EFFECT OF CULTIVAR AND TEMPERATURE ON NUMBER AND SIZE OF LEAF RUST PUSTULES ON WHEAT SEEDLINGS

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CHAPTER I

INTRODUCTION

Wheat leaf rust results from the interaction between the genic and cytoplasmic complex of both the host and the rust fungus under the influence of the environment. Environment affects host and pathogen individually, and also the interaction between them (8). Host and pathogen have two different characters relative to the disease designated as "Reaction" and "Pathogenicity", respectively. Host character, reaction, is phenotypically expressed as resistance or susceptibility. Pathogen character, pathogenicity, is expressed as virulence or avirulence. "Infection type" is the measure of these two characters in a given host-pathogen-environment situation (15).

The environment, affecting the rust race, wheat cultivar, and the interaction between them, can cause significant phenotypic variability in infection types. If this variability exceeds the host reaction or the pathogen pathogenicity classes then it is very possible to misclassify either host or pathogen for disease response. The range of environmental conditions causing such variability may be different or may be similar for each rust race - wheat cultivar combination and must be determined for each combination. Temperature and light are the main factors that affect the variability of infection types (21).

In the absence of specific resistance the number of pustules (severity) from a given inoculum level, and the relative size of pustules for individual cultivar-race-environment situations have not been measured. The purpose of this study was to find the affect of two temperature levels on the number and size of pustules produced with several different rust race-wheat cultivar combinations. Cultivars both with and without known genes for specific resistance were used.

CHAPTER II

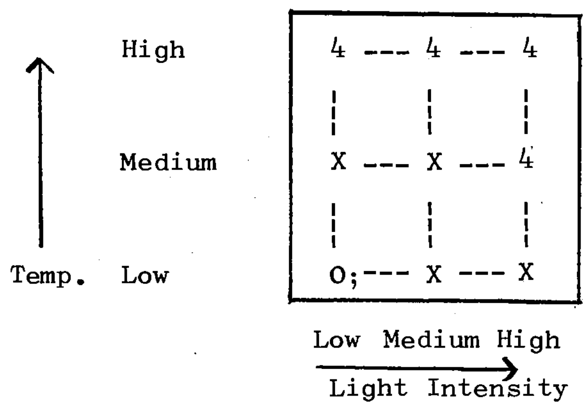
LITERATURE REVIEW

Stakman and Piemeisel (22) in 1917, observed the variability in uredial development of physiologic forms of Puccinia graminis on cereals and grasses. Different size, shape, and color of uredia were noticed on different hosts. The age, vegetative condition of the plant, temperature and light intensity each had affect on the incubation period of various forms. They proposed the first system of nomenclature for stem rust disease infection types.

Mains and Jackson (16) in 1926, reported the discovery of physiologic specialization in the wheat leaf rust pathogen. Inoculation of several wheat cultivars with different isolates of leaf rust resulted in different disease reaction types. They proposed a physiologic race identification key and system of nomenclature for disease reaction types in wheat leaf rust. Reaction types were divided into five classes, and corresponding classes were designated by the symbols from 0 thru 4. The system was later modified somewhat by Johnston and Mains (14) and by Heyne and Johnston (11), but infection type classes in both leaf and stem rust are based upon the size of uredial development in combination with tissue damage associated with the uredial lesion. Recently Browder (5) and Browder and Young (6) have proposed a system for leaf rust whereby lesion size, pustule size, and tissue damage are classified separately.

Loegering (15) in 1962, has also introduced the terms "H" or "High" for all infection types found in compatible host-parasite combinations and "L" or "Low" for all infection types exhibiting some form of host-pathogen incompatibility.

Johnson (12) in 1931, reported that fluctuations in temperature produced significant effects on the development of certain physiologic forms of the wheat stem rust fungus on some host cultivars. He observed that disease infection types on certain differential cultivars at different temperatures and light intensities were modified according to the following chart:



Melander (17) in 1935, found that 20 C temperature was optimum for uredial development of P. graminis, and that lower temperatures extend the time required for the appearance of uredia. High light intensities shortened the time required for uredial appearance whereas low light intensities delayed uredial appearance.

Roberts (19) found an increase in resistance of normally susceptible varieties was associated with low light intensity and low temperatures. Generally, resistant reactions were less sensitive to environmental fluctuations than susceptible reactions.

Johnson and Newton (13) in 1937, observed that higher temperatures inhibited pustule development in some wheat cultivar-leaf rust race combinations. Physiologic races that normally produced a "4" infection type on a given wheat cultivar at optimum temperature, developed "3" to "X" infection types when tested at higher temperatures.

On the other hand, Hassebrauk, reported that low temperatures tended to increase the resistance of different wheat cultivars to Puccinia recondita races, particularly those that were somewhat unstable in their reaction (10).

More recently Williams and Johnston (23) showed that temperature affected infection types produced on certain differential wheat cultivars by some leaf rust races. High temperatures increased the infection types of Carina, Brevit, and Hussar with most races used but had little, if any, effect on the response of Webster or Mediterranean.

Hart and Zaleski (9) suggested that every individual host-parasite complex had its optimum environmental condition. Different rust-host combinations might be influenced by different or similar environmental conditions. The influence of temperature and light was claimed to be on the host-parasite complex rather than on either component.

Asuyama (1) studied wheat leaf rust infection and found that at 23 C, urediospores germinated within one hour, and appressorium formation took place in three to nine hours, after inoculation of wheat seedlings. Stomatal invasion started within four to nine hours, and haustoria developed after 20 hours. At 8 C, the infection process was quite slow with infection hyphae just beginning to develop 24 hours after inoculation.

Zahir and Peterson (25) noted that with the wheat cultivar Little Club, which was very susceptible to races, 1, 5, 15, 53, and 104 B of Puccinia recondita, both pustule maturation time and total spore production were affected by temperature and both light intensity and total darkness. Pustule maturation time was more than double at both temperatures, however, if the light intensity was doubled.

Prabhu and Wallin (18) in 1971, reported that spore production of Puccinia graminis tritici race 15B-2 on the wheat cultivar Baart was greater in the light than in the dark. Temperature also had an affect on spore production in their studies.

CHAPTER III

MATERIALS AND METHODS

In the study presented here, eight wheat cultivars were tested with three leaf rust races under two different temperatures. The wheat cultivars used were:

Morocco: A spring wheat from Australia, uniformly susceptible to races of *P. recondita* f. sp. *tritici* found in the Central Plains of the United States.

Triumph 64: A popular, early, hard red winter wheat cultivar from Oklahoma which has occupied as much as 70% of the Oklahoma wheat acreage. It is susceptible to the races present in Oklahoma at the time of this writing, but does have at least one gene for resistance. It is susceptible to the races used in this study.

Danne: An early, hard red winter wheat cultivar developed in Oklahoma. It has a higher yield potential and may replace much of the Triumph 64 acreage in Oklahoma. It has no known genes for resistance to leaf rust.

Cheyenne: A selection from the original Turkey hard red winter wheat introduced into the Central Plains. It is late and has no known genes for resistance to leaf rust. It is grown on a small acreage in Nebraska and Montana, but is no longer grown in Oklahoma.

RF Line (Rockefeller Foundation breeding line from the cross Kitakami Komoughi/Pumafen, RF 71 D 9641): An unreleased selection of a winter wheat x spring wheat cross from the breeding program of the late Dr. J. Rupert. It does not have any known genes for resistance to leaf rust.

Scout: A very popular mid-season hard red winter cultivar originated in Nebraska, Scout has come to occupy about 50% of the wheat acreage of Nebraska, Kansas, Oklahoma, and Colorado. It has one or more genes for resistance to leaf rust.

Centurk: A Turkey-Type cultivar recently released from Nebraska to celebrate the introduction of Turkey wheat to the Central Plains of the United States in 1874. This cultivar also has one or more genes for resistance to leaf rust.

Kharkov: Like the cultivar Cheyenne, Kharkov is a selection from Turkey. It is no longer grown, but has been used as a permanent check cultivar in regional yield nurseries for over 30 years.

The races of <u>Puccinia</u> <u>recondita</u> f. sp. <u>tritici</u> used were UN 2AAG, UN 6B, and UN 9, which were isolated from field collections made in Oklahoma. Identification of these races was made using differential cultivars and a diagnostic key developed by Basile (2), and amended as follows: 1) "A" = virulence on the cultivar Westar C.I. 12110; 2) "AG" = virulence on the cultivar Agent C.I. 13523 (LR 24); and 3) "B" = virulence on both Westar and Wesel C.I. 13090.

Urediospores used in the study were produced on the cultivar Cheyenne C.I. 8885. Sufficient Cheyenne seed was treated with Arasan (50% Thiram) to plant ten pots each containing 20-25 seeds. Inoculation of seven-day old seedlings was accomplished by placing the pots horizontally on the greenhouse bench and moistening the seedlings by spraying them with a hand atomizer containing tap water and a surfactant, Tween 20 (polyoxyethelene 20 sorbitan monolaurate), at a rate of 3-4 drops per 1000 ml. water. Spores were dusted on the moistened leaves and then the leaves were brushed together. The inoculated leaves were sprayed again and placed in a moist chamber covered with a sheet of glass. Inoculated plants were incubated for 14 - 16 hours at 15 - 20 C and then placed in a growth chamber (Sherer-Gillet Model CEL 25-7) which was set at a temperature of 20 $\pm$ 2 C, with 215 lx. light intensity and a 12 hour photoperiod. Approximately 10-12 days after inoculation the plants were removed from the growth chamber and the urediospores were harvested onto aluminum foil by gently tapping the leaves. These fresh urediospores were used on the same day to inoculate the cultivars to be tested.

Seven Arasan (50% Thiram) treated seeds of each cultivar were planted in each of four 5 cm. x 5 cm. x 7.5 cm. plastic pots filled with a soil mixture composed of four parts clay loam, one part sand, and one part peat moss. Four replications of each of eight cultivars (32 pots) were used for each race at each of two temperatures. Each race was tested separately. The pots were held in the growth chamber for seven days. At that time the plants in each pot were thinned to four seedlings per pot just before inoculation.

Inoculation was accomplished by the "spore-oil suspension" inoculation technique developed by Rowell (20) and also described by Browder (3, 4). Preliminary tests indicated four mg of spores in 14 drops (approximately 0.6 ml.) of oil (Mobilsol 100) gave the best results with the number of plants used in these tests. The spore-oil suspension was placed in a 00 gelatin capsule, shaken vigorously, and attached to an atomizer developed and described by Browder (4).

The suspension was atomized onto the plants with an air pressure of approximately 4.5 kg/6.5 sq. cm. at a distance of 25 to 30 cm. Maximum care was given to obtain a uniform spread of the oil-spore suspension over all the leaves. After each inoculation the plants were placed in moist chambers as described previously. The plants were removed from the moist chamber after 14-16 hours and placed into two separate growth chambers one of which was adjusted to 20 $\pm$ 2 C and the other adjusted to 25 $\pm$ 2 C. The light intensity (215 lx.) and photoperiod (12 hr.) were the same in both chambers. Plants were watered once each day and checked for pustule appearance. On the first day that pustules appeared the plants were removed from the growth chamber, and number of pustules were counted on each individual leaf. Immediately after the pustules were counted the plants were replaced in the growth chambers. Then, 12-14 days after inoculation, the plants were again removed and each individual infection type was scored for size according to a scale from 0 to 4 where the fleck or "0;" reaction of Stakman et al. (21) was scored as 0.5 and 1 to 4 were used similarly to their scale.

CHAPTER IV

RESULTS

Before inoculation, plants were thinned to four plants per pot. Care was used to retain plants of uniform height to minimize the effect of leaf length on the number of pustules that developed. The mean leaf length from coleoptile to tip of 16 leaves used for testing (four plants per pot - four replications) for each cultivar at each temperature is presented in Table I. For all practical purposes, width of all leaves at this stage of growth was quite uniform at 5 mm. and was not recorded. There were some significant differences between cultivars within the same temperature, but differences were small compared to differences in number of pustules that developed. Therefore, number of pustules per leaf, counted on the first day of appearance (20 C - 8 days; 25 C - 6 days), is presented rather than calculating the number of pustules in relation to leaf area. Data for race UN 9 are presented in Table II, and also in diagramatic form in Figure 1. In general, there were fewer pustules produced with race UN 9 on plants kept at low temperature than at high temperature, and with cultivars Triumph 64 and Scout these differences were significant. With the cultivars Cheyenne and Danne there were less pustules at the higher temperature but the differences were not significant. Morocco had the highest number of pustules at both temperatures whereas Centurk had the least. Centurk was resistant to this race and while all other cultivars were susceptible it is

TABLE I

MEAN LEAF LENGTH FROM COLEOPTILE TO TIP OF SEVEN DAY OLD SEEDLINGS OF EIGHT WHEAT CULTIVARS JUST PRIOR TO INOCULATION

	Leaf Length in cms[1]					
	Race UN 9		Race UN 6B		Race UN 2AAG	
	Temp.[2]		Temp.		Temp.	
Cultivars	20 C	25 C	20 C	25 C	20 C	25 C
Morocco	10.43	11.37	9.62	9.56	10.00	10.31
Triumph 64	8.56	8.75	9.18	9.37	10.06	10.68
Scout	9.87	11.87	10.00	10.25	10.06	9.75
Cheyenne	9.56	8.43	9.00	10.00	10.56	10.00
RF Line[3]	8.37	7.87	8.75	8.75	9.87	9.12
Danne	8.68	9.37	9.37	9.00	9.18	9.37
Centurk	9.68	10.81	10.56	10.00	8.87	9.62
Kharkov	9.75	10.12	9.62	10.18	10.50	10.00
Mean	9.36	10.07	9.51	9.64	9.89	9.85
LSD (0.05)-Cultivar means (in same temp.)	1.20		1.07		1.05	
LSD (0.05)-Temp. means (for same cultivar)	1.38		1.16		1.32	
LSD (0.05)-Temp. means	0.81		0.58		0.89	

[1]Means of four replications of four plants each.

[2]Temperature at which the seedlings were held after inoculation.

[3]Abbreviation for a Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen.

TABLE II

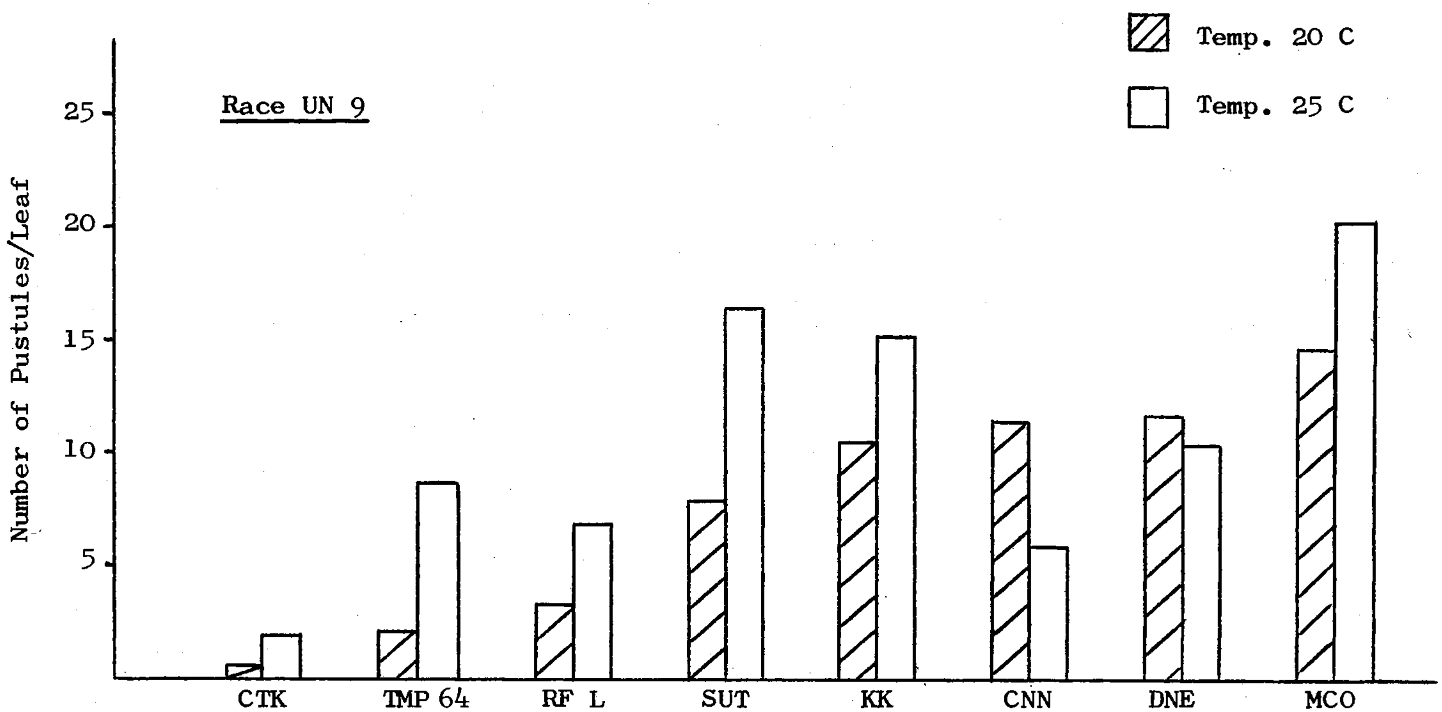
NUMBER OF PUSTULES PER PRIMARY LEAF OF EIGHT WHEAT CULTIVARS GROWN AT TWO TEMPERATURES COUNTED ON THE FIRST DAY OF APPEARANCE AFTER INOCULATION WITH RACE UN 9

	Number of Pustules[1]		
	Temperatures		
Cultivar	20 C (8 days)	25 C (6 days)	Mean
Morocco	14.75	20.43	17.59
Triumph 64	2.25	8.87	5.56
Scout	8.06	16.56	12.31
Cheyenne	11.62	5.87	8.75
RF Line[2]	3.31	6.93	5.12
Danne	11.68	10.56	11.12
Centurk	0.31	2.06	1.19
Kharkov	10.62	15.37	12.99
Mean	7.82	10.83	

LSD(0.05)-Cultivar means within the same temperature	5.03
LSD(0.05)-Temperature means for the same cultivar	6.13
LSD(0.05)-Temperature means	3.97
LSD(0.05)-Cultivar means	3.55

[1]Means of four leaves for each of four replications.

[2]Abbreviation for a Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen.



Abbreviations as follows:

MCO - Morocco
TMP 64 - Triumph 64
SUT - Scout
CNN - Cheyenne
RF L - A Rockefeller Foundation breedling line selection of the cross Kitakami Komoughi/Pumafen
DNE - Danne
CTK - Centurk
KK - Kharkov

Figure 1. The Effect of Temperature and Cultivar on the Number of Pustules Per Leaf With Race UN 9

interesting to note that there were significantly fewer pustules on Triumph 64 and the RF Line than there were on any of the others except Centurk. Conversely, there were more pustules on Morocco than on any other cultivar regardless of temperature.

After 12 days, each pustule on each leaf was graded according to size and placed in one of six classes as follows; 0, 0.5, 1, 2, 3, and 4. These classes correspond to the pustule types of Stakman et al. (21); 0, 0;, 1, 2, 3, and 4. The number of pustules in each class was multiplied by the corresponding class value and divided by the total number of pustules on each leaf to give a pustule size index for each leaf.

These pustule size indices for cultivars inoculated with race UN 9 and tested at two temperature levels are presented in Table III and diagramatically in Figure 2. As mentioned previously, all cultivars except Centurk were susceptible to this race, with pustule size indices of 3 or higher. Even so, there were significant differences in pustule sizes observed between temperatures and between cultivars within the same temperature. Although practically all of the cultivars tended to have larger pustules at the higher temperature, these differences were significant only with Scout and the RF Line. These two cultivars also had significantly smaller pustules than any of the other susceptible cultivars at 20 C, but at 25 C Triumph 64 had the smallest pustules.

Although the same amount of fresh spores were used to inoculate with all races, considerably fewer pustules developed with race UN 6B (Table IV and Figure 3). Again, there were more pustules produced at 25 C than at 20 C but none of the differences was significant. Also, there were no significant differences among cultivars except that the

TABLE III

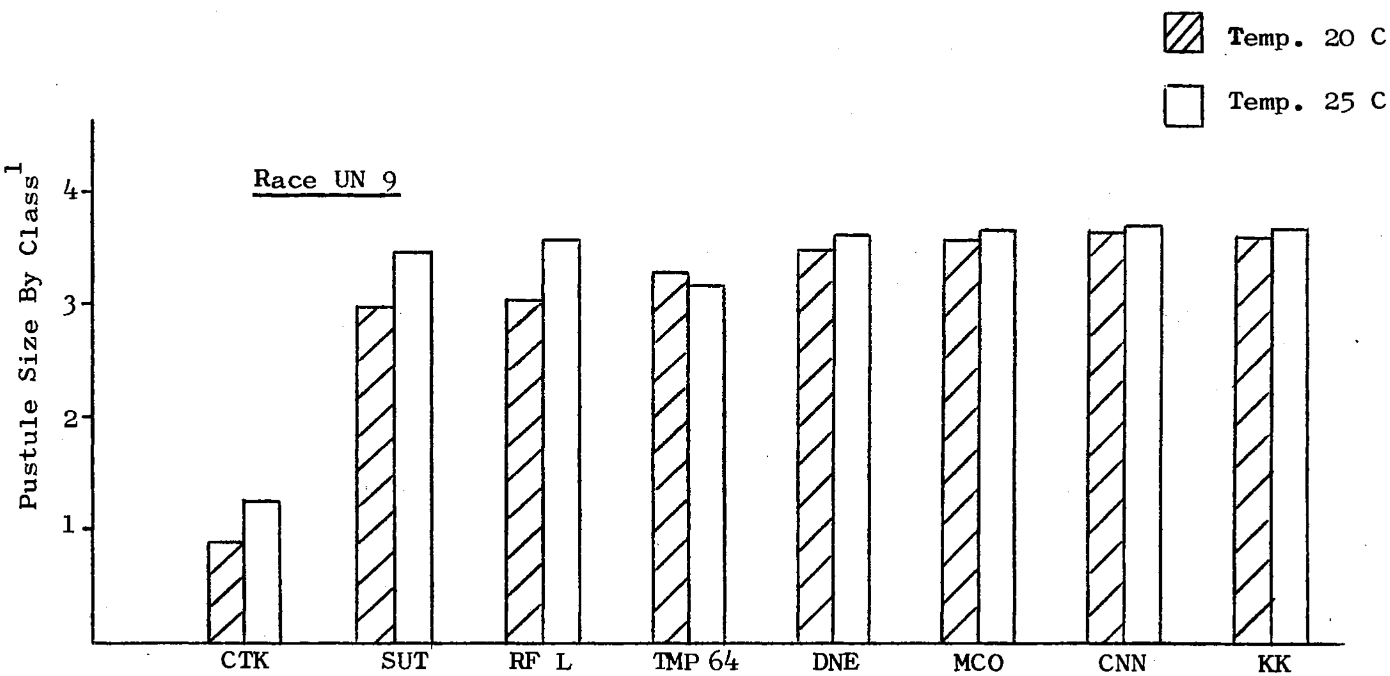
THE EFFECT OF TEMPERATURE AND CULTIVAR ON THE PUSTULE SIZE ON SEEDLINGS INOCULATED WITH RACE UN 9

	Pustule Size[1]		
	Temperatures		
Cultivar	20 C	25 C	Mean
Morocco	3.601	3.729	3.665
Triumph 64	3.299	3.174	3.436
Scout	3.002	3.498	3.250
Cheyenne	3.647	3.769	3.708
RF Line[2]	3.043	3.579	3.311
Danne	3.517	3.648	3.583
Centurk	0.922	1.285	1.104
Kharkov	3.696	3.704	3.700
Mean	3.091	3.298	

LSD(0.05)-Cultivar means within the same temperature	0.435
LSD(0.05)-Temperature means for the same cultivar	0.426
LSD(0.05)-Temperature means	0.128
LSD(0.05)-Cultivar means	0.307

[1]Means of all pustules on four leaves of each of four replications measured on a scale from 0 to 4 where 0 = no fruiting lesion and 4 = large uredium.

[2]Abbreviation for a Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen.



Abbreviations as follows:

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SUT - Scout
CNN - Cheyenne
RF L - A Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen
DNE - Danne
CTK - Centurk
KK - Kharkov

[1]Scale from 0 to 4 where 0 = no fruiting lesion and 4 = large uredium.

Figure 2. The Effect of Temperature and Cultivar on Pustule Size With Race UN 9

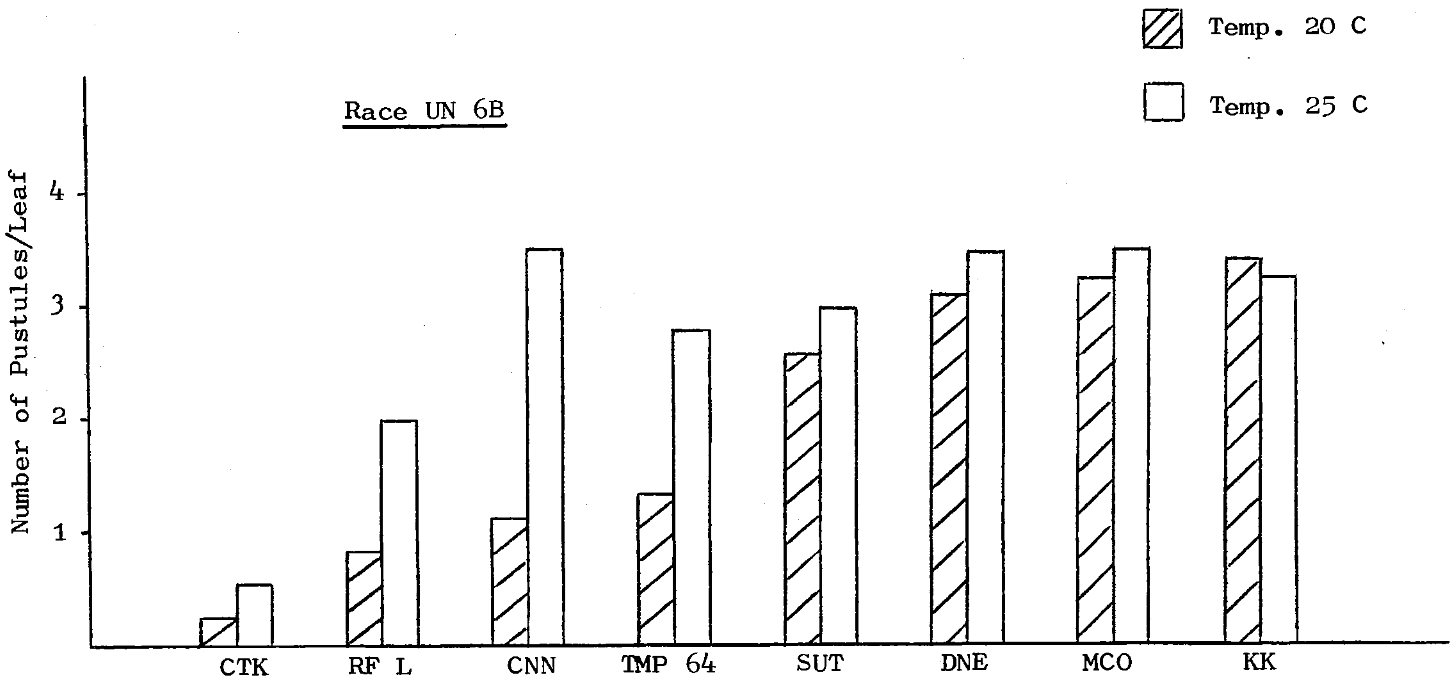
TABLE IV

NUMBER OF PUSTULES PER PRIMARY LEAF OF EIGHT WHEAT CULTIVARS GROWN AT TWO TEMPERATURES COUNTED ON THE FIRST DAY OF APPEARANCE AFTER INOCULATION WITH RACE UN 6B

	Number of Pustules[1]		
	Temperatures		
Cultivar	20 C (7 days)	25 C (7 days)	Mean
Morocco	3.25	3.56	3.41
Triumph 64	1.37	2.81	2.09
Scout	2.56	3.00	2.78
Cheyenne	1.12	3.56	2.34
RF Line[2]	0.87	2.00	1.44
Danne	3.12	3.50	3.31
Centurk	0.25	0.56	0.41
Kharkov	3.43	3.25	3.34
Mean	1.99	2.78	

[1]Means of all pustules on four leaves of each of four replications measured on a scale from 0 to 4 where 0 = no fruiting lesion and 4 = large uredium.

[2]Abbreviation for a Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen.



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CNN - Cheyenne
RF L - A Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen
DNE - Danne
CTK - Centurk
KK - Kharkov

Figure 3. The Effect of Temperature and Cultivar on the Number of Pustules Per Leaf With Race UN 6B

resistant Centurk had significantly fewer pustules than Morocco, Danne, and Kharkov.

Pustule size indices for wheat cultivar seedlings inoculated with race UN 6B is shown in Table V and illustrated in Figure 4. All varieties were susceptible to this race at both temperatures except Centurk and Scout. Centurk was highly resistant at both temperatures while Scout was resistant only at the higher temperature. The gene for resistance to this race in Scout is apparently temperature sensitive in the range between 20 C and 25 C. The cultivar Cheyenne was susceptible at both temperatures, but pustule size was significantly smaller at 20 C than at 25 C. The pustule size of the remaining cultivars Morocco, Triumph 64, RF Line, Danne, and Kharkov was not affected by temperature.

The number of pustules produced on plants inoculated with race UN 2AAG is presented in Table VI and diagramatically in Figure 5. Significantly fewer pustules developed with this race at the low temperature than at the high temperature, except on the resistant cultivar Centurk. Triumph 64 and the RF Line, although susceptible to this race with relatively large pustules, had about the same number of pustules as Centurk. Pustule production differences on Scout and Cheyenne between the two temperatures was significant, and nearly so with the cultivars Morocco and Kharkov.

The effect of temperature and cultivar on pustule size with race UN 2AAG is presented in Table VII and Figure 6. All cultivars, except Centurk, were susceptible to this race also. Pustule size was significantly affected by temperature on the cultivars Triumph 64 and Centurk and the mean of all cultivars was significantly smaller at the low temperature.

TABLE V

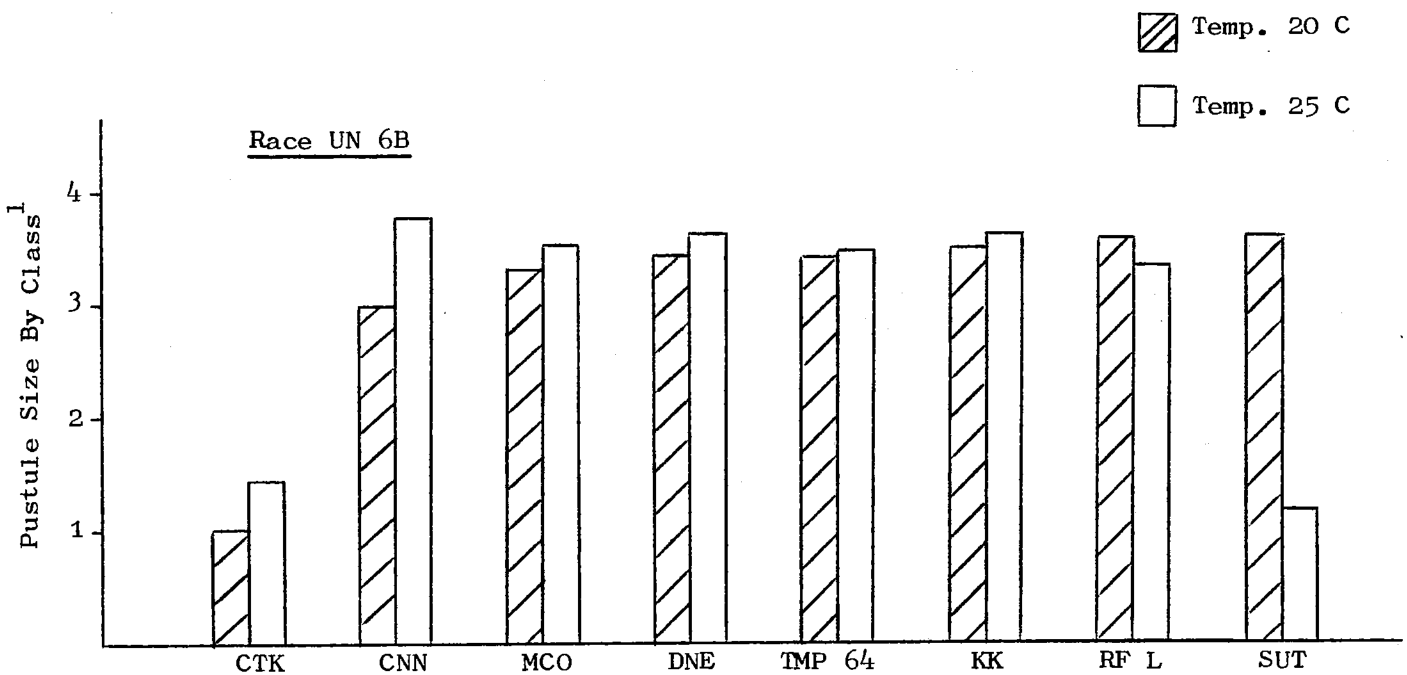
THE EFFECT OF TEMPERATURE AND CULTIVAR ON THE PUSTULE SIZE ON SEEDLINGS INOCULATED WITH RACE UN 6B

Cultivar	Pustule Size[1] Temperatures 20 C	25 C	Mean
Morocco	3.352	3.548	3.450
Triumph 64	3.425	3.536	3.481
Scout	3.623	1.138	2.381
Cheyenne	3.026	3.793	3.410
RF Line[2]	3.601	3.346	3.474
Danne	3.415	3.587	3.501
Centurk	1.000	1.472	1.236
Kharkov	3.553	3.615	3.584
Mean	3.124	3.004	

LSD(0.05)-Cultivar means within the same temperature	0.310
LSD(0.05)-Temperature means for the same cultivar	0.336
LSD(0.05)-Temperature means	0.170
LSD(0.05)-Cultivar means	0.219

[1]Means of all pustules on four leaves of each of four replications measured on a scale from 0 to 4 where 0 = no fruiting lesion and 4 = large uredium.

[2]Abbreviation for a Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen.



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DNE - Danne
CTK - Centurk
KK - Kharkov

[1]Scale from 0 to 4 where 0 = no fruiting lesion and 4 = large uredium.

Figure 4. The Effect of Temperature and Cultivar on Pustule Size With Race UN 6B

TABLE VI

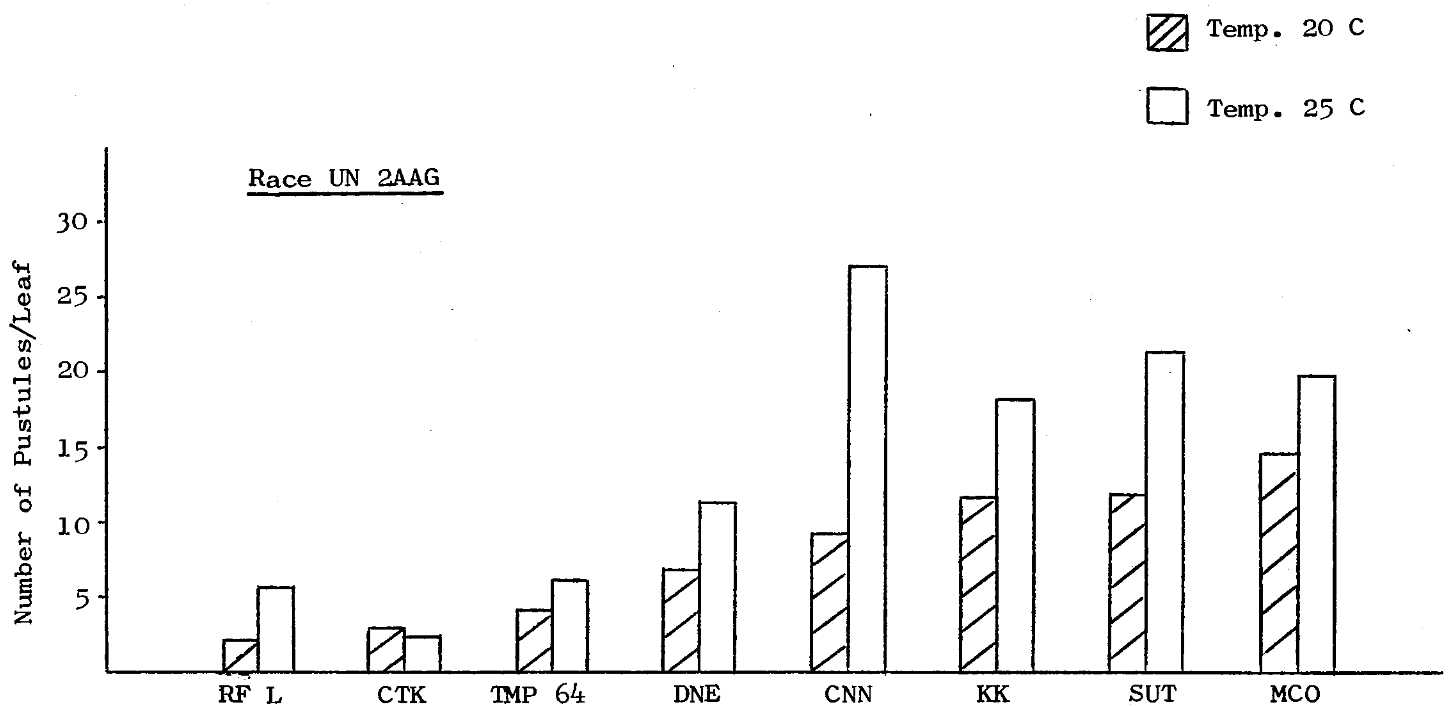
NUMBER OF PUSTULES PER PRIMARY LEAF OF EIGHT WHEAT CULTIVARS GROWN AT TWO TEMPERATURES COUNTED ON THE FIRST DAY OF APPEARANCE AFTER INOCULATION WITH RACE 2AAG

Cultivar	Number of Pustules[1] Temperatures 20 C (8 days)	25 C (6 days)	Mean
Morocco	14.62	20.06	17.34
Triumph 64	4.12	6.12	5.12
Scout	12.00	21.43	16.71
Cheyenne	9.31	27.31	18.31
RF Line	2.25	5.75	4.00
Danne	6.93	11.12	9.03
Centurk	3.00	2.50	2.75
Kharkov	11.68	18.12	14.90
Mean	7.99	14.05	

LSD(0.05)-Cultivar means within the same temperature	8.19
LSD(0.05)-Temperature means for the same cultivar	8.41
LSD(0.05)-Temperature averages	3.49
LSD(0.05)-Cultivar means	5.79

[1]Means of four leaves for each of four replications.

[2]Abbreviation for a Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen.



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DNE - Danne
CTK - Centurk
KK - Kharkov

Figure 5. The Effect of Temperature and Cultivar on the Number of Pustules Per Leaf With Race UN 2AAG

TABLE VII

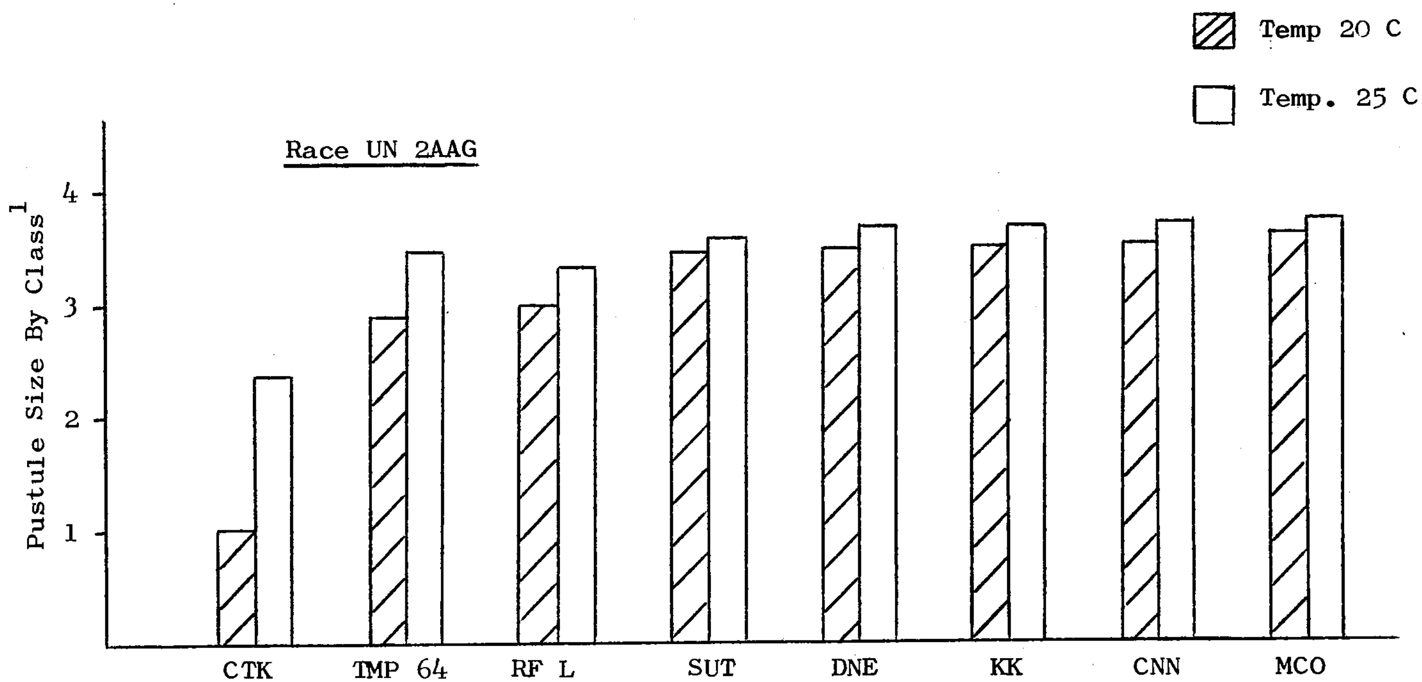
THE EFFECT OF TEMPERATURE AND CULTIVAR ON THE PUSTULE SIZE ON SEEDLINGS INOCULATED WITH RACE UN 2AAG

Cultivar	Pustule Size[1] Temperatures 20 C	25 C	Mean
Morocco	3.623	3.745	3.684
Triumph 64	2.929	3.507	3.218
Scout	3.492	3.593	3.543
Cheyenne	3.576	3.725	3.651
RF Line[2]	3.036	3.377	3.207
Danne	3.526	3.669	3.598
Centurk	1.095	2.410	1.753
Kharkov	3.557	3.685	3.621
Mean	3.104	3.460	

LSD(0.05)-Cultivar means within the same temperature	0.420
LSD(0.05)-Temperature means for the same cultivar	0.476
LSD(0.05)-Temperature means	0.272
LSD(0.05)-Cultivar means	0.296

[1]Means of all pustules on four leaves of each of four replications measured on a scale from 0 to 4 where 0 = no fruiting lesion and 4 = large uredium.

[2]Abbreviation for a Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen.



Abbreviations as follows:

MCO - Morocco
TMP 64 - Triumph 64
SUT - Scout
CNN - Cheyenne
RF L - A Rockefeller Foundation breeding line selection of the cross Kitakami Komoughi/Pumafen
DNE - Danne
CTK - Centurk
KK - Kharkov

[1]Scale from 0 to 4 where 0 = no fruiting lesion and 4 = large uredium.

Figure 6. The Effect of Temperature and Cultivar on Pustule Size With Race UN 2AAG

CHAPTER V

DISCUSSION

Pustules were counted on the first day of appearance. Since "slow-rusting" has been indicated to be a form of resistance to rust (7), a smaller number of pustules early in the development period might be indicative of the "slow-rusting" characteristic. It was found that all of the cultivars tested in this study were influenced by temperature in the number of pustules produced at this early stage. In general, there were fewer pustules on plants held at 20 C than at 25 C. There was one notable exception, however. The cultivar Cheyenne had significantly fewer pustules at 25 C than at 20 C when race UN 9 was used.

Races UN 9 and UN 2AAG produced approximately the same numbers of pustules overall, but with race UN 6B there were considerably fewer pustules produced on the same cultivars regardless of temperature. Although some unrecognized factor may be involved, it is also possible that race UN 6B has more restrictive environmental requirements.

The cultivar, however, seemed to be more important than either race or temperature in determining how many pustules developed. In general, the resistant cultivar Centurk had fewer pustules than the others, but with race UN 2AAG the susceptible cultivars Triumph 64 and the RF Line had almost the same number of pustules as Centurk. Among the susceptible varieties, Triumph 64 and the RF Line consistently had the least number of pustules while Morocco had the most. It is interesting that over a period of years Triumph 64 has consistently had lower leaf rust severity readings in field plots in Oklahoma than the cultivar Danne (24). In these tests also, Triumph 64 consistently had fewer pustules than Danne although the pustule size was nearly equal on both cultivars.

Pustule size was evaluated at 10-12 days after inoculation when pustules on the primary leaf reached maximum size. At this age pustule size is undoubtedly related to the number of spores produced and, therefore, also related to the food drain on the host and to inoculum potential for further disease development. Again, plants held at the higher temperature tended to produce the largest pustules. These differences were significant for Scout and RF Line inoculated with race UN 9, and Triumph 64 and Centurk inoculated with UN 2AAG. On the other hand Scout produced large pustules (3.6) when inoculated with race UN 6B and held at 20 C, but very small pustules (1.1) at 25 C.

All three races tended to produce the same type or size of pustules on each cultivar, but there were significant interactions with specific cultivars at one temperature or the other. With race UN 9 at 20 C, for example, Scout and the RF Line had significantly smaller pustules than Morocco or Kharkov although the mean infection types produced on all four varieties were type 3 or higher.

It would appear that both the number of pustules produced (severity of infection) and the size of pustules, even in the absence of other evidence of incompatability such as tissue damage, are influenced not only by temperature but also by specific host-parasite combinations.

CHAPTER VI

SUMMARY

1. Eight wheat cultivars (Morocco, Triumph 64, Scout, Cheyenne, RF Line (Kitakami Komoughi/Pumafen), Danne, Centurk, and Kharkov), and three leaf rust races (UN 9, UN 6B, and UN 2AAG) were used to study the effect of temperature on leaf rust severity and pustule size on seedling plants.
2. In general, plants held at 25 C had greater numbers of pustules 6 to 8 days after inoculation than plants held at 20 C. Specific exceptions were noted in certain cultivar-race combinations.
3. There were more pustules developed by races UN 9 and UN 2AAG than UN 6B regardless of temperature or cultivar.
4. There were more pustules produced on susceptible cultivars than on the resistant cultivar (Centurk) regardless of temperature or race.
5. Pustules tended to be larger at 25 C than at 20 C.
6. Pustules produced by each of the three races were approximately the same size on each of the seven susceptible cultivars.
7. Cultivar was more important than temperature or race in determining pustule size.
8. There were specific exceptions to each of the generalizations made with respect to temperature, race, or cultivar.

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