Inoculation procedures differed from experiment 1 only in that two more inoculations with S. tritici and the two cultures of P. recondita were made at later stages of plant development. Twenty-one days after the first seedling inoculations, all plants were removed to cold frames to induce vernalization. Six weeks later, they were moved back to the greenhouse for continued growth. The second inoculation with the P. recondita cultures was made 30 days after the plants



Legend:

TM64, CNF and TPA are cultivars representing main plots. S, 6b and 2AG are isolates of S. tritici and P. recondita respectively representing sub-plot treatments. The numbers 1, 2 and 3 are designations of the three pots of plants used for each treatment on each cultivar with each replication.

Figure 2. Experimental Design Used in the Second Experiment to Measure the Effects of Septoria tritici and Puccinia recondita Alone and in Combination on the Growth of Mature Wheat Plants

were returned to the greenhouse following vernalization. The second inoculation with S. tritici was made 15 days after inoculation with rust. When the majority of plants had started to produce a flag leaf, they were inoculated for the third time with S. tritici and both cultures of P. recondita.

Thirty days after the last inoculation, disease severity was scored on individual leaves. The severity was rated on a 0-9 scale, ranging from no infection to heavy infection in which at least 90 percent of the leaf area was affected, then converted to percentage of infection per plant as shown in Appendix Tables XIII through XXX. Before harvesting, the number of tillers per plant and number of heads per plant were recorded.

At the end of the experiment, all seeds were harvested from each plant, counted and weighed. The plant stems were cut-off at the soil level and the pots containing soil and root systems were soaked in water and the roots washed free of soil, measured by volume and weighed as described for experiment 1.

The results were summarized and expressed as the means of single plants. All statistical analyses were conducted at Oklahoma State University Computer Center with assistance in programming provided by R. D. Morrison of the Department of Statistics.

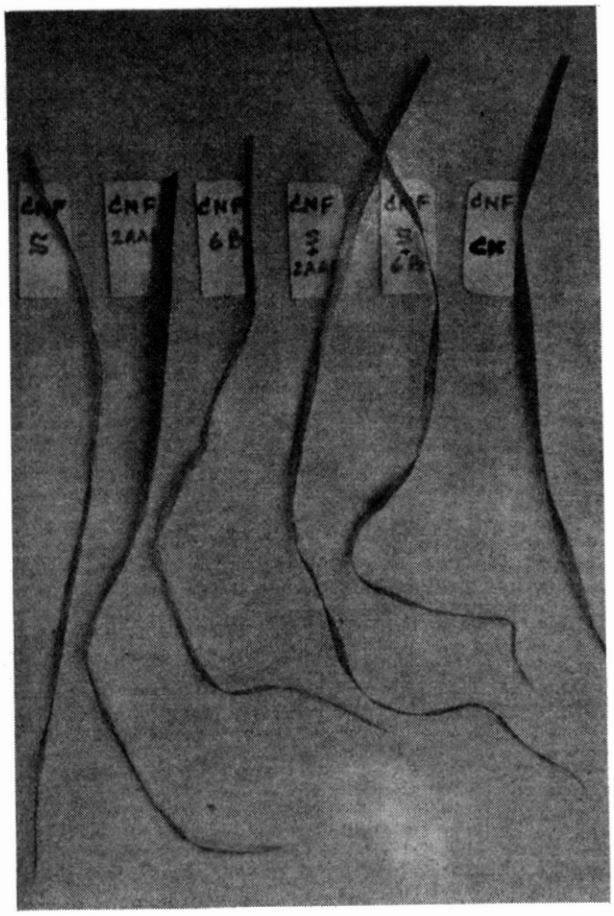
CHAPTER IV

RESULTS

Experiment 1

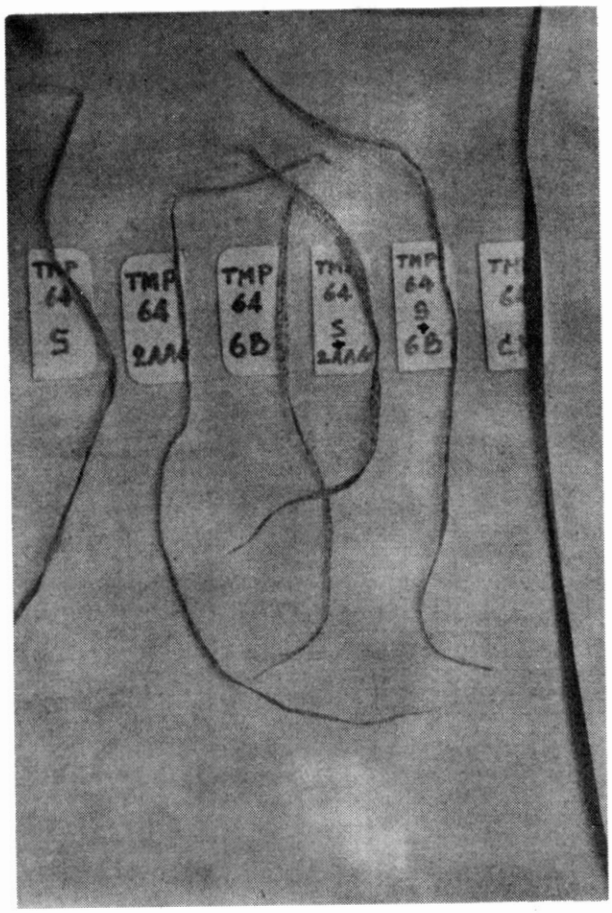
Although disease severity was not recorded in this experiment, ten days after inoculation treatments inoculated with both cultures of P. recondita showed symptoms on wheat seedlings as shown in Figures 3, 4 and 5. TMP64 was susceptible to both cultures, TPA was susceptible to culture 2AAG but resistent to 6B (the latter showing only flecks on the inoculated leaves) while CNF was susceptible to culture 6B but resistent to 2AAG. Plants inoculated with S. tritici showed pronounced lesions 20 days after inoculation and pycnidia within the next week (Figures 3, 4 and 5). The reaction of the three wheat cultivars to both P. recondita cultures and S. tritici are shown in Table I.

Dry weights of infected leaves cut 30 days after inoculations showed no significant differences between wheat cultivars (Table II and Figure 6) when the means of all treatments are considered. Dry leaf weight means of all cultivars showed that all inoculation treatments differ significantly from the non-inoculated plants. All inoculation treatments, however, had significantly less leaf dry weight than the uninoculated check. The resistance of TPA to S. tritici was evident since the leaf weight of TPA inoculated with S. tritici was not significantly different from the uninoculated control and was significantly higher than the other two cultivars inoculated with S. tritici alone.



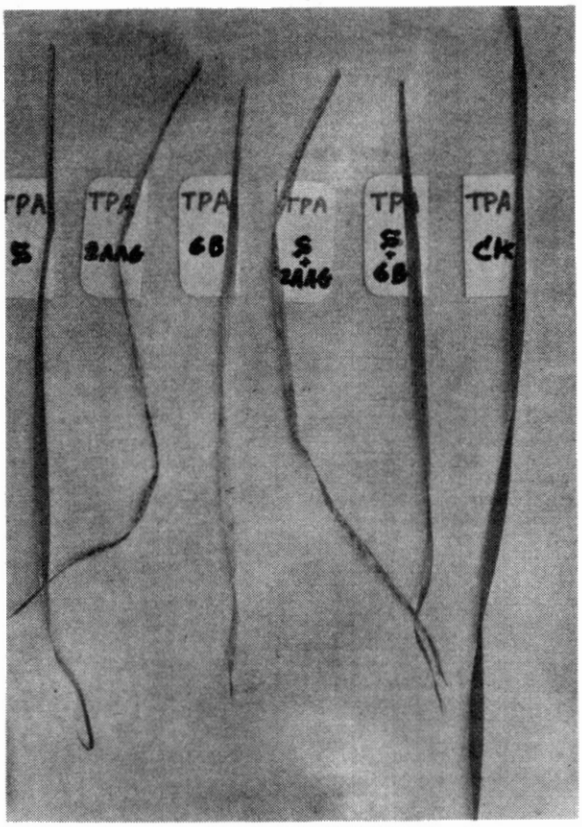
S = Septoria tritici
2AAG and 6B = Races of Puccinia recondita
Ck = Uninoculated Check

Figure 3. Seedling Leaves of Wheat Cultivar Chinofuz (CNF) Affected by Different Inoculation Treatments



S = Septoria tritici
2AAG and 6B = Races of Puccinia recondita
Ck = Uninoculated Check

Figure 4. Seedling Leaves of Wheat Cultivar Triumph 64 (TMP64) Affected by Different Inoculation Treatments



S = Seporia tritici
2AAG and 6B = Races of Puccinia recondita
Ck = Uninoculated Check

Figure 5. Seedling Leaves of Wheat Cultivar Timpaw (TPA) Affected by Different Inoculation Treatments

TABLE I

THE REACTION [1] OF WHEAT SEEDLINGS TO SPECKLED LEAF BLOTCH AND TWO RACES OF THE LEAF RUST FUNGUS

Wheat Cultivars [2]	Organisms		
	S. tritici	*P. recondita* race 2AAG	*P. recondita* race 6B
CNF	S	R	S
TMP64	S	S	S
TPA	R	S	R

1/ S = Susceptible, R = Resistant

2/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw

TABLE II

MEANS[1/] OF DRY LEAF WEIGHT IN GRAMS 45 DAYS AFTER PLANTING OF WHEAT CULTIVARS INFECTED IN THE SEEDLING STAGE WITH *SEPTORIA TRITICI* AND TWO RACES OF *PUCCINIA RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	CK	S	S+AG	S+6B	AG	6B	
CNF	0.51	0.13	0.17	0.13	0.18	0.13	0.21
TMP64	0.61	0.23	0.20	0.16	0.16	0.18	0.26
TPA	0.44	0.38	0.21	0.27	0.19	0.25	0.29
Treatment Mean	0.52	0.24	0.19	0.19	0.18	0.19	

Cultivar means not significantly different.
LSD .05 between 2 treatments = 0.08.
LSD .05 between 2 treatments within the same cultivar = 0.14
LSD .05 between 2 cultivars within the same treatment = 0.08
Prob. > F of interaction between treatments and cultivars = 0.08.
CV = 24.08

1/ Mean of 9 plants in 3 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita* race 6B, AG = *P. recondita* race 2AAG only, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

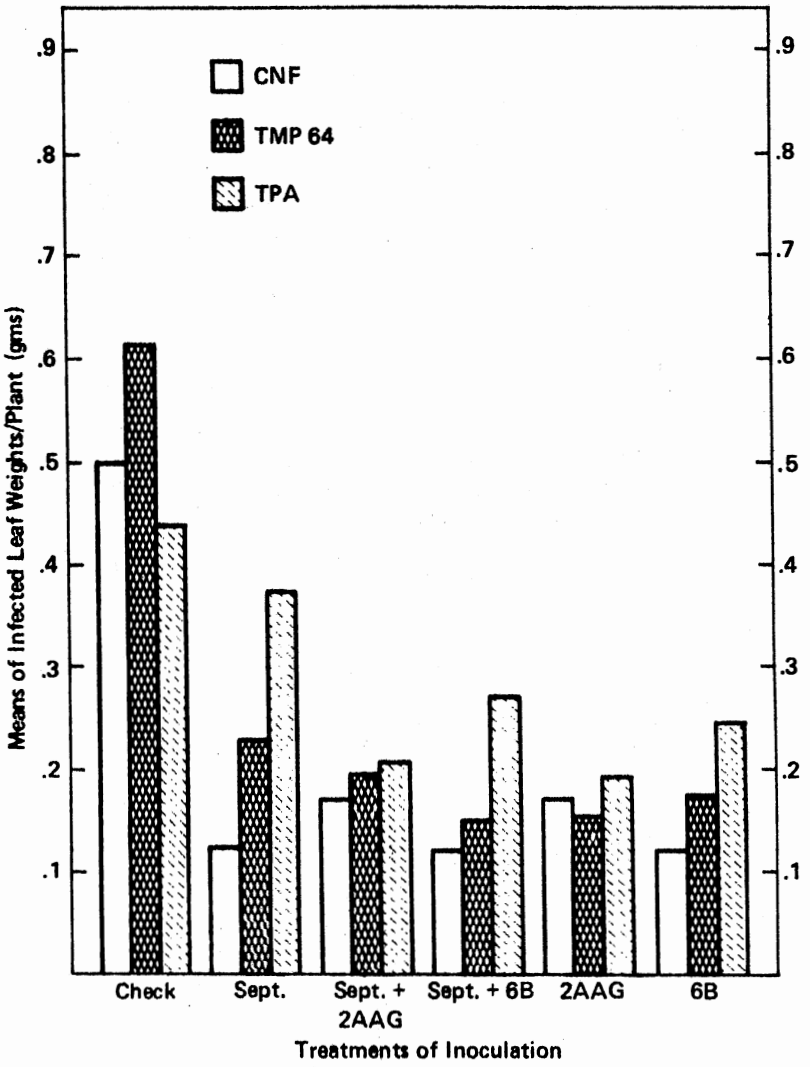


Figure 6. Means of Dry Weights of Seedling Leaves From Nine Plants in Three Replications of Three Wheat Cultivars Inoculated with Septoria tritici (Sept.), Races 2AAG and 6B of Puccinia recondita and Combinations of These Organisms

When culture 2AAG, to which TPA is susceptible was used either alone or with S. tritici the leaf weight of that cultivar was reduced significantly below that of the S. tritici alone treatment. There were no significant differences between the rust inoculated treatments, however. The combination of S. tritici and P. recondita culture 2AAG, or S. tritici and P. recondita culture 6B did not reduce the leaf weights significantly below those inoculated with P. recondita cultures 2AAG and 6B alone. Analysis indicated no significant interaction between cultivar and inoculation treatments.

The cultivar CNF, resistant to culture 2AAG, had a greater leaf weight when inoculated with culture 2AAG than with culture 6B; and conversely, cultivar TPA, resistant to culture 6B, had a greater leaf weight when inoculated with that culture than with culture 2AAG, but these differences were not significant.

In percentage terms, S. tritici and P. recondita culture 6B, and the combination of these two organisms reduced the leaf weights of cultivar CNF 76 percent, 74 percent and 74 percent respectively. On TMP64, S. tritici reduced the leaf weights 57 percent and P. recondita cultures 2AAG and 6B reduced the leaf weights 69 percent and 65 percent, respectively, while the combinations of S. tritici and P. recondita cultures 2AAG and 6B reduced leaf weight 61 percent and 69 percent, respectively. On TPA, S. tritici did not reduce leaf weights significantly, while P. recondita culture 2AAG and the combination of culture 2AAG and S. tritici reduced the leaf weights 57 percent and 53 percent, respectively.

Two weeks after removing the infected leaves, regrowth leaves were harvested from each plant, dried and weighed. Means of each

treatment of each cultivar are presented in Table III and Figure 7. There were not significant differences in the amount of foliar regrowth between disease and non-disease treatments. Likewise, there were no significant differences between the three cultivars. However, all of the treatments with S. tritici had better regrowth than the treatments with rust alone, and better regrowth occurred on TMP64 and CNF than on TPA when S. tritici was combined with culture 2AAG to which TPA is susceptible. Similarly, greater regrowth occurred on TPA than on TMP64 or CNF when S. tritici was combined with culture 6B, a culture to which TPA is resistent. These latter differences, however, were not significant.

The measurements of the effects on roots of plants inoculated with S. tritici and two cultures of P. recondita were made immediately after the regrowth leaves had been harvested. The data on root volume and dry root weight are presented in Tables IV and V and Figures 8 and 9 respectively. Analysis of these data indicated that there were no differences between wheat cultivars in either root volume or root weight. However, all treatments inoculated with either S. tritici or P. recondita had significantly less root volume and less root dry weight than the uninoculated control treatment. However, TMP64 inoculated with S. tritici alone and with S. tritici and culture 2AAG had root volume and root weight equal to the uninoculated treatment. Similarly, TPA inoculated with S. tritici alone and with S. tritici and culture 6B and with culture 6B alone had root volume and root weight equal to the uninoculated treatment. However, when this cultivar was inoculated with culture 2AAG alone or combined with S. tritici the root volume and root weight was reduced below either TMP64 or CNF, reflecting

TABLE III

MEANS[1/] OF REGROWTH LEAF WEIGHT IN GRAMS 14 DAYS AFTER INITIAL LEAF REMOVAL OF WHEAT CULTIVARS INFECTED IN THE SEEDLING STAGE WITH S. TRITICI AND TWO RACES OF P. RECONDITA AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	CK	S	S+AG	S+6B	AG	6B	
CNF	2.57	2.40	2.88	2.49	2.43	2.15	2.49
TMP64	2.44	2.87	3.03	2.39	2.09	1.84	2.44
TPA	2.40	2.66	2.39	2.70	2.07	2.76	2.50
Treatment Mean	2.47	2.64	2.77	2.53	2.20	2.26	

Cultivar means not significantly different.
LSD .05 between 2 treatments = 0.38.
LSD .05 between 2 treatments within the same cultivar = 0.66.
LSD .05 between 2 cultivers within the same treatment = 0.38.
Prob. > F of interaction between treatments and cultivars = 0.12.
CV = 22.56

1/ Mean of 9 plants in 3 replications.
2/ Ck = disease free, S = S. tritici, S+AG = S. tritici + P. recondita race 2AAG, S+6B = S. tritici + P. recondita race 6B, AG = P. recondita race 2AAG only, 6B = P. recondita race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

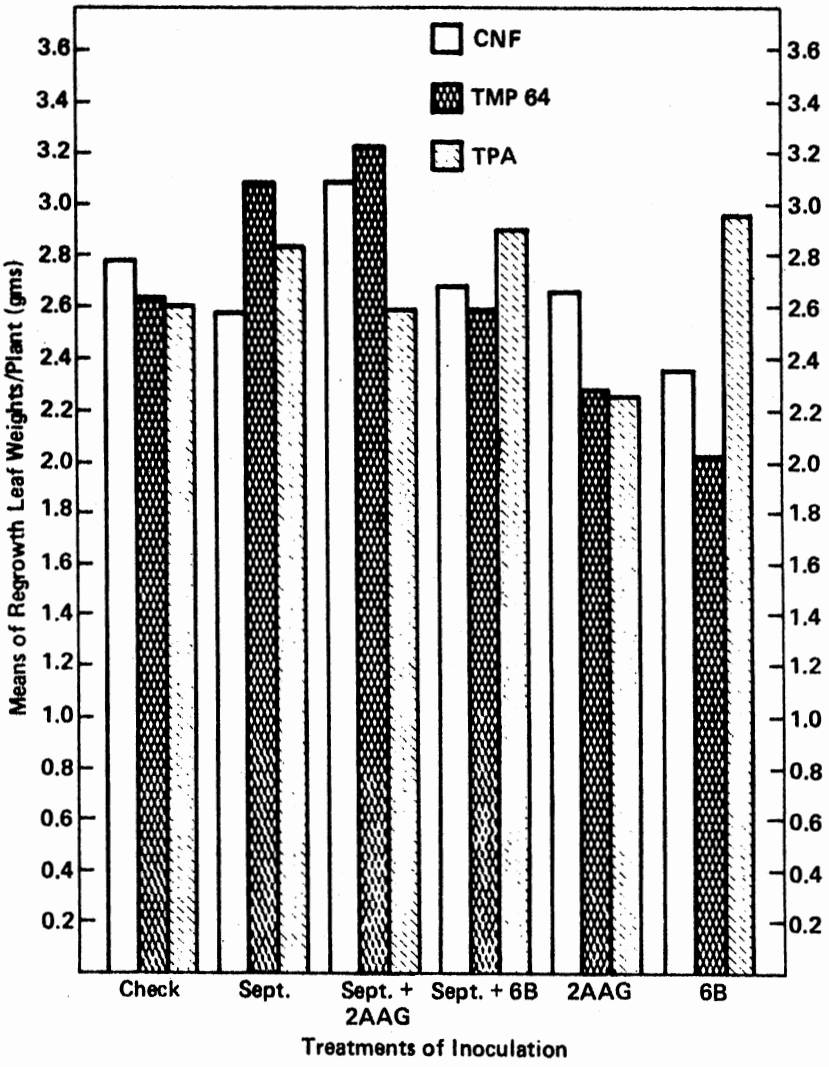


Figure 7. Means of Dry Weight of Regrowth of Seedling Leaves of Three Wheat Cultivars Inoculated with S. tritici and Races 2AAG and 6B of P. recondita and Combinations of These Organisms

TABLE IV

MEANS[1/] OF ROOT VOLUME IN ML 45 DAYS AFTER PLANTING OF WHEAT CULTIVARS INFECTED IN THE SEEDLING STAGE BY S. TRITICI AND TWO RACES OF P. RECONDITA AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	5.85	2.83	3.65	3.16	3.52	3.63	3.77
TMP64	4.48	4.03	4.12	2.84	3.14	3.10	3.62
TPA	4.30	3.31	2.50	3.17	2.64	3.37	3.22
Treatment Mean	4.88	3.39	3.43	3.06	3.10	3.37	

Cultivar not significantly different
LSD .05 between 2 treatments = 0.68
LSD .05 between 2 treatments within the same cultivar = 1.18
LSD .05 between 2 cultivars within the same treatment = 0.68
Prob. > F of interaction between treatments and cultivars = 0.08
CV = 33.69

1/ Mean of 9 plants in 3 replications.
2/ Ck = disease free, S = S. tritici, S+AG = S. tritici + P. recondita race 2AAG, S+6B = S. tritici + P. recondita race 6B, AG = P. recondita race 2AAG only, 6B = P. recondita race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

TABLE V

MEANS[1/] OF DRY ROOT WEIGHT IN GRAMS 45 DAYS AFTER PLANTING OF WHEAT CULTIVARS INFECTED IN THE SEEDLING STAGE BY S. TRITICI AND TWO RACES OF P. RECONDITA AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	0.813	0.481	0.596	0.508	0.552	0.556	0.585
TMP64	0.858	0.675	0.707	0.509	0.577	0.497	0.637
TPA	0.731	0.575	0.364	0.473	0.537	0.544	0.537
Treatment mean	0.801	0.577	0.556	0.496	0.555	0.533	

Cultivar not significantly different
LSD .05 between 2 treatments = 0.099
LSD .05 between 2 treatments within the same cultivar = 0.172
LSD .05 between 2 cultivars within the same treatment = 0.099
Prob. > F of interaction between treatments and cultivars = 0.11
CV = 27.52

1/ Mean of 9 plants in 3 replications.
2/ Ck = disease free, S = S. tritici, S+AG = S. tritici + P. recondita race 2AAG, S+6B = S. tritici + P. recondita race 6B, AG = P. recondita race 2AAG only, 6B = P. recondita race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

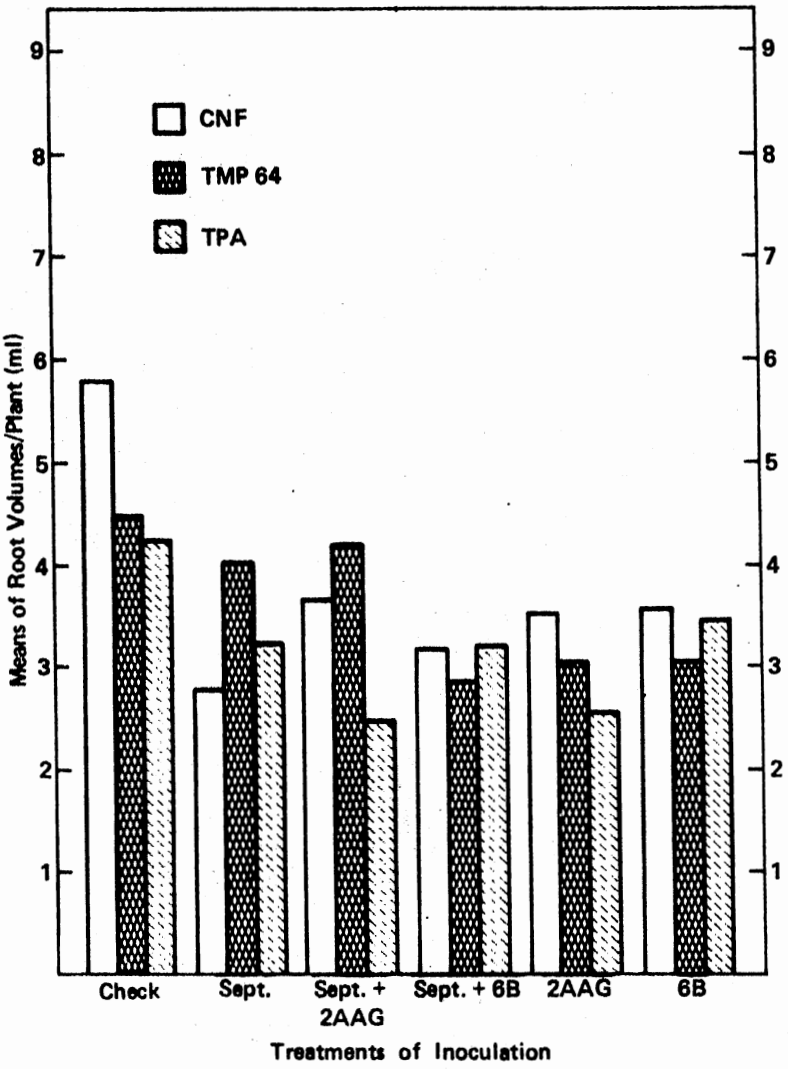


Figure 8. Means of Nine Plants in Three Replications of Seedling Root Volume in ml Inoculated with S. tritici (Sept.), Races 2AAG and 6B of P. recondita and Combinations of These Organisms

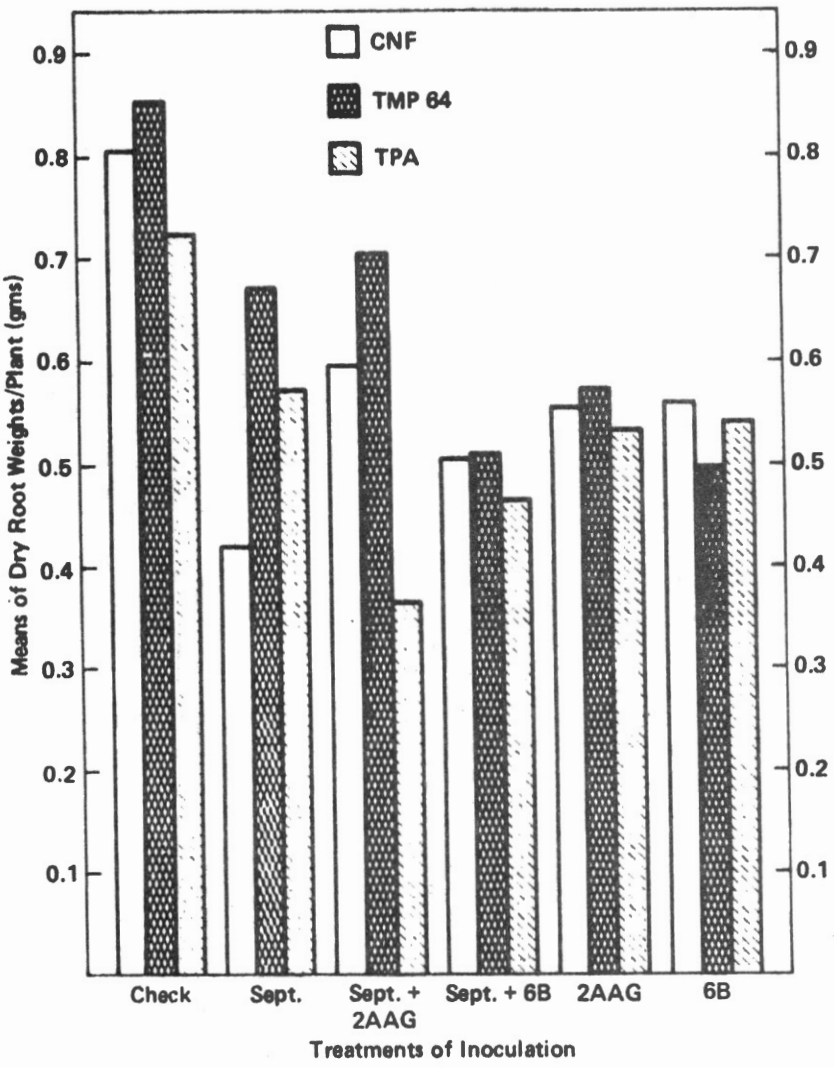


Figure 9. Means of Nine Plants in Three Replications of Seedling Dry Root Weight of Three Wheat Cultivars Inoculated with S. tritici (Sept.) and Races 2AAG and 6B of P. recondita and Combinations of These Organisms

its resistance to culture 6B and susceptibility to culture 2AAG. CNF inoculated with S. tritici alone produced much less root volume and root weight than the other two cultivars while TPA showed more or less the opposite effect reflecting the susceptivility of the former cultivar and the resistance of the latter.

Experiment 2

The individual and combined effects of Septoria leaf blotch and leaf rust on mature wheat plants was measured using seven parameters; number of tillers, number of heads, number of seeds, grain yield (seed weight), root volume, root weight, and percentage of disease severity. All of these measurements were made on a single plant basis with three plants in each of six replications (total of 18 plants). The percentage of disease severity was taken after the third inoculation when most of the plants had started to produce heads (Figure 10) and symptoms of both diseases had appeared (Figures 11, 12 and 13). Scoring for disease incidence was done on every leaf by using a scale of 0 to 90 percent. The raw data for each plant in each replication are given in Appendix Tables XIII through XXX. The percentage of severity for any single plant was expressed as an average for all of the leaves scored on that plant and each score measured the combined effect of both diseases. Scores for all of the plants were then summarized and analyzed statistically. These data are presented in Table VI and Figure 14. As expected, plant response to all inoculation treatments differed significantly and the response of each cultivar was controlled by the resistance of the particular cultivar. TMP64, susceptible to all fungi used had the highest severity (37.2 percent), followed by CNF (18.4 percent)

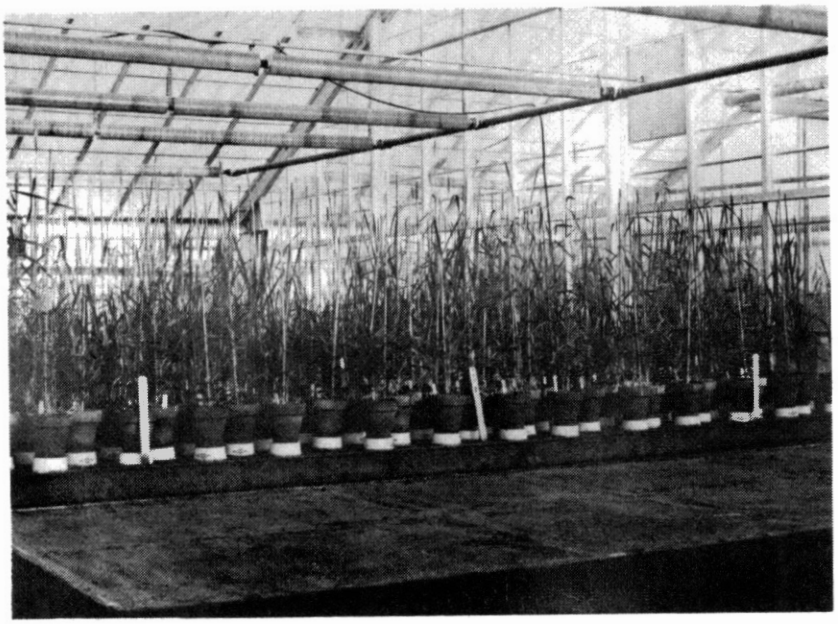


Figure 10. Adult Plants of Experiment 2 in the Greenhouse Showing the Nature of the Plant Arrangement

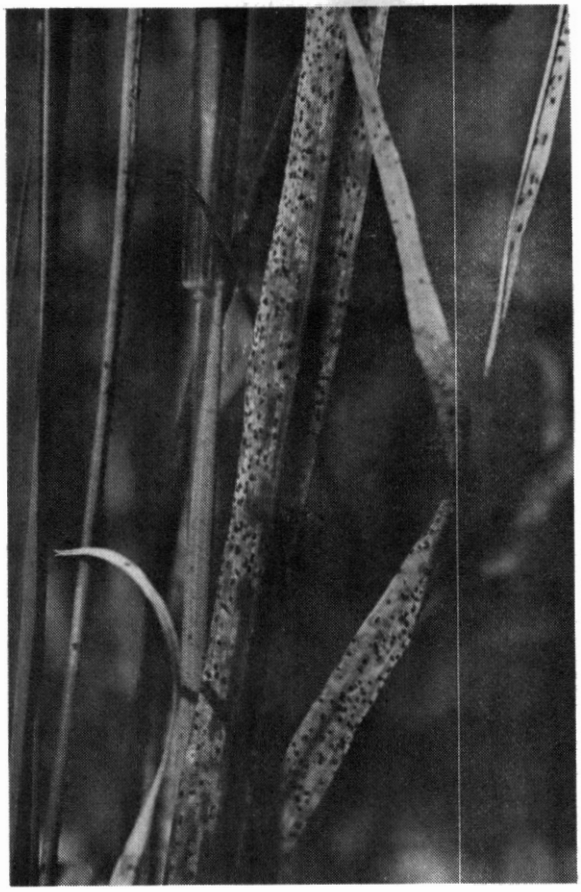


Figure 11. Leaf Rust Severity on Triumph 64

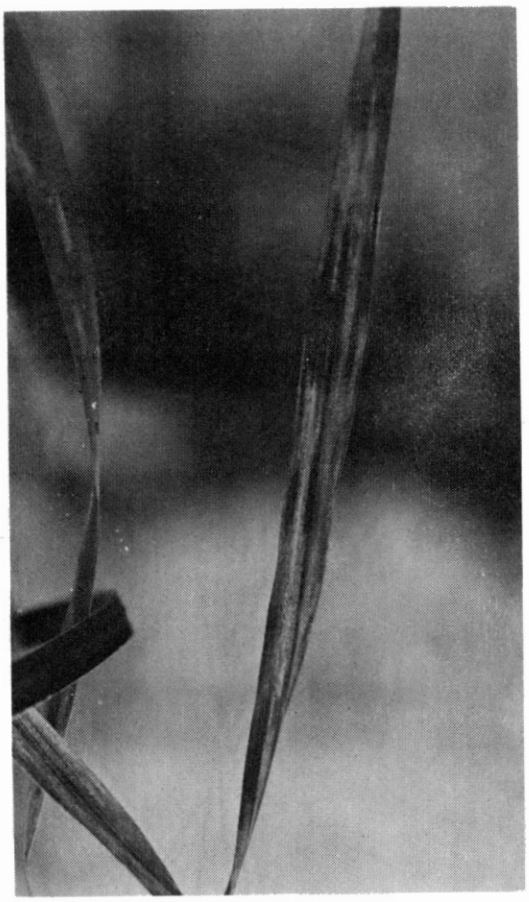


Figure 12. Speckled Leaf Blotch Severity on Triumph 64

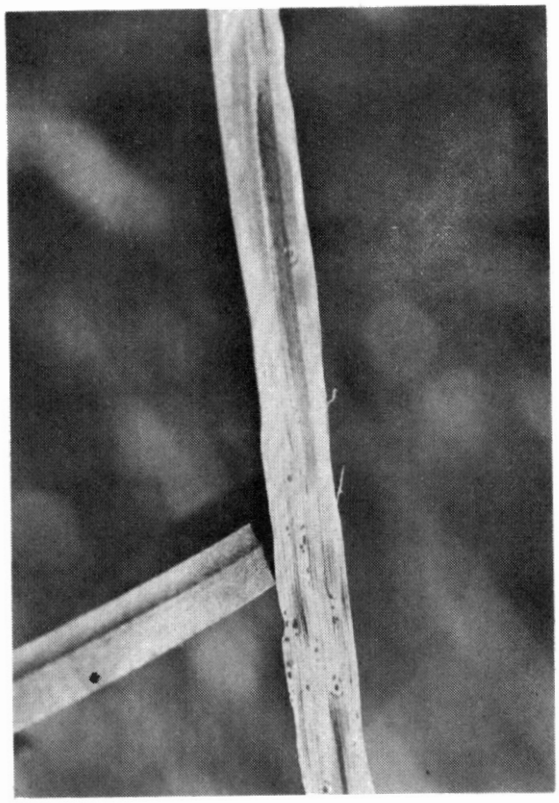


Figure 13. Leaf Rust and Speckled Leaf Blotch Severity on the Same Leaf of Triumph 64

TABLE VI

MEANS[1/] OF THE DISEASE SEVERITY IN PERCENT OF LEAF AREA COVERED OF THREE WHEAT CULTIVARS AT MATURITY INOCULATED WITH *S. TRITICI* AND TWO RACES OF *P. RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	0	21.70	22.48	42.39	0	23.89	18.41
TMP64	0	34.64	52.29	61.54	35.42	39.51	37.23
TPA	0	0	29.12	0	26.63	0	9.29
Treatment mean	0	18.78	34.63	34.64	20.68	21.13	

LSD .05 between 2 cultivars = 5.73
LSD .05 between 2 treatments = 3.48
LSD .05 between 2 treatments within the same cultivar = 6.02
LSD .05 between 2 cultivars within the same treatment = 3.48
Prob. > F of interaction between treatments and cultivars = .0001
CV = 24.05

1/ Mean of 18 plants in 6 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita* race 6B, AG = *P. recondita* race 2AAG, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

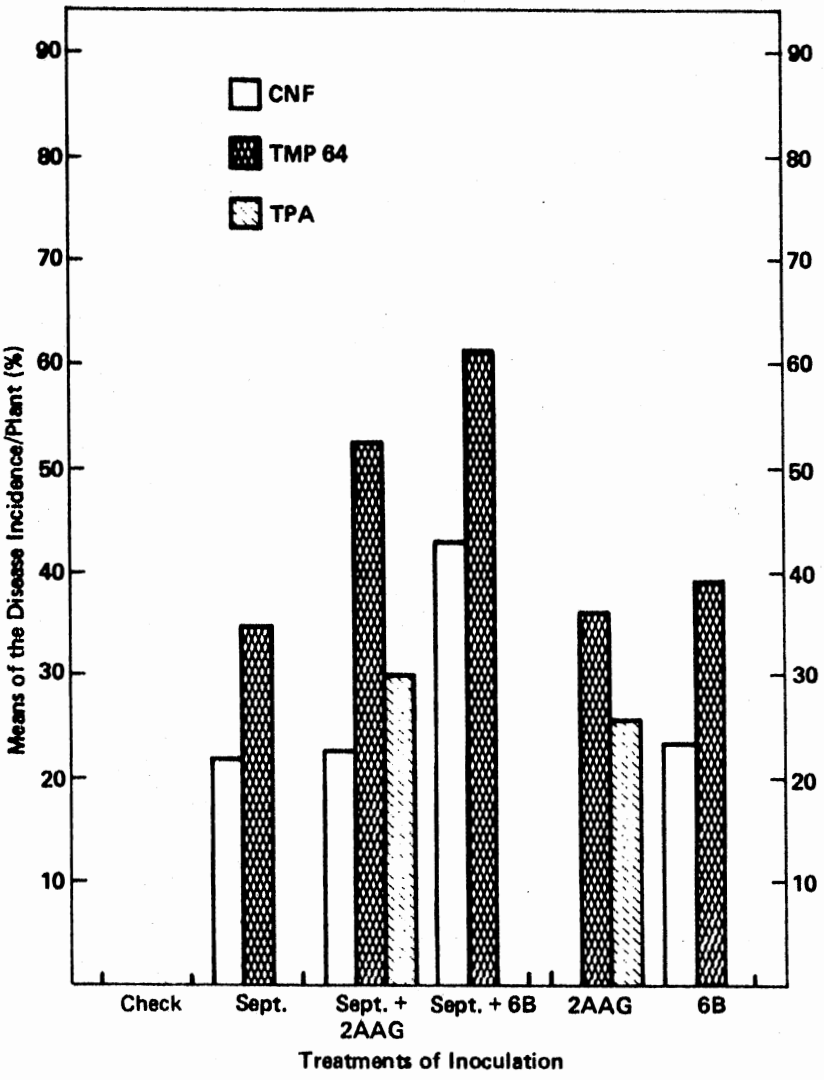


Figure 14. Means of Disease Severity on Mature Plants of Three Wheat Cultivars Following Inoculation with S. tritici (Sept.) and Races 2AAG and 6B of P. recondita and Combinations of These Organisms

which was resistant to one rust race and S. tritici. Each single organism produced a severity of about 18 to 20 percent but the combinations of S. tritici and races of P. recondita were a little less than double that figure at about 34 percent, indicating an additive but not a synergistic effect. The number of tillers per plant was recorded after the plants were scored for disease incidence. There were significant differences only between the three wheat cultivars (Table VII, Figure 15) and this appeared to be a reflection of the inherent tillering capacity of the cultivars rather than any effect of inoculation treatments. The inoculations reduced the number of tillers when compared to the uninoculated check but not significantly, and there were no differences between the inoculated treatments.

The results with the number of heads were similar (Table VIII, Figure 16). CNF produced the greatest number of heads, followed by TPA and TMP64. Among the various treatments, inoculation with S. tritici and races 2AAG and 6B alone were all similar in number of heads and were significantly lower than the uninoculated check. Combinations of S. tritici with both races, however, produced a greater number of heads than the other single inoculations, but were not different from the uninoculated check. If these differences are real, it would appear that the effect of one organism may cancel out the effect of the other.

The number of seed produced by the three cultivars subjected to the different inoculation treatments, are presented in Table IX and Figure 17. There was a significant difference in the number of seed produced among the three cultivars. TPA produced the most seed, even though CMF had a greater number of heads, and TMP64 produced the least. Among the inoculated treatments the plants inoculated singly

TABLE VII

MEANS[1/] OF THE NUMBER OF TILLERS OF THREE WHEAT CULTIVARS AT MATURITY INOCULATED WITH *S. TRITICI* AND TWO RACES OF *P. RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	6.67	6.17	6.17	6.06	6.33	5.89	6.21
TMP64	3.00	2.72	2.78	2.94	2.78	2.67	2.81
TPA	4.00	3.55	3.89	4.11	3.44	3.78	3.79
Treatment mean	4.56	4.15	4.28	4.37	4.18	4.11	

LSD .05 between 2 cultivars = 0.43
Differences between 2 treatments not significant
LSD .05 between 2 treatments within the same cultivar = 0.58
LSD .05 between 2 cultivars within the same treatment = 0.33
Prob. > F of interaction between treatments and cultivars = 0.59
CV = 16.46

1/ Mean of 18 plants in 6 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita* race 6B, AG = *P. recondita* race 2AAG only, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

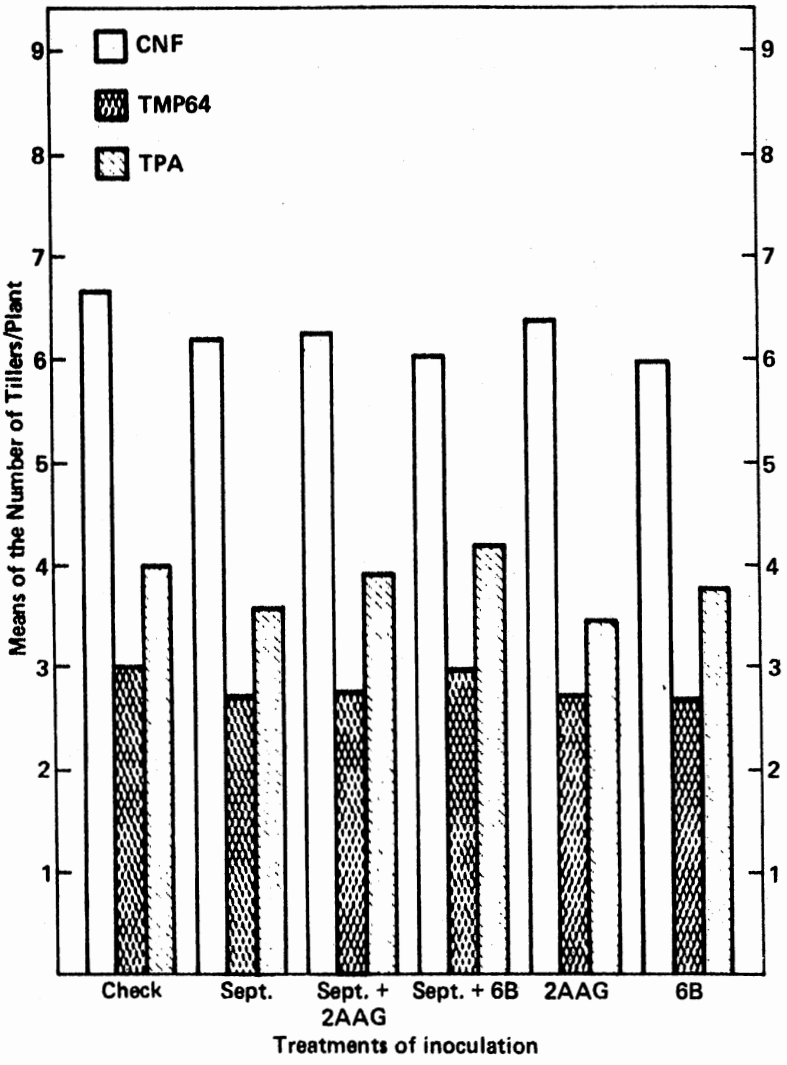


Figure 15. Means of the Number of Tillers at Maturity of Three Wheat Cultivars Following Inoculation with S. tritici (Sept.) and Races 2AAG and 6B of P. recondita and Combinations of These Organisms

TABLE VIII

MEANS[1/] OF THE NUMBER OF HEADS OF THREE WHEAT CULTIVARS AT MATURITY INOCULATED WITH *S. TRITICI* AND TWO RACES OF *P. RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	3.72	3.61	4.05	3.55	3.50	3.50	3.66
TMP64	2.55	2.28	2.67	2.33	2.28	2.28	2.40
TPA	3.61	2.94	3.39	3.66	3.11	3.00	3.29
Treatment mean	3.30	2.94	3.37	3.18	2.96	2.92	

LSD .05 between 2 cultivars = 0.26
LSD .05 between 2 treatments = 0.29
LSD .05 between 2 treatments within the same cultivar = 0.50
LSD .05 between 2 cultivars within the same treatment = 0.29
Prob. > F of interaction between treatments and cultivars = 0.54
CV = 21.92

1/ Mean of 18 plants in 6 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita* race 6B, AG = *P. recondita* race 2AAG only, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

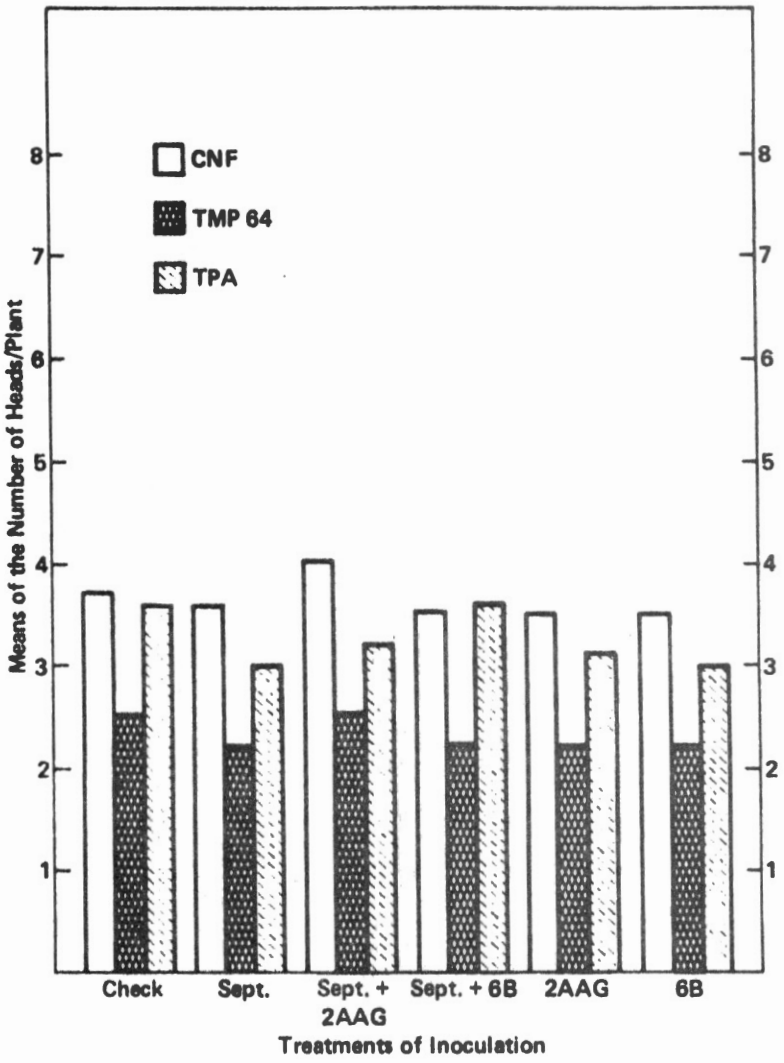


Figure 16. Means of the Number of Heads Produced by Plants of Three Wheat Cultivars Infected with S. tritici (Sept.) and Races 2AAG and 6B of P. recondita and Combinations of These Organisms

TABLE IX

MEANS[1/] OF THE NUMBER OF SEEDS PRODUCED BY THREE WHEAT CULTIVARS INOCULATED WITH *S. TRITICI* AND TWO RACES OF *P. RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	78.61	60.61	70.72	69.28	62.33	70.39	68.66
TMP64	62.11	53.00	61.67	48.72	45.11	47.39	53.00
TPA	91.67	77.89	91.22	87.17	81.61	83.11	85.44
Treatment mean	77.46	63.83	74.54	68.39	63.02	66.96	

LSD .05 between 2 cultivars = 7.86
LSD .05 between 2 treatments = 7.00
LSD .05 between 2 treatments within the same cultivar = 12.13
LSD .05 between 2 cultivars within the same treatment = 7.00
Prob. > F of interaction between treatments and cultivars = 0.74
CV = 22.76

1/ Mean of 18 plants in 6 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita* race 6B, AG = *P. recondita* race 2AAG only, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

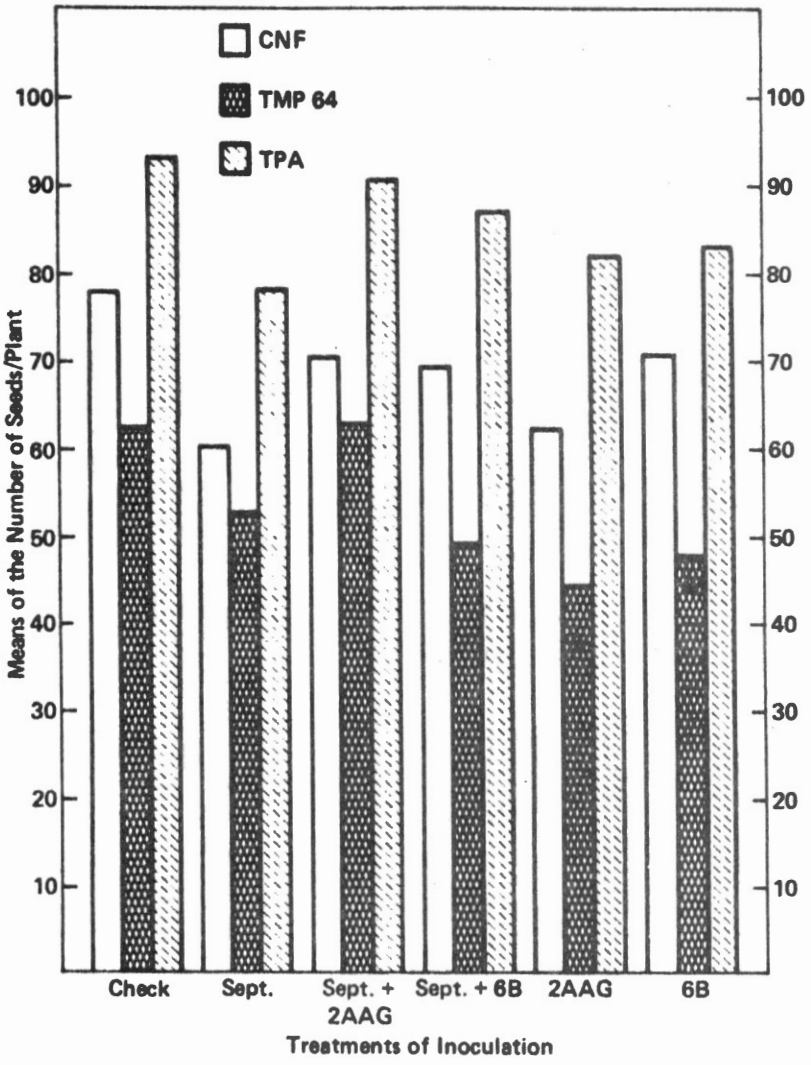


Figure 17. Means of Number of Seeds Produced by Plants of Three Wheat Cultivars Inoculated with S. tritici (Sept.) and Races 2AAG and 6B of P. recondita and Combinations of These organisms

with S. tritici and P. recondita races 2AAG and 6B, and the combination of S. tritici and race 6B produced significantly fewer seed than did the non-inoculated plants. The combination of S. tritici with race 2AAG was not different than the non-inoculated check, which may be a reflection of the reaction of TPA which is resistant to both of these organisms. The cultivar CNF produced fewer seed than the check only when inoculated with S. tritici and race 2AAG of P. recondita alone. This was not expected since CNF is resistant to race 2AAG. Similarly with TPA, only the plants inoculated with S. tritici alone produced fewer seed than the check, and TPA is resistant to Septoria. Even TMP64, which is susceptible to all three organisms, did not differ from the check when inoculated with S. tritici alone or in combination with race 2AAG, which may be evidence of some degree of tolerance in this cultivar.

The seeds per plant were weighed as well as counted, since most grain is sold in the commercial market on the basis of weight, to see if the effect of the pathogens applied to grain weight as well as the number of seed produced (Table X and Figure 18). TPA not only produced the most seed but also the greatest seed weight. TPA had greater seed weight than either CNF or TMP64 in all treatments including the uninoculated check. Although CNF had more heads and more seed than TMP64 the seed weight of that cultivar was no greater than TMP64. Among the treatments only the combination of S. tritici and race 2AAG of P. recondita produced as much seed as the uninoculated check; again, perhaps due to the resistance of TPA to both of these organisms.

From the study on the effect of the pathogens on root volume (Table XI and Figure 19), it was found that CNF had a greater root volume than

TABLE X

MEANS[1/] OF SEED WEIGHT IN GRAMS OF THREE WHEAT CULTIVARS INOCULATED WITH *S. TRITICI* AND TWO RACES OF *P. RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	2.02	1.29	1.60	1.46	1.33	1.43	1.52
TMP64	1.92	1.76	1.94	1.54	1.42	1.56	1.69
TPA	2.62	2.30	2.47	2.28	2.09	2.44	2.37
Treatment mean	2.19	1.78	2.00	1.76	1.61	1.81	

LSD .05 between 2 cultivars = 0.26
LSD .05 between 2 treatments = 0.27
LSD .05 between 2 treatments within the same cultivar = 0.46
LSD .05 between 2 cultivars within the same treatment = 0.27
Prob. > F of interaction between treatments and cultivars = 0.87
CV = 22.37

1/ Mean of 18 plants in 6 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita* race 6B, AG = *P. recondita* race 2AAG only, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

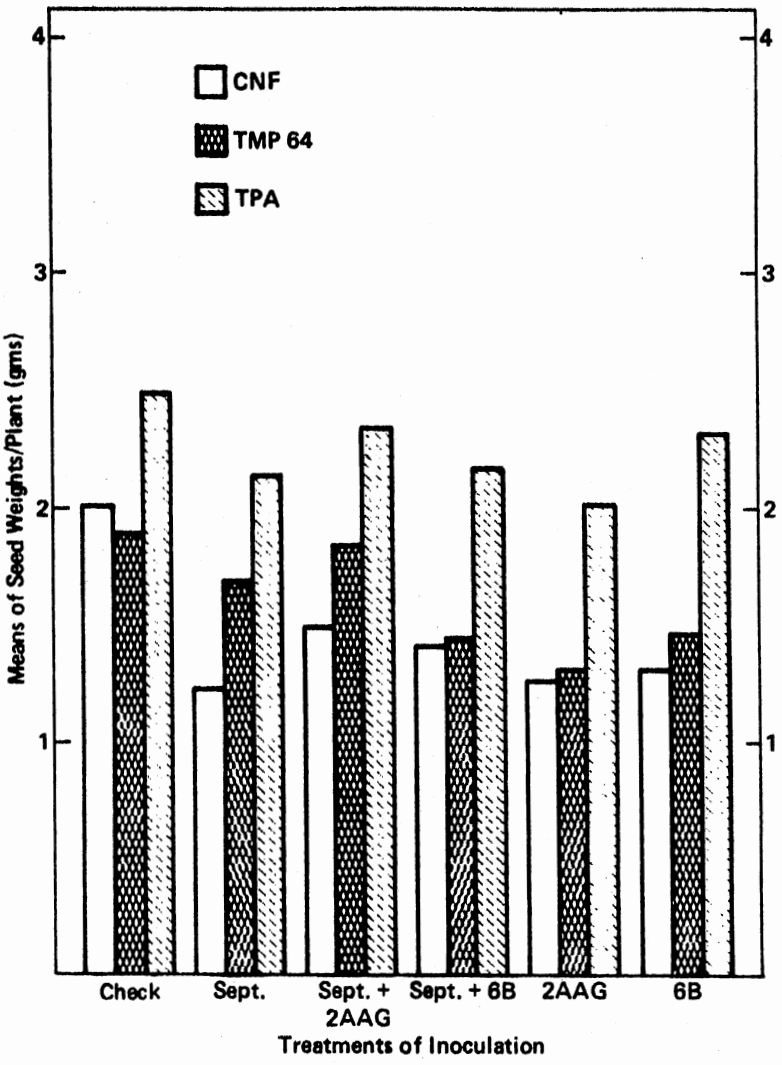


Figure 18. Means of Seed Weights of Three Wheat Cultivars Inoculated with S. tritici and Two Races of P. recondita and Combinations of These Organisms

TABLE XI

MEANS[1/] OF ROOT VOLUME IN ML AT MATURITY OF THREE WHEAT CULTIVARS INOCULATED WITH *S. TRITICI* AND TWO RACES OF *P. RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	4.95	3.04	3.29	2.61	4.23	3.52	3.61
TMP64	3.52	2.18	1.62	1.68	2.11	1.99	2.18
TPA	3.57	2.64	2.19	2.50	1.66	2.69	1.54
Treatment mean	4.02	2.62	2.37	2.26	2.66	2.73	

LSD .05 between 2 cultivars = 0.47
LSD .05 between 2 treatments = 0.32
LSD .05 between 2 treatments within the same cultivar = 0.54
LSD .05 between 2 cultivars within the same treatment = 0.32
Prob. > F of interaction between treatments and cultivars = 0.0001
CV = 23.72

1/ Mean of 18 plants in 6 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita* race 6B, AG = *P. recondita* race 2AAG only, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

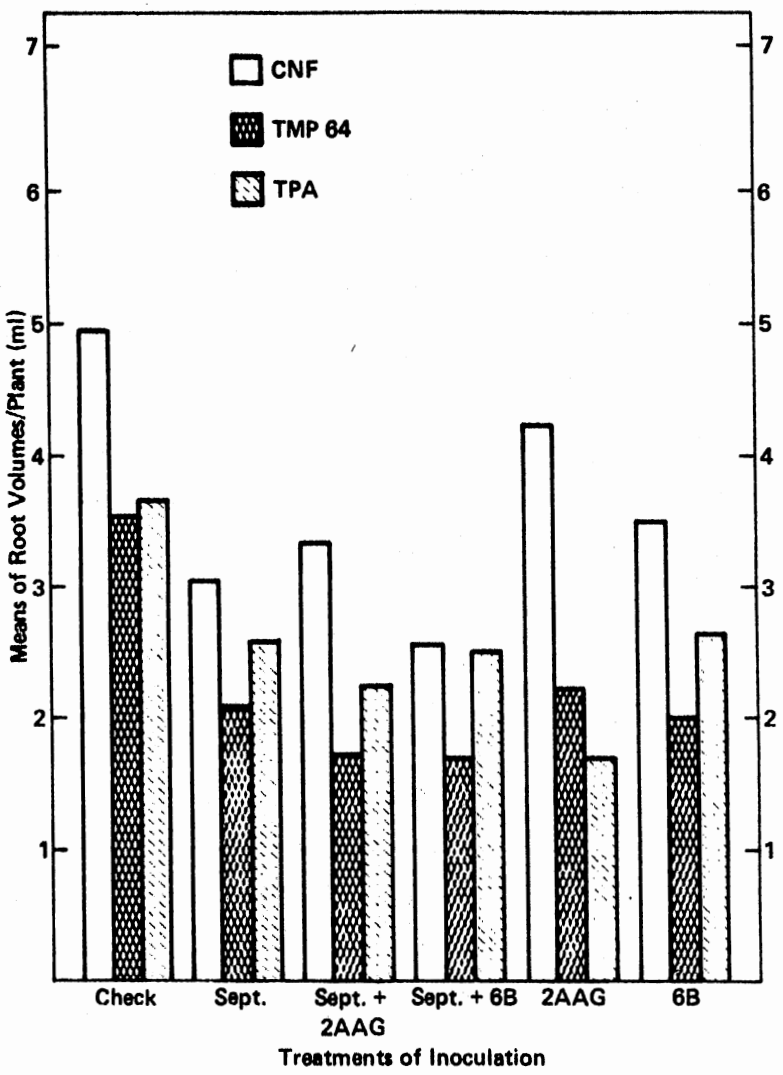


Figure 19. Means of Root Volume of Three Wheat Cultivars at Maturity Inoculated with S. tritici and Two Races of P. recondita and Combinations of These Organisms

TMP64 which, in turn, had a greater root volume than TPA. This is interesting inasmuch as CNF also had the most tillers and the most heads, but produced less yield (seed weight) than TPA. All of the inoculated plants produced less root volume than the uninoculated ones, and there was no difference among the inoculated plants. With the cultivar CNF, inoculation with race 2AAG resulted in less root volume than the check, but all other inoculations resulted in less root volume than with race 2AAG. CNF is resistant to race 2AAG but not to S. tritici. With TMP64, inoculation with combinations of S. tritici with both race 2AAG and 6B resulted in less root volume than of the inoculations with these organisms singly. With the cultivar TPA inoculation with race 2AAG alone and in combination with S. tritici resulted in less root volume than the check or the other treatments which, again was probably due to the susceptibility of TPA to race 2AAG. The effect of the pathogens on root growth of TMP64 is illustrated in Figure 20.

The effect of the pathogens on dry root weight (Table XII, Figure 21), as expected, closely paralleled those of root volumes. There were some differences, however. TMP64 had greater root volume than TPA, but TPA had greater root weight than TMP64. All of the inoculation treatments produced smaller root weights than the uninoclulated control, and the combinations of S. tritici with both race 2AAG and 6B had smaller root weights than the other inocluation treatments.

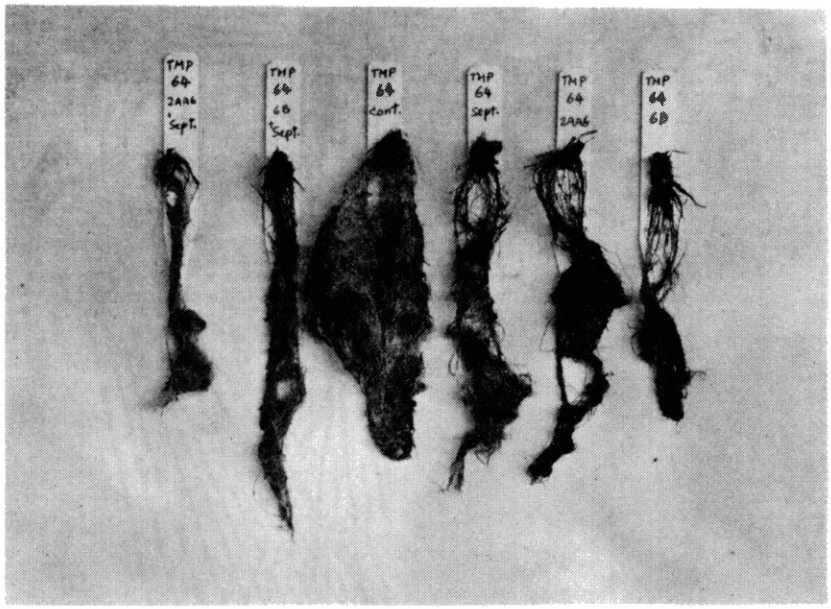


Figure 20. Root Masses of Wheat Cultivar Triumph 64 Affected by Different Inoculation Treatments. Cont. = Uninoculated Control; Sept., 2AAG and 6B are Treatments Inoculated with S. tritici and Races 2AAG and 6B of P. recondita Respectively

TABLE XII

MEANS[1/] OF DRY ROOT WEIGHT IN GRAMS AT MATURITY OF THREE WHEAT CULTIVARS INOCULATED WITH *S. TRITICI* AND TWO RACES OF *P. RECONDITA* AND COMBINATIONS OF THESE ORGANISMS

Wheat[3/] Cultivars	Inoculation Treatments[2/]						Cultivar Mean
	Ck	S	S+AG	S+6B	AG	6B	
CNF	0.98	0.66	0.70	o.53	0.81	0.67	0.72
TMP64	0.54	0.36	0.29	0.34	0.35	0.33	0.37
TPA	0.73	0.58	0.48	0.57	0.40	0.57	0.56
Treatment mean	0.75	0.54	0.49	0.48	0.52	0.53	

LSD .05 between 2 cultivars = 0.07
LSD .05 between 2 treatments = 0.05
LSD .05 between 2 treatments within the same cultivar = 0.09
LSD .05 between 2 cultivars within the same treatment = 0.05
Prob. > F of interaction between treatments and cultivars = 0.0001
CV = 23.34

1/ Mean of 18 plants in 6 replications.
2/ Ck = disease free, S = *S. tritici*, S+AG = *S. tritici* + *P. recondita* race 2AAG, S+6B = *S. tritici* + *P. recondita*, race 6B, AG = *P. recondita* race 2AAG only, 6B = *P. recondita* race 6B only.
3/ CNF = Chinofuz, TMP64 = Triumph 64, TPA = Timpaw.

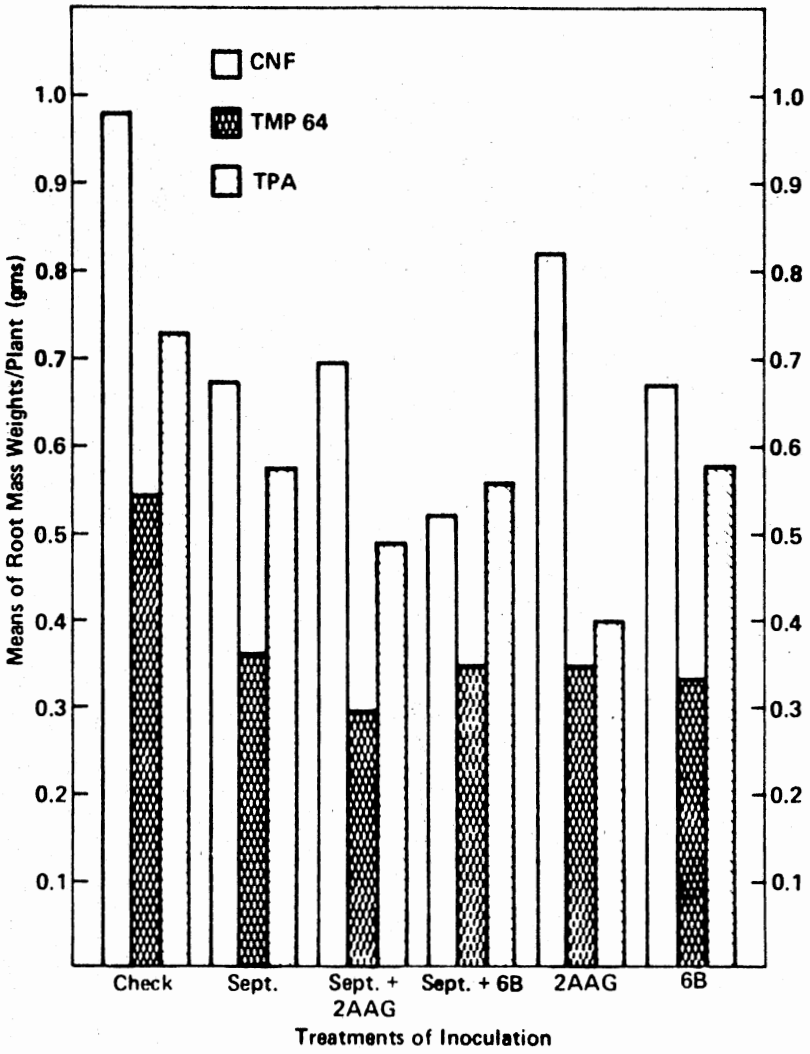


Figure 21. Means of Dry Root Weight in Grams of Three Mature Wheat Cultivars Inoculated with S. tritici and Two Races of P. recondita and Combinations of These Organisms

CHAPTER V

DISCUSSION

Experiments described in this paper were an attempt to measure the response of three wheat cultivars to infection by two pathogenic organisms, S. tritici and P. recondita. The data were collected before and after vernalization to correspond to the growth pattern of wheat in Oklahoma: i.e., rapid seedling growth during the fall; continued but slow prostrate growth through the winter, during which time vernalization occurs and much of the foliage may be grazed off by livestock; rapid and erect growth of tillers through flowering in the spring; and finally grain development and senescence of the plant. Parameters measured prior to vernalization were; dry leaf weight, dry weight of leaf regrowth after clipping, root volume, and root dry weight. Parameters measured after vernalization included; numbers of tillers, heads, and kernels per plant; grain yield in terms of seed weight; root volume; dry root weight and disease severity. Disease severity was not recorded for plants inoculated in the seedling stage because the infection was very uniform and such information would have contributed very little to the type of data being sought.

The effect of leaf rust and Septoria leaf blotch in reducing leaf weight agreed with what has been reported by Johnston and Miller (20), Williams (40) and Gough and Smith (17). However, in this experiment the weights of seedling regrowth leaves, after clipping to simulate

grazing, were not reduced significantly as had been indicated earlier in work by Williams (40).

From the experiment at the mature plant stage, no significant effect of these two diseases was found on the production of tillers but the number of heads per plant was reduced by inoculation with each of the organisms singly. However, when S. tritici was combined with the two races of P. recondita the number of heads was not different from the uninoculated check. If this difference is real, it presents some interesting antagonistic effects. Clear evidence of reductions brought about by these pathogens were shown in grain yield (as measured both by seed weight and seed count) and root growth. All inoculation treatments reduced yield except the combination of S. tritici and race 2AAG of P. recondita. This latter combination may well have been higher due to the resistance of TPA to S. tritici and the resistance of CNF to race 2AAG. This was the only combination used where two of the three cultivars were resistant.

However, some evidence of tolerance also exists in these data, particularly with the cultivar TMP64 which has a susceptible response to all of the pathogens used in the study. All of the inoculated treatments reduced root volume and root weight compared to the uninoculated check. The resistant cultivars responded to the pathogens by developing only fleck infection types characteristic of hypersensitive reactions, but most of the parameters measured were reduced by inoculation of these cultivars. Perhaps it should be expected that some damage to the plant would occur after establishment of the pathogens in the plants since they were only resistant, not immune. Although the disease response of the two cultivars was similar, Timpaw gave higher yields than did CNF when compared to the checks. However, two

other factors must be considered in this case because TPA was resistant to both S. tritici and one race of P. recondita whereas CNF was resistant only to one of the races of P. recondita. Also, CNF has inherently smaller seed than the other cultivars. It had a seed count between TPA and TMP64, but the seed weight of this cultivar was the lowest. Leaf rust and Septoria leaf blotch significantly reduced yields in this experiment even though they did not effect the number of tillers produced. Yield reduction was a result of fewer and smaller-sized kernels in the diseased plants than in the healthy ones. This might be attributed to a reduction in the total quantity of starch transported to the kernels as a result of the disease as reported by Caldwell (5).

A distinct reduction in root development was caused by both S. tritici and P. recondita and in this respect the observations reported here agree very well with reports by other workers (16, 20, 40). The results of these experiments indicated no significant differences in the effects on root development induced by the two races of P. recondita and by S. tritici. These data indicate that either pathogen can cause significant amounts of damage to roots.

Shearer (30) reported that barley leaves infected with P. hordei were more severely infected with S. avenae f. sp. triticea than when the rust was absent. In the present study it could not be concluded that the combination of P. recondita and S. tritici enhanced the severity of infection of either organism. The percent of infection on plants inoculated with the two organisms was almost double that of those inoculated with each organism singly, but the amount of inoculum also was about double in quantity when the organisms were combined. When the diseases were scored separately in plants inoculated with both causal organisms, their relative severities appeared dependent upon

the amount of inoculum used. Under natural field conditions the relative incidence of the diseases would most likely have been different. Chester (9) reported that low leaf rust incidence was associated with late winter temperatures that held the reproduction rate of P. triticina to such low levels that S. tritici was able to destroy leaf rust infected wheat leaves faster than the rust could infect new ones.

The present study indicated that concurrent infection of wheat by the two pathogens used did not interact to enhance the effect of one or the other pathogen. Van Der Wal, et. al. (37) reported that the yield of wheat infected with both P. recondita and S. nodorum was reduced more than would be predicted from the additive effects of both pathogens taken separately. That report does not agree with the results obtained in this study. A number of experiments involving infection of wheat plants with P. recondita and Leptosphaeria nodorum were reported bu Hyde (18). He suggested that there were no interactions between these two organisms in the amount of leaf area infected or mean seed weights which would more fully agree with what was found in this study.

In most cases the effect of rust seemed more severe than the effect of Septoria leaf blotch but many of these differences were not significant. As far as combinations of these pathogens was concerned it would have to be concluded from these experiments that the effects of S. tritici and the two races of P. recondita on most of the parameters measured were additive, and no real evidence of predisposition or enhancement of the effect of one organism on the other was found. However, further investigations of pathogen interactions in relation to environmental factors such as light, temperature, nutrition, and the levels of inoculum would certainly be productive.

CHAPTER VI

SUMMARY

The response of winter wheat (Triticum aestivum) to infections by Septoria tritici and two races of Puccinia recondita f. sp. tritici singly and in combinations, was studies in a greenhouse using three cultivars; Chinofuz, Timpaw, and Triumph 64. Disease reactions of the cultivars to the two organisms were as follows: Triumph 64 was susceptible to S. tritici and to both races of P. recondita; Chinofuz was susceptible to S. tritici and race 6B of P. recondita and resistent to race 2AAG, Timpaw was susceptible to race 2AAG but resistent to race 6B of P. recondita and also resistant to S. tritici. Ten parameters of growth were measured as indices of host reponse. They were: (1) seedling dry leaf weight, (2) regrowth leaf dry weight, (3) seedling root weight, (4) seedling root volume, (5) number of tillers per plant, (6) number of heads per plant, (7) number of seeds per plant, (8) yield per plant, in terms of weight of seeds per plant, (9) root volume of mature plants, and (10) root dry weight of mature plants. The results were as follows:

1. There were no differences between cultivars in dry leaf weight. All inoculation treatements reduced dry leaf weight below the uninoculated checks except that inoculation of the resistent cultivar TPA with S. tritici did not reduce the dry leaf weight below that of the uninoculated check.

2. None of the inoculated treatments affected the dry weight of regrowth leaves.

3. There were no differences between cultivars in the effect of inoculation on root growth as measured by root volume or dry root weight. All inoculation treatments were equal in their effect and all reduced root growth below the uninoculated check. With the cultiver Timpaw, however, only the two treatments inoculated with race 2AAG of P. recondita were reduced significantly below the uninoculated check.

4. Neither leaf rust nor Septoria leaf blotch affected the production of tillers and only the organisms inoculated singly reduced the number of heads. The combinations of S. tritici with either race 2AAG or 6B did not reduce the number of heads, however. Chinofuz produced significantly more tillers and heads than Timpaw, which in turn had more than Triumph 64.

5. Seed numbers were greater with Timpaw followed by Chinofuz and Triumph 64. All of the inoculation treatments except S. tritici combined with race 2AAG reduced the number of seed below the uninoculated check.

6. Timpaw had the greatest yield in terms of seed weight, but Chinofuz and Triumph 64 were not different even though Chinofuz had more seed. As with seed count, all of the inoculation treatments except S. tritici combined with race 2AAG reduced the seed weight below that of the inoculated check.

7. With both root volume and root weight Chinofuz exceeded both Timpaw and Triumph 64. With root volume Triumph 64 exceeded Timpaw, but interestingly, with root weight Timpaw exceeded Triumph 64. All of the inoculation treatments reduced both root volume and root weight

below the level of the unincoluated checks. The combinations of S. tritici with races 6B and 2AAG reduced root weight, and at least with Triumph 64, root volume below that of any of the other treatments.

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APPENDIX

TABLES OF DISEASE SEVERITY INCITED ON THREE WHEAT CULTIVARS BY *SEPTORIA TRITICI* AND BY TWO RACES OF *PUCCINIA RECONDITA* IN EACH OF SIX REPLICATIONS

TABLE XIII

1/

DISEASE SEVERITY ON CULTIVAR CHINOFUZ IN REPLICATION 1

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																					
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	2	1	4	4	0	4	0	4	0	3	2	3	4	2	4	0	0	0	6	4	3
	4	0	0	0	2	4	4	3	0	4	0	4	0	3	2	3	4	2	4	0	0	0	6	4	3
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	4	1	3	4	0	3	0	2	0	4	3	3	3	3	4	0	0	0	4	3	4
	4	0	0	0	2	4	4	3	0	2	0	2	0	4	3	3	3	3	4	0	0	0	4	3	4
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	3	0	0	0	3	2	3	4	0	5	0	1	0	3	2	3	4	2	3	0	0	0	3	4	4
	4	0	0	0	2	2	3	4	0	5	0	1	0	3	2	3	4	2	3	0	0	0	3	4	4
4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	3	0	0	0	3	2	3	2	0	6	0	4	0	4	2	2	3	2	4	0	0	0	5	4	4
	4	0	0	0	3	2	3	3	0	5	0	7	0	4	2	2	3	2	4	0	0	0	5	4	4
5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	4
	3	0	0	0	2	3	3	2	0	4	0	2	0	4	2	2	3	3	5	0	0	0	5	-	4
	4	0	0	0	3	3	3	4	0	6	0	2	0	4	2	2	3	3	6	0	0	0	6	-	4
6	1	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	0	0	0	0	-	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	0	0	0	0	-	4
	3	0	0	0	3	3	3	3	0	4	0	2	0	-	-	2	3	2	4	0	0	0	4	-	5
	4	0	0	0	3	3	3	3	0	4	0	2	0	-	-	2	3	3	6	0	0	0	4	-	5
7	1	0	-	0	0	0	-	0	0	0	0	-	-	-	-	-	-	-	-	0	0	0	0	-	-
	2	0	-	0	0	0	-	0	0	0	0	-	-	-	-	-	-	-	-	0	0	0	0	-	-
	3	0	-	0	3	3	-	4	0	4	0	-	-	-	-	-	-	-	-	0	0	0	4	-	-
	4	0	-	0	6	3	-	2	0	7	0	-	-	-	-	-	-	-	-	0	0	0	5	-	-
8	1	0	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-
	2	0	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-
	3	0	-	-	-	-	-	4	0	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-
	4	0	-	-	-	-	-	4	0	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-
Means		0	0	0	1.5	1.2	1.9	1.7	0	2.3	0	1.4	0	1.8	1.1	1.3	1.8	1.2	2.0	0	0	0	2.3	1.9	2.6
								1.7		2.3		1.4		2.9		3.1		3.2							

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XIV

1/

DISEASE SEVERITY ON CULTIVAR CHINOFUZ IN REPLICATION 2

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																					
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	3	1	4	4	0	2	0	3	0	1	3	1	2	2	2	0	0	0	4	1	3
	3	0	0	0	3	2	3	4	0	4	0	4	0	2	4	3	3	5	4	0	0	0	3	1	4
	4	0	0	0	3	2	3	4	0	4	0	4	0	2	4	3	3	5	4	0	0	0	3	1	4
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	2	2	2	3	0	4	0	3	0	5	2	3	4	2	4	0	0	0	3	4	4
	3	0	0	0	3	2	2	3	0	5	0	4	0	1	4	4	5	2	5	0	0	0	3	2	5
	4	0	0	0	3	2	2	3	0	5	0	4	0	1	4	4	5	2	5	0	0	0	3	2	5
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	2	3	3	2	0	3	0	2	0	2	1	4	2	3	3	0	0	0	1	2	3
	3	0	0	0	2	3	3	4	0	4	0	5	0	1	5	2	4	4	4	0	0	0	2	1	4
	4	0	0	0	2	3	3	4	0	4	0	5	0	1	5	2	4	4	4	0	0	0	2	1	4
4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	2	2	4	4	0	3	0	3	0	2	2	2	3	3	3	0	0	0	5	4	3
	3	0	0	0	2	3	3	4	0	4	0	4	0	1	4	2	4	4	4	0	0	0	3	3	3
	4	0	0	0	2	3	3	4	0	3	0	5	0	1	3	2	5	4	5	0	0	0	3	2	4
5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	4	1	2	4	0	3	0	5	0	2	3	5	4	5	3	0	0	0	2	3	4
	3	0	0	0	4	2	3	5	0	3	0	4	0	2	4	3	4	3	5	0	0	0	2	1	4
	4	0	0	0	4	2	3	5	0	4	0	3	0	2	5	4	4	3	4	0	0	0	2	2	3
6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	4	1	1	4	0	3	0	2	0	3	4	2	4	4	2	0	0	0	1	5	5
	3	0	0	0	5	1	0	5	0	4	0	4	0	1	4	0	5	4	3	0	0	0	2	1	4
	4	0	0	0	0	2	4	5	0	3	0	4	0	1	4	3	5	5	3	0	0	0	2	1	3
7	1	0	0	0	-	0	0	-	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0
	2	0	0	0	-	1	4	-	-	3	0	6	0	1	6	4	5	3	3	-	0	0	6	3	2
	3	0	0	0	-	0	4	-	-	4	0	5	0	2	3	1	4	3	4	-	0	0	0	3	6
	4	0	0	0	-	0	4	-	-	4	0	5	0	2	3	1	2	3	4	-	0	0	0	3	5
8	1	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
	2	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
	3	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
	4	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
								3.0	0	2.6	0	2.9	0	1.3	2.7	2.0	2.8	2.6	2.8						
Means		0	0	0	2.1	1.3	2.1	3.0		2.0		2.9		4.0		4.8		5.4		0	0	0	1.9	1.8	3.2

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with *S. tritici*, S+AG = inoculated with *S. tritici* + *P. recondita* race 2AAG, S+6B = inoculated with *S. tritici* + *P. recondita* race 6B, AG = inoculated with *P. recondita* race 2AAG, 6B = inoculated with *P. recondita* race 6B.

TABLE XV

1/

DISEASE SEVERITY ON CULTIVAR CHINOFUZ IN REPLICATION 3

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																					
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	4	8	4	4	0	4	0	5	0	4	5	5	4	6	2	0	0	0	6	4	6
	4	0	0	0	6	2	4	6	0	6	0	5	0	3	2	4	5	3	4	0	0	0	6	4	5
2	1	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	3	0	0	0	5	6	4	5	0	5	0	4	0	5	4	5	4	1	4	0	0	0	6	5	5
	4	0	0	0	4	4	4	6	0	6	0	5	0	2	1	4	5	2	4	0	0	0	6	6	5
3	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	6	4	3
	2	0	0	0	4	2	4	0	0	0	0	3	0	0	0	6	0	3	4	0	0	0	6	4	2
	3	0	0	0	0	4	3	6	0	1	0	2	0	4	5	2	6	5	4	0	0	0	2	4	2
	4	0	0	0	2	4	0	5	0	0	0	0	0	5	4	0	0	5	3	0	0	0	4	6	2
4	1	0	0	0	0	0	2	4	0	4	0	1	0	0	0	4	5	1	0	0	0	0	5	3	2
	2	0	0	0	2	2	4	3	0	2	0	4	0	0	0	2	6	3	4	0	0	0	5	3	4
	3	0	0	0	2	4	3	3	0	4	0	3	0	4	5	2	6	5	4	0	0	0	2	2	2
	4	0	0	0	2	4	4	4	0	0	0	0	0	2	4	0	0	5	4	0	0	0	2	6	4
6	1	0	0	0	0	0	3	1	0	1	0	4	0	0	0	2	4	2	4	0	0	0	3	4	4
	2	0	0	0	5	4	0	3	0	3	0	2	0	2	7	2	2	0	0	0	0	0	3	4	4
	3	0	0	0	4	7	0	2	0	3	0	2	0	4	2	4	0	3	3	0	0	0	0	2	0
	4	0	0	0	4	0	0	2	0	0	0	0	0	4	2	0	0	0	0	0	0	0	2	4	2
6	1	0	0	0	0	-	3	2	0	0	0	2	0	0	3	3	4	-	-	0	0	0	0	3	-
	2	0	0	0	6	-	7	3	0	3	0	2	0	4	5	4	4	-	-	0	0	0	0	4	-
	3	0	0	0	7	-	7	2	0	2	0	4	0	3	3	5	0	-	-	0	0	0	4	0	-
	4	0	0	0	7	-	2	2	0	0	0	0	0	4	2	0	0	-	-	0	0	0	3	0	-
7	1	0	0	0	-	-	0	4	0	-	-	-	-	0	4	-	-	-	-	-	-	0	4	-	-
	2	0	0	0	-	-	0	2	0	-	-	-	-	5	4	-	-	-	-	-	-	0	4	-	-
	3	0	0	0	-	-	0	0	0	-	-	-	-	3	4	-	-	-	-	-	-	0	0	-	-
	4	0	0	0	-	-	0	0	0	-	-	-	-	4	4	-	-	-	-	-	-	0	0	-	-
								2.5	0	1.8	0	2	0	2.2	2.5	2.4	2.3	2.3	2.4						
Means		0	0	0	2.7	3.5	2.6	2.5		1.8		2		4.7		4.7		4.7		0	0	0	2.8	3	2.6

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with *S. tritici*, S+AG = inoculated with *S. tritici* + *P. recondita* race 2AAG, S+6B = inoculated with *S. tritici* + *P. recondita* race 6B, AG = inoculated with *P. recondita* race 2AAG, 6B = inoculated with *P. recondita* race 6B.

TABLE XVI

1/

DISEASE SEVERITY ON CULTIVAR CHINOFUZ IN REPLICATION 4

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																					
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	3	0	0	1	2	5	2	4	0	0	0	0	0	0
	3	0	0	0	2	3	4	2	0	0	0	5	0	4	3	1	2	3	3	0	0	0	5	3	6
	4	0	0	0	4	4	4	4	0	3	0	6	0	5	4	2	4	6	3	0	0	0	6	7	4
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	4	2	2	5	0	2	0	0	0	0	0	0
	3	0	0	0	3	3	3	0	0	4	0	0	0	2	0	0	1	0	4	0	0	0	5	4	4
	4	0	0	0	6	4	3	4	0	4	0	4	0	2	0	3	4	0	4	0	0	0	6	7	4
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	4	2	2	5	0	2	0	0	0	0	0	0
	3	0	0	0	2	4	6	2	0	0	0	0	0	2	0	0	2	0	2	0	0	0	4	4	5
	4	0	0	0	6	4	4	6	0	0	0	6	0	3	3	2	3	4	2	0	0	0	7	7	5
4	1	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	-	0	4	0	3	0	4	0	4	0	4	3	2	3	0	2	0	0	0	0	0	0
	3	0	0	-	3	3	8	2	0	0	0	4	0	4	3	3	4	0	4	0	0	0	4	3	4
	4	0	0	-	6	5	4	6	0	6	0	4	0	5	4	3	5	3	4	0	0	0	7	6	4
5	1	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	-	5	4	4	3	0	4	0	4	0	2	4	4	5	0	3	0	0	0	0	0	0
	3	0	0	-	3	3	8	3	0	4	0	3	0	5	4	0	2	0	3	0	0	0	0	4	5
	4	0	0	-	4	5	5	5	0	6	0	4	0	5	4	0	1	2	2	0	0	0	6	7	6
6	1	0	0	-	0	-	0	0	0	2	0	4	0	0	0	0	0	0	0	0	-	0	0	0	0
	2	0	0	-	4	-	4	4	0	5	0	4	0	2	4	4	5	0	5	0	-	0	0	0	0
	3	0	0	-	3	-	3	4	0	4	0	4	0	5	4	0	2	2	5	0	-	0	5	5	7
	4	0	0	-	4	-	5	5	0	0	0	4	0	5	4	0	1	2	2	0	-	0	6	7	6
7	1	-	0	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	-	-	0	-	-
	2	-	0	-	-	-	-	-	-	-	-	-	-	4	5	4	4	0	5	0	-	-	0	-	-
	3	-	0	-	-	-	-	-	-	-	-	-	-	5	4	0	2	2	5	0	-	-	4	-	-
	4	-	0	-	-	-	-	-	-	-	-	-	-	4	5	0	0	0	5	0	-	-	4	-	-
8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
Means		0	0	0	2.3	2.5	2.9	2.3	0	2.1	0	2.6	0	2.5	2.1	1.6	2.5	1	2.4	0	0	0	2.5	2.8	2.6
								2.3		2.1		2.6		4.6		4.1		3.4							

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XVII
1/
DISEASE SEVERITY ON CULTIVAR CHINOFUZ IN REPLICATION 5

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																					
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	4	0	3	2	2	1	0	2	0	0	0	3	2	2
	4	0	0	0	4	2	2	1	0	3	0	3	0	3	2	2	1	3	2	0	0	0	3	3	3
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	3	0	3	2	3	3	3	2	0	0	0	0	0	0
	3	0	0	0	4	2	0	2	0	3	0	4	0	4	3	2	1	4	2	0	0	0	3	3	2
	4	0	0	0	4	3	3	2	0	1	0	3	0	2	3	1	1	3	5	0	0	0	3	3	3
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	4	4	4	3	0	4	0	2	0	2	3	2	3	2	4	0	0	0	0	4	0
	3	0	0	0	4	2	4	4	0	4	0	3	0	3	1	3	2	2	3	0	0	0	4	4	3
	4	0	0	0	2	3	3	2	0	2	0	2	0	3	2	3	4	2	4	0	0	0	4	3	3
4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	2	4	4	2	0	3	0	3	0	3	4	3	2	3	2	0	0	0	2	4	2
	3	0	0	0	2	4	4	2	0	4	0	3	0	3	2	2	4	2	3	0	0	0	3	4	3
	4	0	0	0	3	3	4	3	0	2	0	6	0	3	2	1	3	3	4	0	0	0	6	4	4
5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0
	2	0	0	0	4	3	2	2	0	3	0	4	0	4	3	3	4	4	3	0	0	0	4	-	4
	3	0	0	0	3	3	2	2	0	4	0	4	0	3	3	2	2	3	2	0	0	0	3	-	3
	4	0	0	0	2	3	2	4	0	4	0	8	0	2	4	1	3	2	2	0	0	0	4	-	4
6	1	0	0	0	0	0	0	-	-	0	0	0	0	0	0	-	-	0	0	-	-	0	0	-	-
	2	0	0	0	4	4	4	-	-	4	0	4	0	4	4	-	-	3	3	-	-	0	4	-	-
	3	0	0	0	3	4	4	-	-	4	0	5	0	3	3	-	-	2	3	-	-	0	3	-	-
	4	0	0	0	2	4	6	-	-	4	0	3	0	2	4	-	-	4	3	-	-	0	3	-	-
7	1	-	0	0	-	0	0	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	2	-	0	0	-	2	4	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-
	3	-	0	0	-	3	3	-	-	-	-	-	-	-	-	-	-	4	2	-	-	-	-	-	-
	4	-	0	0	-	3	3	-	-	-	-	-	-	-	-	-	-	6	4	-	-	-	-	-	-
Means		0	0	0	2.0	2.0	2.1	1.8 0		2 0		2.7 0		2.1 2		1.6 1.7		2.1 2.1		0	0	0	2.2	2.4	1.8
								1.8		2		2.7		4.1		3.3		4.2							

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XVIII
1/
DISEASE SEVERITY ON CULTIVAR CHINOFUZ IN REPLICATION 6

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	1	0	3	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	4	0	6	0	0	0	0	0	5	4	0	0	0	0	0	0	0	0
	3	0	0	0	3	1	2	6	0	6	0	2	0	4	4	5	4	4	3	0	0	0	3	4	3
	4	0	0	0	3	2	3	6	0	7	0	2	0	5	4	4	5	4	5	0	0	0	6	6	6
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6	0	0	0	0	0	3	4	0
	3	0	0	0	4	1	3	2	0	4	0	3	0	3	4	5	4	3	3	0	0	0	1	4	2
	4	0	0	0	3	2	3	2	0	4	0	3	0	2	6	4	5	5	4	0	0	0	4	4	6
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	3	0	2	0	0	0	0	3	0	0	0	3	2	0	0	0	0	0	2	3	0
	3	0	0	0	3	3	2	3	0	2	0	3	0	5	4	5	4	3	3	0	0	0	2	2	4
	4	0	0	0	3	3	3	3	0	2	0	3	0	4	4	5	4	5	4	0	0	0	4	6	3
4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	4	4	0	0	0	0	0	0
	2	0	0	0	4	3	3	0	0	0	0	0	0	0	0	-	-	4	4	0	0	0	4	3	3
	3	0	0	0	4	2	4	4	0	3	0	3	0	5	4	-	-	4	2	0	0	0	4	2	3
	4	0	0	0	3	2	3	4	0	3	0	3	0	4	3	-	-	6	2	0	0	0	4	7	3
5	1	0	-	0	0	0	-	0	0	-	-	2	0	-	-	-	-	0	0	0	0	0	0	-	0
	2	0	-	0	2	4	-	0	0	-	-	2	0	-	-	-	-	2	5	0	0	0	2	-	4
	3	0	-	0	3	4	-	0	0	-	-	2	0	-	-	-	-	3	3	0	0	0	3	-	4
	4	0	-	0	3	5	-	6	0	-	-	0	0	-	-	-	-	3	4	0	0	0	4	-	3
6	1	0	-	0	0	0	-	-	-	-	-	0	0	-	-	-	-	0	0	0	-	0	-	-	-
	2	0	-	0	4	4	-	-	-	-	-	2	0	-	-	-	-	3	4	0	-	0	-	-	-
	3	0	-	0	6	6	-	-	-	-	-	3	0	-	-	-	-	3	4	0	-	0	-	-	-
	4	0	-	0	8	6	-	-	-	-	-	4	0	-	-	-	-	0	5	0	-	0	-	-	-
7	1	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	0	0	-	-	0	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	4	0	-	-	-	-	4	5	-	-	0	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	4	0	-	-	-	-	0	4	-	-	0	-	-	-
	4	-	-	-	-	-	-	-	-	-	-	3	0	-	-	-	-	0	3	-	-	0	-	-	-
Means		0	0	0	2.5	2.1	1.7	2.3 0		2.6 0		1.8 0		1.9 2.1		3.1 3.5		2.1 2.4		0	0	0	2.3	2.3	2.2
								2.3		2.6		1.8		4.0		6.6		4.5							

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XIX

1/

DISEASE SEVERITY ON CULTIVAR TRIUMPH 64 IN REPLICATION 1

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	1	4	1	0	1	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	6	6	8	4	2	7	2	6	2	3	4	0	0	4	0	0	0	0	0	0	0
	3	0	0	0	8	6	6	5	3	7	2	5	4	0	2	3	2	6	2	2	2	0	6	5	2
	4	0	0	0	8	8	8	5	4	7	2	4	5	3	5	4	5	5	4	6	6	0	6	6	4
	5	0	0	0	0	0	0	0	0	0	0	0	0	3	5	4	5	4	5	0	0	6	8	8	6
2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	4	2	2	0	0	1	2	4	2	4	4	5	3	0	2	0	0	0	0
	3	0	0	0	4	2	6	5	4	0	0	1	4	3	1	4	2	2	0	6	5	6	6	6	0
	4	0	0	0	4	4	8	5	4	5	4	4	5	3	2	4	5	0	0	6	6	6	4	6	4
	5	0	0	0	0	0	0	0	0	5	4	0	0	3	2	4	5	0	0	0	0	6	6	6	6
3	1	0	0	0	0	0	6	0	0	0	0	-	-	0	0	0	0	0	0	6	0	2	0	0	6
	2	0	0	0	0	0	8	0	2	4	0	-	-	5	4	3	6	3	6	8	2	2	0	0	8
	3	0	0	0	4	3	0	6	2	6	2	-	-	3	4	3	6	2	3	0	6	4	5	6	8
	4	0	0	0	3	3	0	4	5	6	2	-	-	4	5	0	6	3	6	0	5	6	6	6	0
	5	0	0	0	0	0	0	0	0	0	2	-	-	4	5	0	0	3	6	0	0	0	6	7	0
4	1	0	-	0	0	0	-	-	-	0	0	-	-	0	0	0	0	0	0	-	-	-	-	0	-
	2	0	-	0	0	0	-	-	-	0	0	-	-	0	0	0	0	0	0	-	-	-	-	6	-
	3	0	-	0	0	6	-	-	-	0	0	-	-	0	0	0	0	0	0	-	-	-	-	6	-
	4	0	-	0	0	0	-	-	-	4	4	-	-	0	0	0	0	0	0	-	-	-	-	0	-
	5	0	-	0	0	8	-	-	-	0	0	-	-	0	0	0	0	0	0	-	-	-	-	0	-
5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
Means		0	0	0	1.9	2.5	3.7	2.4 1.9 4.3		2.6 1.3 3.9		2.4 2.2 4.6		1.9 2.1 4.0		1.8 2.2 4.0		1.4 1.4 2.8		2.3	2.3	2.5	3.5	3.4	4.4

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with *S. tritici*, S+AG = inoculated with *S. tritici* + *P. recondita* race 2AAG, S+6B = inoculated with *S. tritici* + *P. recondita* race 6B, AG = inoculated with *P. recondita* race 2AAG, 6B = inoculated with *P. recondita* race 6B.

TABLE XX

1/

DISEASE SEVERITY ON CULTIVAR TRIUMPH 64
IN REPLICATION 2

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	6	1	3	1	0	3	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0
	2	0	0	0	6	2	4	8	0	8	0	8	0	2	2	1	6	1	0	0	0	0	0	0	0
	3	0	0	0	6	1	3	5	4	5	4	7	2	4	5	5	4	5	4	0	5	4	6	4	4
	4	0	0	0	8	1	3	5	4	5	4	4	3	5	4	4	5	5	4	5	6	4	7	4	6
	5	0	0	0	9	3	3	0	0	0	0	0	0	0	8	0	0	0	0	4	6	5	0	0	0
2	1	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	2	5	3	0	0	0	0	2	0	0	4	0	6	0	0	0	0	0	0	0	0
	3	0	0	0	2	6	4	5	4	1	4	6	3	4	5	4	5	0	4	0	6	5	7	4	6
	4	0	0	0	2	6	4	5	4	4	5	4	3	5	4	4	5	5	4	5	6	4	7	2	6
	5	0	0	0	3	4	4	0	0	0	0	0	0	0	8	0	0	0	0	5	6	5	0	0	0
3	1	0	-	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	-	4	-
	2	0	-	0	4	6	0	0	0	0	0	0	0	0	4	0	6	0	0	0	-	0	-	4	-
	3	0	-	0	4	6	4	0	5	2	3	6	3	0	4	0	6	0	5	0	-	5	-	0	-
	4	0	-	0	5	6	4	5	4	2	3	4	4	0	4	0	6	0	5	4	-	5	-	1	-
	5	0	-	0	6	6	4	0	0	0	0	0	0	0	4	0	0	0	0	4	-	0	-	0	-
4	1	-	-	-	-	-	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	0	-
	2	-	-	-	-	-	0	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	0	-
	3	-	-	-	-	-	2	-	-	-	-	0	3	-	-	-	-	-	-	-	-	-	-	0	-
	4	-	-	-	-	-	2	-	-	-	-	0	4	-	-	-	-	-	-	-	-	-	-	1	-
	5	-	-	-	-	-	2	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	0	-
								2.8	2.1	2.6	1.8	2.9	1.6	1.3	3.5	1.7	4.0	1.3	2.2						
Means		0	0	0	4.2	4.3	2.5	4.9		4.4		4.5		4.8		5.7		3.5		1.7	3.4	2.5	3.2	1.5	2.8

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXI

1/

DISEASE SEVERITY ON CULTIVAR TRIUMPH 64
IN REPLICATION 3

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																									
		CK			S			S+AG						S+6B						AG			6B				
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3		
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B								
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2	0	0	0	8	6	2	0	0	2	0	2	0	4	0	4	0	2	0	0	0	0	0	5	0		
	3	0	0	0	6	6	6	8	0	4	5	5	4	5	4	5	4	5	4	6	4	4	4	4	7		
	4	0	0	0	8	8	8	5	4	5	4	5	4	5	4	5	4	5	4	6	5	6	6	6	0		
	5	0	0	0	6	4	6	8	0	5	4	5	4	0	0	0	0	0	0	8	5	5	8	6	8		
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2	0	0	0	0	0	5	0	0	6	0	0	0	5	0	4	0	6	0	0	0	0	0	0	0		
	3	0	0	0	6	5	5	0	5	4	5	5	4	5	4	5	4	5	4	6	5	6	5	6	0		
	4	0	0	0	6	4	5	5	4	5	4	5	4	5	4	5	4	5	4	6	2	4	0	5	7		
	5	0	0	0	6	4	6	8	0	5	4	5	4	0	0	0	0	0	0	8	8	5	0	5	8		
3	1	0	0	0	0	-	4	6	4	-	-	-	-	-	-	-	-	0	0	-	-	-	0	-	0		
	2	0	0	0	0	-	4	6	0	-	-	-	-	-	-	-	-	6	0	-	-	-	0	-	0		
	3	0	0	0	0	-	3	1	0	-	-	-	-	-	-	-	-	5	4	-	-	-	0	-	7		
	4	0	0	0	6	-	0	0	0	-	-	-	-	-	-	-	-	5	4	-	-	-	0	-	0		
	5	0	0	0	6	-	0	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	0	-	6		
4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0		
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0		
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0		
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0		
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0		
								2.9	1.1	3.1	2.8	3.2	2.4	3.6	2.0	3.5	2.0	3.7	2.0								
	Means	0	0	0	3.9	3.3	3.5	4.0		5.9		5.6		5.6		5.5		5.7		3.6	2.9	3.0	1.7	3.7	2.1		

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXII

1/

DISEASE SEVERITY ON CULTIVAR TRIUMPH 64
IN REPLICATION 4

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																								
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	1	0	4	5	0	0	0	6	4	4	6	2	6	0	0	0	6	1	0	0
	2	0	0	0	2	3	0	3	6	0	2	0	2	5	4	6	3	4	5	2	1	8	1	6	4
	3	0	0	0	2	6	0	4	5	5	4	4	5	4	5	4	5	4	5	4	6	8	6	8	6
	4	0	0	0	6	9	4	4	5	5	4	4	5	4	5	4	5	5	4	6	6	6	8	8	8
	5	0	0	0	8	8	6	4	5	4	5	8	0	5	4	4	5	4	5	7	8	8	8	8	8
2	1	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	2	4	5	0	0	0	1	6	0
	2	0	0	0	0	0	0	0	0	2	1	5	4	6	0	4	5	4	5	1	0	8	1	8	0
	3	0	0	0	6	6	0	4	4	0	4	3	6	5	4	4	5	4	5	8	0	8	6	8	4
	4	0	0	0	6	7	6	5	4	5	4	4	5	5	4	4	5	5	4	6	1	8	8	8	6
	5	0	0	0	8	6	8	4	5	4	5	4	0	5	4	4	5	4	5	8	6	8	6	8	8
3	1	0	0	0	-	-	-	0	0	-	-	0	0	0	0	3	6	-	-	0	6	0	-	-	0
	2	0	0	0	-	-	-	0	0	-	-	0	4	1	2	4	5	-	-	0	8	0	-	-	2
	3	0	0	0	-	-	-	0	4	-	-	0	8	5	4	4	5	-	-	2	8	0	-	-	6
	4	0	0	0	-	-	-	5	4	-	-	4	5	5	4	4	5	-	-	6	8	6	-	-	8
	5	0	0	0	-	-	-	5	4	-	-	8	0	6	0	0	0	-	-	6	8	6	-	-	8
4	1	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								2.8	3.4	2.5	2.9	2.9	3.3	4.4	2.9	3.7	4.2	4.4	4.3						
	Means	0	0	0	4.0	4.7	2.6	6.2		5.4		6.2		7.3		7.9		8.7		3.7	4.4	5.6	4.8	6.8	4.5

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXIII

1/

DISEASE SEVERITY ON CULTIVAR TRIUMPH 64 IN REPLICATION 5

qqq bbb

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																								
		CK			S			S+AG						S+6B						AG			6B		
								1		2		3		1		2		3							
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	1	3	4	0	0	4	5	4	5	5	3	3	1	0	5	2	0
	2	0	0	0	6	0	0	1	3	5	4	0	0	5	4	5	4	4	5	5	0	8	6	3	3
	3	0	0	0	4	6	0	4	5	5	4	0	0	4	3	4	5	4	5	5	6	6	5	8	3
	4	0	0	0	3	6	6	4	5	5	4	1	1	4	0	4	5	4	5	6	7	8	7	3	3
	5	0	0	0	3	6	8	5	4	4	5	2	5	4	0	4	5	4	5	5	7	8	6	7	6
2	1	0	0	0	0	0	0	0	0	0	0	4	0	0	4	0	0	5	2	1	4	6	0	0	0
	2	0	0	0	0	0	0	0	0	2	2	4	5	1	6	4	2	4	5	1	8	6	0	6	1
	3	0	0	0	2	0	0	0	0	4	5	4	5	4	5	4	5	5	4	6	8	8	0	6	5
	4	0	0	0	3	5	0	3	6	4	5	4	5	4	4	4	5	4	5	6	6	8	4	6	6
	5	0	0	0	4	6	4	4	5	4	5	4	5	3	4	5	4	4	5	6	8	8	6	0	6
3	1	-	0	0	-	0	0	-	-	-	-	0	0	0	0	-	-	4	5	0	0	0	6	0	0
	2	-	0	0	-	0	0	-	-	-	-	0	0	1	0	-	-	4	5	0	0	0	6	1	6
	3	-	0	0	-	6	6	-	-	-	-	0	0	4	5	-	-	4	5	0	0	0	6	6	6
	4	-	0	0	-	6	6	-	-	-	-	4	6	4	6	-	-	0	7	0	5	6	6	6	0
	5	-	0	0	-	6	6	-	-	-	-	4	5	4	5	-	-	0	7	0	6	8	6	7	0
4	1	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								2.1	2.9	3.6	3.8	2.1	2.3	3.1	3.3	3.6	4.2	3.7	4.9						
Means		0	0	0	2.5	3.1	2.4	5.0		7.4		4.4		6.4		7.8		8.6		3.1	5.1	5.3	4.7	4.9	4.0

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with *S. tritici*, S+AG = inoculated with *S. tritici* + *P. recondita* race 2AAG, S+6B = inoculated with *S. tritici* + *P. recondita* race 6B, AG = inoculated with *P. recondita* race 2AAG, 6B = inoculated with *P. recondita* race 6B.

TABLE XXIV

1/

DISEASE SEVERITY ON CULTIVAR TRIUMPH 64 IN REPLICATION 6

Tiller No.	Leaf 2/ Position	Inoculation Treatments 3/																					
		Ck			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	3	0	4	0	5	1	5	4	0	2	5	4	0	0	0	4	2	2
	2	0	0	0	2	0	1	5	4	6	3	5	4	5	4	4	4	4	5	1	5	0	8	6	6
	3	0	0	0	6	2	3	6	3	5	4	5	4	5	4	3	6	4	5	1	7	1	6	8	8
	4	0	0	0	6	6	6	5	4	5	4	5	4	5	4	4	5	0	7	6	8	4	7	8	8
	5	0	0	0	6	6	8	4	5	4	5	4	5	5	4	4	5	0	8	5	8	2	7	7	8
2	1	0	0	0	8	6	8	0	0	0	0	0	0	0	0	5	2	5	4	0	0	0	0	0	0
	2	0	0	0	8	6	6	0	1	0	2	0	0	1	0	5	4	4	5	4	4	0	0	1	1
	3	0	0	0	8	8	6	5	3	4	0	4	5	4	0	4	5	4	5	6	8	6	4	4	7
	4	0	0	0	6	6	6	5	4	4	5	5	4	5	4	4	5	4	5	6	7	7	6	4	0
	5	0	0	0	6	6	8	6	3	4	5	4	5	5	4	4	5	4	5	5	0	6	6	6	7
3	1	-	-	0	-	-	-	0	0	0	0	0	0	0	0	0	5	-	-	0	6	0	-	-	-
	2	-	-	0	-	-	-	0	0	6	0	0	0	0	0	4	5	-	-	6	8	0	-	-	-
	3	-	-	0	-	-	-	5	4	4	4	0	0	4	0	4	5	-	-	8	8	6	-	-	-
	4	-	-	0	-	-	-	4	5	5	4	0	0	4	4	4	5	-	-	8	7	7	-	-	-
	5	-	-	0	-	-	-	4	5	5	4	0	0	4	4	4	5	-	-	8	0	6	-	-	-
								3.5	2.7	3.9	2.5	2.4	2.1	3.5	2.4	3.5	4.6	3.4	5.1						
Means		0	0	0	4.4	5.0	3.8	3.2		3.4		4.5		5.9		8.1		8.5		4.3	4.9	3.1	5.3	4.8	5.5

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXV

1/

DISEASE SEVERITY ON CULTIVAR TIMPAW IN REPLICATION 1

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0	4	0	0	0	0	0
	4	0	0	0	0	0	0	0	2	0	2	0	4	0	0	0	0	0	0	3	4	2	0	0	0
	5	0	0	0	0	0	0	0	2	0	2	0	4	0	0	0	0	0	0	3	4	2	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	4	0	2	0	4	0	0	0	0	0	0	3	5	0	0	0	0
	4	0	0	0	0	0	0	0	2	0	2	0	3	0	0	0	0	0	0	2	3	2	0	0	0
	5	0	0	0	0	0	0	0	2	0	3	0	3	0	0	0	0	0	0	2	6	3	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
	2	0	0	0	0	0	0	0	3	0	4	0	3	0	0	0	0	0	0	0	0	8	0	0	0
	3	0	0	0	0	0	0	0	3	0	3	0	3	0	0	0	0	0	0	2	4	6	0	0	0
	4	0	0	0	0	0	0	0	3	0	2	0	2	0	0	0	0	0	0	4	6	5	0	0	0
	5	0	0	0	0	0	0	0	4	0	3	0	3	0	0	0	0	0	0	4	6	5	0	0	0
4	1	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
	2	0	0	0	-	0	0	0	3	0	4	0	3	0	0	0	0	0	0	0	0	3	0	0	0
	3	0	0	0	-	0	0	0	3	0	3	0	0	0	0	0	0	0	0	3	6	3	0	0	0
	4	0	0	0	-	0	0	0	3	0	3	0	0	0	0	0	0	0	0	5	4	3	0	0	0
	5	0	0	0	-	0	0	0	3	0	3	0	0	0	0	0	0	0	0	5	3	2	0	0	0
5	1	-	0	-	-	-	0	0	0	-	-	-	-	0	0	0	0	0	0	-	-	4	0	0	0
	2	-	0	-	-	-	0	0	4	-	-	-	-	0	0	0	0	0	0	-	-	4	0	0	0
	3	-	0	-	-	-	0	0	3	-	-	-	-	0	0	0	0	0	0	-	-	4	0	0	0
	4	-	0	-	-	-	0	0	4	-	-	-	-	0	0	0	0	0	0	-	-	3	0	0	0
	5	-	0	-	-	-	0	0	4	-	-	-	-	0	0	0	0	0	0	-	-	2	0	0	0
Means		0	0	0	0	0	0	0 2.5	2.5	0 2.8	2.8	0 2.1	2.1	0	0	0	0	0	0	2.0	2.8	2.8	0	0	0

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXVI

1/

DISEASE SEVERITY ON CULTIVAR TIMPAW
IN REPLICATION 2

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	2	0	4	0	4	0	0	0	0	0	0	2	3	2	0	0	0
	3	0	0	0	0	0	0	0	3	0	4	0	3	0	0	0	0	0	0	2	3	2	0	0	0
	4	0	0	0	0	0	0	0	3	0	4	0	3	0	0	0	0	0	0	2	3	2	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	4	0	4	0	6	0	0	0	0	0	0	4	3	2	0	0	0
	3	0	0	0	0	0	0	0	4	0	5	0	5	0	0	0	0	0	0	4	3	3	0	0	0
	4	0	0	0	0	0	0	0	4	0	5	0	5	0	0	0	0	0	0	2	4	2	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	3	0	5	0	7	0	0	0	0	0	0	2	3	3	0	0	0
	3	0	0	0	0	0	0	0	3	0	5	0	4	0	0	0	0	0	0	2	3	2	0	0	0
	4	0	0	0	0	0	0	0	3	0	5	0	4	0	0	0	0	0	0	2	2	3	0	0	0
4	1	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	0	-	0
	2	-	0	0	0	0	0	0	3	0	6	0	6	0	0	0	0	0	0	-	-	-	0	-	0
	3	-	0	0	0	0	0	0	3	0	5	0	8	0	0	0	0	0	0	-	-	-	0	-	0
	4	-	0	0	0	0	0	0	3	0	5	0	8	0	0	0	0	0	0	-	-	-	0	-	0
								0	3.0	0	3.6	0	4.0												
means		0	0	0	0	0	0	3.0		3.6		4.0		0	0	0	0	0	0	1.8	2.4	1.8	0	0	0

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXVII

1/

DISEASE SEVERITY ON CULTIVAR TIMPAW IN REPLICATION 3

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		Ck			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	E	0	0	0
	3	0	0	0	0	0	0	0	4	0	2	0	4	0	0	0	0	0	0	3	4	4	0	0	0
	4	0	0	0	0	0	0	0	5	0	E	0	4	0	0	0	0	0	0	4	5	4	0	0	0
	5	0	0	0	0	0	0	0	0	0	5	0	4	0	0	0	0	0	0	0	5	5	0	0	0
2	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	4	0	2	0	5	0	0	0	0	0	0	4	4	4	0	0	0
	3	0	0	0	0	0	0	0	4	0	4	0	3	0	0	0	0	0	0	5	4	3	0	0	0
	4	0	0	0	0	0	0	0	4	0	4	0	3	0	0	0	0	0	0	5	4	2	0	0	0
	5	0	0	0	0	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	3	4	0	0	0
3	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0
	2	0	0	0	0	0	0	0	4	0	2	0	5	0	0	0	0	0	0	4	4	-	0	0	0
	3	0	0	0	0	0	0	0	4	0	4	0	3	0	0	0	0	0	0	5	4	-	0	0	0
	4	0	0	0	0	0	0	0	4	0	4	0	3	0	0	0	0	0	0	E	4	-	0	0	0
	5	0	0	0	0	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	3	-	0	0	0
4	1	0	0	0	0	-	-	-	-	0	0	0	4	0	0	-	-	0	0	-	-	-	-	0	0
	2	0	0	0	0	-	-	-	-	0	4	0	6	0	0	-	-	0	0	-	-	-	-	0	0
	3	0	0	0	0	-	-	-	-	0	4	0	6	0	0	-	-	0	0	-	-	-	-	0	0
	4	0	0	0	0	-	-	-	-	0	4	0	4	0	0	-	-	0	0	-	-	-	-	0	0
	5	0	0	0	0	-	-	-	-	0	2	0	4	0	0	-	-	0	0	-	-	-	-	0	0
								0	3.3	0	2.8	0	3.6												
means		0	0	0	0	0	0	3.3		2.8		3.6		0	0	0	0	0	0	2.7	3.3	3.1	0	0	0

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXVIII

1/

DISEASE SEVERITY ON CULTIVAR TIMPAW
IN REPLICATION 4

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	4	0	6	0	8	0	0	0	0	0	0	4	5	6	0	0	0
	5	0	0	0	0	0	0	0	6	0	8	0	8	0	0	0	0	0	0	8	8	7	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	4	0	6	0	0	0	0	0	0	0	0	0	0	5	0	0	0
	5	0	0	0	0	0	0	0	7	0	8	-	6	0	0	0	0	0	0	8	6	8	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	4	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	6	6	0	0	0
	4	0	0	0	0	0	0	0	6	0	8	0	8	0	0	0	0	0	0	0	6	6	0	0	0
	5	0	0	0	0	0	0	0	8	0	8	0	8	0	0	0	0	0	0	8	6	6	0	0	0
4	1	-	-	0	-	0	-	0	0	0	0	-	-	0	0	0	0	0	0	6	-	-	-	0	-
	2	-	-	0	-	0	-	0	6	0	6	-	-	0	0	0	0	0	0	4	-	-	-	0	-
	3	-	-	0	-	0	-	0	4	0	8	-	-	0	0	0	0	0	0	6	-	-	-	0	-
	4	-	-	0	-	0	-	0	6	0	8	-	-	0	0	0	0	0	0	7	-	-	-	0	-
	5	-	-	0	-	0	-	0	8	0	7	-	-	0	0	0	0	0	0	5	-	-	-	0	-
								0	3.4	0	3.8	0	4.0												
Means		0	0	0	0	0	0	3.4		3.8		4.0		0	0	0	0	0	0	2.9	2.6	3.0	0	0	0

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXIX

1/

DISEASE SEVERITY ON CULTIVAR TIMPAW IN REPLICATION 5

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																							
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0
	4	0	0	0	0	0	0	0	4	0	5	0	5	0	0	0	0	0	0	5	5	6	0	0	0
	5	0	0	0	0	0	0	0	6	0	8	0	6	0	0	0	0	0	0	6	5	4	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
	4	0	0	0	0	0	0	0	4	0	5	0	5	0	0	0	0	0	0	6	6	6	0	0	0
	5	0	0	0	0	0	0	0	4	0	4	0	6	0	0	0	0	0	0	6	6	8	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
	3	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	3	6	0	0	0	0
	4	0	0	0	0	0	0	0	5	0	6	0	6	0	0	0	0	0	0	4	6	0	0	0	0
	5	0	0	0	0	0	0	0	5	0	6	0	6	0	0	0	0	0	0	4	7	6	0	0	0
4	1	0	0	0	-	0	-	0	0	-	-	0	0	0	0	0	0	-	-	0	0	0	0	-	-
	2	0	0	0	-	0	-	0	0	-	-	0	0	0	0	0	0	-	-	0	0	0	0	-	-
	3	0	0	0	-	0	-	0	6	-	-	0	0	0	0	0	0	-	-	2	8	0	0	-	-
	4	0	0	0	-	0	-	0	5	-	-	0	6	0	0	0	0	-	-	4	3	7	0	-	-
	5	0	0	0	-	0	-	0	5	-	-	0	6	0	0	0	0	-	-	4	0	9	0	-	-
Means		0	0	0	0	0	0	0 2.5		0 2.3		0 2.5		0	0	0	0	0	0	2.2	3.1	3.0	0	0	0

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

3/ Ck = uninoculated, S = inoculated with S. tritici, S+AG = inoculated with S. tritici + P. recondita race 2AAG, S+6B = inoculated with S. tritici + P. recondita race 6B, AG = inoculated with P. recondita race 2AAG, 6B = inoculated with P. recondita race 6B.

TABLE XXX

1/

DISEASE SEVERITY ON CULTIVAR TIMPAW
IN REPLICATION 6

Tiller No.	Leaf Position 2/	Inoculation Treatments 3/																								
		CK			S			S+AG						S+6B						AG			6B		
		1	2	3	1	2	3	1		2		3		1		2		3		1	2	3	1	2	3
								S	AG	S	AG	S	AG	S	6B	S	6B	S	6B						
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0
	4	0	0	0	0	0	0	0	4	0	3	0	3	0	0	0	0	0	0	3	5	3	0	0	0
	5	0	0	0	0	0	0	0	3	0	8	0	6	0	0	0	0	0	0	1	3	4	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
	4	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	5	3	0	0	0
	5	0	0	0	0	0	0	0	6	0	8	0	6	0	0	0	0	0	0	0	6	4	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
	3	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	3	6	0	0	0	0
	4	0	0	0	0	0	0	0	5	0	6	0	6	0	0	0	0	0	0	4	6	1	0	0	0
	5	0	0	0	0	0	0	0	5	0	6	0	5	0	0	0	0	0	0	4	7	0	0	0	0
4	1	0	0	0	-	0	-	0	0	-	-	0	0	0	0	0	0	-	-	0	0	0	0	-	-
	2	0	0	0	-	0	-	0	0	-	-	0	0	0	0	0	0	-	-	0	0	0	0	-	-
	3	0	0	0	-	0	-	0	6	-	-	0	0	0	0	0	0	-	-	2	3	0	0	-	-
	4	0	0	0	-	0	-	0	5	-	-	0	3	0	0	0	0	-	-	4	3	7	0	-	-
	5	0	0	0	-	0	-	0	5	-	-	0	6	0	0	0	0	-	-	4	0	9	0	-	-
								0	2.3	0	1.9	0	2.0												
Means		0	0	0	0	0	0	2.3		1.9		2.0		0	0	0	0	0	0	2.7	2.3	2.3	0	0	0

1/ Rating scale percent of disease severity, 0 = no disease, 9 = 90 percent leaf area covered.

2/ Numbered from the flag leaf.

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VITA

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