# REACTION AND INHERITANCE TO LEAF RUST *PUCCINIA RUBIGO-VERA TRITICI* (ERIKS.) OF THE GREENBUG RESISTANT WHEAT VARIETY DICKINSON SELECTION 28A

By

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K. E. F.

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# INTRODUCTION

Losses from leaf rust, Puccinia Rubigo-Vera Tritici (Eriks.), have caused it to be recognized as the most destructive disease of wheat. Leaf rust resistance is one of the principal objectives of the wheat breeding program at the Oklahoma Agricultural Experiment Station as well as for the wheat areas of favorable environment in the world.

In a breeding program for rust resistance, the genetics of the pathogen as well as the genetics of the host plant must be considered. The genetics of the pathogen can not be controlled. In nature, physiologic races arise within the causal organism. These races are indistinguishable morphologically, but they differ in their ability to attack varieties of the host. In other words, a variety may be resistant to one race, but it may be susceptible to others. Races are identified by their reactions on a set of differential host varieties and are assigned arabic numerals.

The interaction of host and pathogen causes changes in the prevalence of the various races making up the total population. When varieties resistant to prevalent races are released and become widely grown, new or minor races virulent on these varieties will increase. In this case, different races, or groups of races, become prevelant, and rust is again a factor in wheat production.

The plant breeder then has a new problem of developing an acceptable resistant variety. Virulence and competition among races also are believed to affect the prevalence of any particular race. In addition, the greenbug insect, Toxoptera graminum (Round.), is also a problem in the state of Oklahoma and adjacent areas. Experiments have been undertaken to find a resistant variety which resulted in the discovery of the variety Dickinson Selection 28A. This study was undertaken to determine if Dickinson Selection 28A has any resistance to leaf rust, Puccinia Rubigo-Vera Tritici (Eriks.).

Since the association of resistance to different hazards would facilitate greatly the breeding program, the primary objective of the present investigation was to study the reaction of Dickinson Selection 28A to the prevalent races of leaf rust, namely 5, 9, 21, 105A, and 105B. The greenbug resistant $F_3$ lines of the cross, Dickinson Selection 28A x Ponca, also were studied to obtain an idea of the inheritance and reaction to race 9 to which Ponca is resistant.

## REVIEW OF LITERATURE

According to Schlehuber (14), in order to proceed most intelligently in a breeding program of disease resistance, it is helpful to have a knowledge of the qualities of the parent pertaining to resistance.

The literature on the inheritance of resistance to wheat leaf rust, *Puccinia Rubigo-Vera Tritici* (Eriks.), is divided into two categories: (1) the inheritance of mature plant resistance and (2) the inheritance of seedling resistance.

Studies on the inheritance of seedling resistance in the greenhouse, where rust races and environment can be controlled, generally are considered more reliable than field studies. This study deals with seedling reactions to various races of leaf rust.

Since the present investigation was undertaken to study the inheritance of seedling resistance, the literature has been reviewed from this point of view.

In the first report on the mode of inheritance of leaf rust resistance, Maines, Leighty, and Johnston (11) found that seedling resistance to six different races was controlled by one factor pair in four different varieties.

Resistance was dominant in some crosses, intermediate in some, and recessive in others.

Maines (10) reported seedling resistance to race 3 dependent on one gene pair in a Norka x Ceres cross with resistance being dominant.

Schlehuber (15) found that resistance to race 9 could be explained by a single recessive factor in four crosses:

(Mediterranean Hope x Pawnee) x Comanche

(Oro-Mediterranean-Hope) x Comanche

(Kawvale-Marquillo x Kawvale-Tenmarq) x Cheyenne

(Kawvale-Marquillo-x Kawvale-Tenmarq) x Comanche

However, in the $F_2$ of the cross (Mediterranean-Hope x Pawnee) x Cimarron studied by the same author, for resistance to race groups 12 and 45 of leaf rust, Chi-square values for goodness of fit to the 3:1 ratio showed probabilities of less than 1 per cent. Since the segregation obtained did not give any definite indication as to genetic ratio, no conclusions were made by him as to the mode of inheritance of reaction to these races. All selections of this cross studied for reactions to races 12 and 45 were completely susceptible in the $F_3$, and for these results two explanations have been offered: (a) that the reactions exhibited by this cross to race groups 12 and 45 were "x" type and (b) that the source of rust used in the $F_2$ and $F_3$ was different.

In studies of resistance to race 9 found in the Pawnee variety, Heyne and Johnston (8) stated that this resistance was dependent on one major gene. They also found this factor was non-allelic to the factor controlling resistance to race 9 in Timstein. These workers further reported that Timstein seedling resistance to five races was controlled by one major recessive gene and one or more modifying factors.

By the use of the monosomic method, Heyne and Livers (9) found that Pawnee wheat has one major factor for resistance to race 9 of leaf rust which is located on chromosome X. They also reported that a factor from Pawnee probably interacted with a factor from Chinese Spring to give a two factor segregation in the seedling stage. The other factor or factors involved were not assigned to any of the other 15 chromosomes studied.

Caldwell and Compton (3) reported the inheritance of seedling resistance to leaf rust races 9, 31, 65, 78, 79, 80, 101, and 110. Their studies were carried out by means of greenhouse inoculations in $F_3$ and bulk $F_4$ progenies of individual $F_2$ plants of the cross Wabash C.I. 11384 x Michigan Amber 29-1-1-1, C.I. 4770.

Each progeny reacted uniformly to the group of eight races, indicating that for all eight races the same gene controlled either the resistance or "x" reaction.

Martinez, Ausemus, and Burnham (12) found that in a cross of Thatcher x (Premier x Bobin-Gaza-Bobin) N.S. No. 11-39-2, the inheritance of mature plant reaction to a mixture of leaf rust races in the field could be explained by assuming the action of three genetic factor pairs inherited independently. Any factor in the dominant condition caused susceptibility.

They also reported that the seedling reaction to races 1, 2, 5, 15, 28, and 128A appeared to be controlled by six different genetic factors; in all cases susceptibility was dominant. The reactions to these races were highly but not completely associated, suggesting linkage of these six genes. Assuming linkage, a gene order was set up that fits the observed recombination value closely. In the same study segregations fitting a two factor ratio were observed when races 3, 58, 126, and a bulk of 18 races were used. The relatively large number of genetic factors segregating in this cross may account for the difference in recovery of lines equal in resistance to the original resistant parents.

Wu and Ausemus (17) concluded from seedling studies of $F_4$ progenies of 90 $F_3$ lines of the cross Lee x Mida that the resistance of Lee to race 126 was governed by a single recessive factor and to race 5 by a single dominant factor. These two factors were linked with a recombination percentage of 21 $\pm$ 2.7. Both these parents were highly resistant to race 9 and showed segregation for moderate resistance.

This was explained on the basis of duplicate factors. The Lee factors for resistance to races 9, 5, and 126 in the seedling stage, whether dominant or recessive, as well as one of the two factors for mature plant resistance in the field, all appeared to be associated in inheritance, as it was explained by the presence of different factors in each parent.

Adams (1) in his studies found that the inheritance of resistance to leaf rust sometimes shows a complicated result due to varying conditions of soil, climate, time of maturity, and mixture of physiologic forms and that accurate determination of the factors of inheritance is difficult.

Biffin (2), on crossing immune and susceptible varieties, found that the resulting offspring is susceptible. On self-fertilization, these susceptible individuals produce immune and susceptible descendants in the proportion of one of the former to three of the latter. However, he found that the degree of susceptibility is variable. He also reported that where the degree of susceptibility differs in the two parents, the hybrid resembles the more susceptible parent in that respect and that among the descendants of such hybrids, the two degrees of susceptibility appear in the usual Mendelian ratio of one slightly susceptible to three very susceptible individuals. Relatively immune forms breed true to this characteristic in the succeeding generations.

Gaines and Carstens (5) indicated very close, if not complete, linkage of factors as evidenced by a cross between two varieties of wheat.

Neatby (13) reported that genes responsible for the inheritance to one disease may be concerned in susceptibility to another. Any theory offered to explain the nature or cause of resistance to one must at the same time explain the nature and cause of susceptibility to the other.

Hayes (6) found that in order to explain the reaction to leaf rust in his $F_3$ lines, two factors were necessary. He also obtained linkage between these two factors.

Willard (16) explained his results of different reactions to resistance by two genetic factors.

Hayes (7) failed to get any indication of definite segregation in the $F_3$ families of the cross H-44 x (Marquis x Kater No. 11-19-167) and H-44 x Double cross No. 11-21-28. However, he obtained linkage in the inheritance of reaction to leaf rust and stem rust.

Clark (4) in his study of inheritance reported segregation in the $F_2$ as in the $F_3$, and strains homozygous for resistance could be obtained in $F_4$.

## MATERIALS AND METHODS

### Origin and History of Dickinson Greenbug Resistant Selection

The greenbug resistant strains of Dickinson selection (hexaploid wheat) originally were found as a mixture in the Durum variety, Dickinson No. 485, C.I. 3707, U.S.D.A. World Collection, Entry No. D94. This variety was first tested for greenbug reaction in the spring of 1952 at Stillwater, Oklahoma, by R. G. Dahms and E. A. Wood, Jr. In pot tests it was noted that Dickinson showed somewhat more resistance to greenbugs than Pawnee, a susceptible variety. In these tests several plants were grown in each pot, and the reaction of all plants (resistant and susceptible) were averaged, thus giving Dickinson No. 485 a slightly higher over-all rating than the susceptible check. Dr. Dahms, in the first Quarterly Report, 1952, mentioned that some Durum wheat varieties were found to be more resistant to greenbugs than any varieties previously tested, but they were not nearly as resistant as some barley varieties.

In flat tests conducted in the fall of 1952, Dickinson No. 485 (still unselected) showed further indication of possessing some greenbug resistance. No plants were saved from this test. In a subsequent flat test infested on

January 6, 1953, Dickinson continued to show some resistance. Dr. A. M. Schlehuber discovered that certain individual plants in this test were responsible for the resistance. Field tests showed that these greenbug resistant plants made up about 3 per cent of the Dickinson No. 485 sample. (Resistance scores were calculated as an average of number of days plants lived after infestation. Ten individual plants contributed to this average.) These few resistant plants were causing the total resistance score to be slightly higher than susceptible varieties.

In the spring of 1953, a few seeds of Dickinson No. 485 (still unselected, D94 Entry) were planted in a pot for increase by E. A. Wood, Jr. Both Durum (susceptible) and vulgare (resistant) types were harvested from this pot. Both types were entered in a pot test. The "vulgare" type planted in pot 28-B was susceptible. Plants in pot 28-A were grown to maturity and assigned the designation Dickinson Selection 28A.

## Cytological Examination of Dickinson Selection 28A

The cytological examination of Dickinson Selection 28A by Mr. Byrd C. Curtis showed that it contained 21 pairs of chromosomes. Others, including Dr. A. M. Schlehuber and Dr. E. S. McFadden, concluded that Dickinson Selection 28A was a vulgare type.

The Dickinson Selection 28-A 56 Stw. 5681 - Stw. 555716 and 112 $F_3$ lines of Dickinson Selection 28-A x Ponca were furnished by Mr. Byrd C. Curtis of the Small Grain Section.

The leaf rust inoculum used in the experiment was obtained from Dr. Harry C. Young, Jr. and from Mr. Lewis E. Browder of the Botany and Plant Pathology Department.

The rust was collected from natural infection and identified as to race by its reaction on six different varieties in the greenhouse by Lewis E. Browder.

Leaf rust pustule types were rated as follows:

0; = immune

0-1 = infection without pustule development

1-2 = small resistant pustule

X = pustule variable, i.e., has several reactions on same leaf

4 = completely susceptible pustule

## Experimental Method

### Reaction of Dickinson Selection 28A to Five Leaf Rust Races

Leaf rust races 105A, 105B, 9, 21, and 5 were used throughout the study, and varietal reactions were all obtained in the seedling stage.

Two hundred and fifty seeds of Dickinson Selection 28A were planted in five different pots with 50 seeds per pot. The seeds were planted individually in a mixture consisting of approximately three parts Kirkland clay loam, one part moss, one part pulverized cow manure, and one part sand.

When the plants were 10 days old, their leaves were finger-stripped to reduce surface tension and inoculated by brushing with potted plants infected with leaf rust races 105A, 105B, 9, 21, and 5. The inoculated plants were placed in an incubator of approximately 100 per cent relative humidity for 24 hours to insure infection. Leaf rust reaction was recorded 12 days after the inoculation.

The per cent of rust infection was medium to high.

In another test, which was carried out simultaneously, instead of finger-stripping, the leaves were sprayed with a diluted solution of photoflo as a wetting agent for reducing the surface tension. A good infection resulted from this method.

Inheritance Study of Dickinson Selection 28A x Ponca $F_3$ Lines to Leaf Rust Races

Dickinson Selection 28A was crossed with Ponca in the spring of 1954. Forty-seven $F_0$ seed were obtained. Several $F_1$ plants were grown in the field in 1955. Five hundred and twenty-four $F_2$ plants originated from one $F_1$ plant, Stw. 555717-1. These plants were grown as spaced plants in the field in 1956, and they were harvested individually. These were tested for greenbug resistance in the greenhouse in 1956-1957 season by Mr. Byrd C. Curtis. In all, 112 lines were discovered by him which possessed resistance to this pest, and the present investigation on inheritance was carried out with this material only. Since seven families failed to germinate, the investigation was carried out with the remaining 105 lines. Selection numbers for these $F_3$ lines are shown in Tables 1, 2, and 3.

The seeds were planted three-quarters of an inch apart in one and one-half inch rows with 50 seeds per row in flats in the greenhouse. A mixture of approximately three parts Kirkland clay loam, one part peat moss, one part pulverized cow manure, and three parts sand was used. When the plants were 10 days old, they were sprayed with a dilute solution of photo-flo, then inoculated by brushing the potted plants that had been infected with leaf rust race 9. The inoculated plants were placed in an incubator of approximately 100 per cent relative humidity for 24 hours to insure infection. Leaf rust reaction was recorded 12 days after inoculation. For the reaction to leaf rust race 9, plants were classified according to their similarity of reaction to the parents.

Table 1. Reaction of 8 susceptible $F_3$ lines of Dickinson Selection 28A x Ponca to leaf rust race 9

| Variety Selection | Selection Number | No. of Rows | Number of Seeds | Number of Plants | Reaction X | Reaction 4 |
|---|---|---|---|---|---|---|
| D.S.28A x Ponca $F_3$ | Stw.565683-33 | 1 | 50 | 19 | | 19 |
| D.S.28A x Ponca $F_3$ | Stw.565683-52 | 1 | 50 | 33 | | 33 |
| D.S.28A x Ponca $F_3$ | Stw.565683-46 | 1 | 50 | 17 | | 17 |
| D.S.28A x Ponca $F_3$ | Stw.565683-59 | 1 | 50 | 35 | | 35 |
| D.S.28A x Ponca $F_3$ | Stw.565683-124 | 1 | 50 | 12 | | 12 |
| D.S.28A x Ponca $F_3$ | Stw.565689-12 | 1 | 50 | 33 | | 33 |
| D.S.28A x Ponca $F_3$ | Stw.565689-74 | 1 | 50 | 43 | | 43 |
| D.S.28A x Ponca $F_3$ | Stw.565689-121 | 1 | 50 | 39 | | 39 |
| | | 8 | | | | |

Table 2. Reaction of 8 resistant $F_3$ lines of Dickinson Selection 28A x Ponca to leaf rust race 9

| Variety Selection | Selection Number | No. of Rows | Number of | | Reaction | | |
|---|---|---|---|---|---|---|---|
| | | | Seeds | Plants | 0; | 0-1 | 1-2 |
| D.S.28A x Ponca $F_3$ | Stw.565689-97 | 1 | 50 | 42 | 20 | 22 | |
| D.S.28A x Ponca $F_3$ | Stw.565689-98 | 1 | 50 | 40 | 10 | 25 | 5 |
| D.S.28A x Ponca $F_3$ | Stw.565686-22 | 1 | 50 | 25 | 6 | 16 | 3 |
| D.S.28A x Ponca $F_3$ | Stw.565686-22 | 1 | 50 | 16 | | 3 | 13 |
| D.S.28A x Ponca $F_3$ | Stw.565683-60 | 1 | 50 | 31 | | 31 | |
| D.S.28A x Ponca $F_3$ | Stw.565683-73 | 1 | 50 | 29 | | 26 | 3 |
| D.S.28A x Ponca $F_3$ | Stw.565683-58 | 1 | 50 | 23 | | | 23 |
| D.S.28A x Ponca $F_3$ | Stw.565683-70 | 1 | 50 | 22 | | | 22 |
| | | 8 | | | | | |

Table 3. Reaction of 89 segregating and/or intermediate $F_3$ lines of Dickinson Selection 28A x Ponca to leaf rust race 9

| | | Number of | | | Reaction | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variety Selection | Selection Number | Rows | Seeds | Plants | 0; | 0-1 | 1-2 | X | 4 |
| D.S.28A x Ponca $F_3$ | Stw.565689-47 | 1 | 50 | 50 | 6 | 15 | 15 | 0 | 14 |
| D.S.28A x Ponca $F_3$ | Stw.565611-68 | 1 | 50 | 42 | 2 | 12 | 20 | 6 | 2 |
| D.S.28A x Ponca $F_3$ | Stw.565683-21 | 1 | 50 | 48 | 3 | 24 | 8 | 10 | 3 |
| D.S.28A x Ponca $F_3$ | Stw.565689-53 | 1 | 50 | 43 | 1 | 4 | 6 | 16 | 16 |
| D.S.28A x Ponca $F_3$ | Stw.565686-68 | 1 | 50 | 42 | 2 | 12 | 20 | 6 | 2 |
| D.S.28A x Ponca $F_3$ | Stw.565683-119 | 1 | 50 | 39 | 1 | 6 | 9 | 9 | 14 |
| D.S.28A x Ponca $F_3$ | Stw.565683-31 | 1 | 50 | 37 | 8 | 9 | 9 | 5 | 6 |
| D.S.28A x Ponca $F_3$ | Stw.565689-105 | 1 | 50 | 34 | 2 | 2 | 8 | 12 | 10 |
| D.S.28A x Ponca $F_3$ | Stw.565683-42 | 1 | 50 | 33 | 6 | 14 | 1 | 6 | 6 |
| D.S.28A x Ponca $F_3$ | Stw.565683-82 | 1 | 50 | 32 | 4 | 8 | 2 | 10 | 8 |
| D.S.28A x Ponca $F_3$ | Stw.565683-112 | 1 | 50 | 28 | 1 | 2 | 2 | 3 | 20 |
| D.S.28A x Ponca $F_3$ | Stw.565686-30 | 1 | 50 | 28 | 1 | 2 | 7 | 10 | 8 |
| D.S.28A x Ponca $F_3$ | Stw.565689-79 | 1 | 50 | 28 | 2 | 5 | 18 | 1 | 2 |
| D.S.28A x Ponca $F_3$ | Stw.565689-93 | 1 | 50 | 26 | 2 | 5 | 8 | 7 | 4 |
| D.S.28A x Ponca $F_3$ | Stw.565689-128 | 1 | 50 | 20 | 1 | 5 | 4 | 3 | 7 |

Table 3--Continued

| Variety Selection | Selection Number | Number of Rows | Number of Seeds | Number of Plants | Reaction 0; | Reaction 0-1 | Reaction 1-2 | Reaction X | Reaction 4 |
|---|---|---|---|---|---|---|---|---|---|
| D.S.28A x Ponca $F_3$ | Stw.565683-84 | 1 | 50 | 19 | 1 | 2 | 7 | 4 | 5 |
| D.S.28A x Ponca $F_3$ | Stw.565689-35 | 1 | 50 | 19 | 2 | 1 | 1 | 3 | 12 |
| D.S.28A x Ponca $F_3$ | Stw.565686-97 | 1 | 50 | 17 | 6 | 4 | 2 | 3 | 2 |
| D.S.28A x Ponca $F_3$ | Stw.565683-36 | 1 | 50 | 28 | 15 | 5 | | 8 | |
| D.S.28A x Ponca $F_3$ | Stw.565684-94 | 1 | 50 | 18 | 7 | 1 | 6 | 4 | |
| D.S.28A x Ponca $F_3$ | Stw.565683-114 | 1 | 50 | 25 | 9 | 8 | 4 | 1 | 3 |
| D.S.28A x Ponca $F_3$ | Stw.565684-96 | 1 | 50 | 33 | 3 | 11 | 16 | 3 | |
| D.S.28A x Ponca $F_3$ | Stw.565684-114 | 1 | 50 | 30 | 2 | | 15 | 3 | 10 |
| D.S.28A x Ponca $F_3$ | Stw.565689-19 | 1 | 50 | 18 | 2 | 6 | 8 | | 2 |
| D.S.28A x Ponca $F_3$ | Stw.565686-65 | 1 | 50 | 20 | 1 | 2 | 5 | 12 | |
| D.S.28A x Ponca $F_3$ | Stw.565686-71 | 1 | 50 | 37 | | 5 | 9 | 8 | 15 |
| D.S.28A x Ponca $F_3$ | Stw.565683-90 | 1 | 50 | 32 | | 1 | 20 | 10 | 1 |
| D.S.28A x Ponca $F_3$ | Stw.565686-74 | 1 | 50 | 45 | | 7 | 8 | 10 | 20 |
| D.S.28A x Ponca $F_3$ | Stw.565686-85 | 1 | 50 | 39 | | 5 | 5 | 13 | 16 |
| D.S.28A x Ponca $F_3$ | Stw.565686-75 | 1 | 50 | 41 | | 5 | 6 | 5 | 25 |

Table 3--Continued

| Variety Selection | Selection Number | Number of Rows | Number of Seeds | Number of Plants | Reaction 0; | Reaction 0-1 | Reaction 1-2 | Reaction X | Reaction 4 |
|---|---|---|---|---|---|---|---|---|---|
| D.S.28A x Ponca $F_3$ | Stw.565684-64 | 1 | 50 | 38 | | 11 | 15 | 3 | 9 |
| D.S.28A x Ponca $F_3$ | Stw.565684-66 | 1 | 50 | 47 | | 2 | 14 | 4 | 27 |
| D.S.28A x Ponca $F_3$ | Stw.565684-70 | 1 | 50 | 39 | | 9 | 10 | 2 | 18 |
| D.S.28A x Ponca $F_3$ | Stw.565684-138 | 1 | 50 | 18 | | 7 | 2 | 3 | 6 |
| D.S.28A x Ponca $F_3$ | Stw.565683-22 | 1 | 50 | 40 | | 20 | 12 | 8 | |
| D.S.28A x Ponca $F_3$ | Stw.565683-24 | 1 | 50 | 30 | | 8 | 7 | 15 | |
| D.S.28A x Ponca $F_3$ | Stw.565683-7 | 1 | 50 | 30 | | | 5 | 12 | 13 |
| D.S.28A x Ponca $F_3$ | Stw.565683-5 | 1 | 50 | 26 | | | 4 | 16 | 6 |
| D.S.28A x Ponca $F_3$ | Stw.565686-38 | 1 | 50 | 38 | | 10 | 8 | | 20 |
| D.S.28A x Ponca $F_3$ | Stw.565686-79 | 1 | 50 | 29 | | 6 | 13 | 10 | |
| D.S.28A x Ponca $F_3$ | Stw.565686-11 | 1 | 50 | 40 | | 5 | 15 | | 20 |
| D.S.28A x Ponca $F_3$ | Stw.565683-126 | 1 | 50 | 24 | | 5 | 1 | 18 | |
| D.S.28A x Ponca $F_3$ | Stw.565689-39 | 1 | 50 | 35 | | 5 | | 10 | 20 |
| D.S.28A x Ponca $F_3$ | Stw.565689-62 | 1 | 50 | 8 | | 4 | 3 | | 1 |

Table 3--Continued

| Variety Selection | Selection Number | Number of | | | Reaction | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Rows | Seeds | Plants | 0; | 0-1 | 1-2 | X | 4 |
| D.S.28A x Ponca $F_3$ | Stw.565689-63 | 1 | 50 | 12 | | 2 | 2 | | 8 |
| D.S.28A x Ponca $F_3$ | Stw.565683-54 | 1 | 50 | 31 | | | 14 | 5 | 12 |
| D.S.28A x Ponca $F_3$ | Stw.565686-110 | 1 | 50 | 34 | | | 10 | 13 | 11 |
| D.S.28A x Ponca $F_3$ | Stw.565686-36 | 1 | 50 | 28 | | | 7 | 3 | 18 |
| D.S.28A x Ponca $F_3$ | Stw.565686-108 | 1 | 50 | 26 | | | 7 | 3 | 16 |
| D.S.28A x Ponca $F_3$ | Stw.565689-87 | 1 | 50 | 21 | | | 6 | 7 | 8 |
| D.S.28A x Ponca $F_3$ | Stw.565689-173 | 1 | 50 | 13 | | | 6 | 2 | 5 |
| D.S.28A x Ponca $F_3$ | Stw.565689-11 | 1 | 50 | 23 | | | 6 | 4 | 13 |
| D.S.28A x Ponca $F_3$ | Stw.565689-26 | 1 | 50 | 35 | | | 5 | 7 | 23 |
| D.S.28A x Ponca $F_3$ | Stw.565689-89 | 1 | 50 | 34 | | | 4 | 14 | 16 |
| D.S.28A x Ponca $F_3$ | Stw.565686-60 | 1 | 50 | 40 | | | 4 | 20 | 16 |
| D.S.28A x Ponca $F_3$ | Stw.565689-30 | 1 | 50 | 33 | | | 3 | 2 | 28 |
| D.S.28A x Ponca $F_3$ | Stw.565689-75 | 1 | 50 | 12 | | | 2 | | 10 |
| D.S.28A x Ponca $F_3$ | Stw.565689-85 | 1 | 50 | 9 | | | 2 | 1 | 6 |
| D.S.28A x Ponca $F_3$ | Stw.565689-162 | 1 | 50 | 9 | | | 2 | 6 | 1 |

Table 3--Continued

| Variety Selection | Selection Number | Number of Rows | Number of Seeds | Number of Plants | Reaction 0; | Reaction 0-1 | Reaction 1-2 | Reaction X | Reaction 4 |
|---|---|---|---|---|---|---|---|---|---|
| D.S.28A x Ponca $F_3$ | Stw.565686-101 | 1 | 50 | 25 | | | 1 | 5 | 19 |
| D.S.28A x Ponca $F_3$ | Stw.565689-61 | 1 | 50 | 33 | | | 1 | 11 | 21 |
| D.S.28A x Ponca $F_3$ | Stw.565689-72 | 1 | 50 | 26 | | | 1 | 5 | 20 |
| D.S.28A x Ponca $F_3$ | Stw.565689-158 | 1 | 50 | 20 | | | 1 | 11 | 8 |
| | | | | | | | | | |
| D.S.28A x Ponca $F_3$ | Stw.565683-16 | 1 | 50 | 22 | | | 2 | 20 | |
| D.S.28A x Ponca $F_3$ | Stw.565689-81 | 1 | 50 | 8 | | | 2 | 6 | |
| D.S.28A x Ponca $F_3$ | Stw.565689-86 | 1 | 50 | 18 | | | 1 | 17 | |
| D.S.28A x Ponca $F_3$ | Stw.565686-39 | 1 | 50 | 50 | | | | 15 | 35 |
| D.S.28A x Ponca $F_3$ | Stw.565686-63 | 1 | 50 | 50 | | | | 35 | 15 |
| D.S.28A x Ponca $F_3$ | Stw.565686-28 | 1 | 50 | 49 | | | | 24 | 25 |
| D.S.28A x Ponca $F_3$ | Stw.565689-46 | 1 | 50 | 44 | | | | 11 | 33 |
| D.S.28A x Ponca $F_3$ | Stw.565689-18 | 1 | 50 | 42 | | | | 12 | 30 |
| D.S.28A x Ponca $F_3$ | Stw.565683-20 | 1 | 50 | 40 | | | | 6 | 34 |
| D.S.28A x Ponca $F_3$ | Stw.565683-16 | 1 | 50 | 38 | | | | 8 | 30 |

Table 3--Continued

| Variety Selection | Selection Number | Number of Rows | Number of Seeds | Number of Plants | Reaction 0; | Reaction 0-1 | Reaction 1-2 | Reaction X | Reaction 4 |
|---|---|---|---|---|---|---|---|---|---|
| D.S.28A x Ponca $F_3$ | Stw.565689-54 | 1 | 50 | 38 | | | | 21 | 17 |
| D.S.28A x Ponca $F_3$ | Stw.565686-107 | 1 | 50 | 36 | | | | 5 | 31 |
| D.S.28A x Ponca $F_3$ | Stw.565689-40 | 1 | 50 | 33 | | | | 10 | 23 |
| D.S.28A x Ponca $F_3$ | Stw.565686-87 | 1 | 50 | 32 | | | | 10 | 22 |
| D.S.28A x Ponca $F_3$ | Stw.565689-95 | 1 | 50 | 30 | | | | 3 | 27 |
| D.S.28A x Ponca $F_3$ | Stw.565689-119 | 1 | 50 | 17 | | | 7 | 10 | |
| D.S.28A x Ponca $F_3$ | Stw.565689-106 | 1 | 50 | 29 | | | | 5 | 24 |
| D.S.28A x Ponca $F_3$ | Stw.565683-83 | 1 | 50 | 29 | | | | 9 | 20 |
| D.S.28A x Ponca $F_3$ | Stw.565683-78 | 1 | 50 | 28 | | | | 25 | 3 |
| D.S.28A x Ponca $F_3$ | Stw.565683-88 | 1 | 50 | 17 | | | | 11 | 6 |
| D.S.28A x Ponca $F_3$ | Stw.565689-138 | 1 | 50 | 24 | | | | 3 | 21 |
| D.S.28A x Ponca $F_3$ | Stw.565689-120 | 1 | 50 | 16 | | | | 13 | 3 |
| D.S.28A x Ponca $F_3$ | Stw.565683-90 | 1 | 50 | 14 | | | | 10 | 4 |
| D.S.28A x Ponca $F_3$ | Stw.565689-169 | 1 | 50 | 15 | | | | 3 | 12 |

Table 3--Continued

| Variety Selection | Selection Number | Number of Rows | Number of Seeds | Number of Plants | Reaction 0; | Reaction 0-1 | Reaction 1-2 | Reaction X | Reaction 4 |
|---|---|---|---|---|---|---|---|---|---|
| D.S.28A x Ponca $F_3$ | Stw.565689-83 | 1 | 50 | 13 | | | | 5 | 8 |
| D.S.28A x Ponca $F_3$ | Stw.565689-151 | 1 | 50 | 11 | | | | 4 | 7 |
| | | 89 | | | | | | | |

# EXPERIMENTAL RESULTS AND DISCUSSION

## Experimental Results

### Reaction of Dickinson Selection 28A to Five Leaf Rust Races

The reaction of Dickinson Selection 28A to the five leaf rust races, 5, 9, 21, 105A, and 105B, is shown in Table 4.

Table 4. Reaction of Dickinson Selection 28A to five races of leaf rust, Stillwater, Oklahoma, 1957

| Race | No. of Seeds Planted | No. of Plants | Reaction |
|---|---|---|---|
| 5 | 50 | 48 | 4 |
| 9 | 50 | 50 | 4 |
| 21 | 50 | 47 | 4 |
| 105A | 50 | 50 | 4 |
| 105B | 50 | 42 | 4 |

In the table above, it can be seen that Dickinson Selection 28A is susceptible to all five races.

Inheritance Study of Dickinson Selection 28A x Ponca to Leaf Rust Race 9

The reaction of 105 $F_3$ lines of Dickinson Selection 28A x Ponca is summarized and presented in Tables 1, 2, and 3. The plants or lines showing 0-2 reaction were classified as resistant; those having 4 type reaction were called susceptible; those having only 0-1, 1-2, and X types of reaction were assumed to be homozygous intermediate types. Those lines having plants in all reaction classes were assumed to be double heterozygotes, and the remaining lines were assumed to be segregating for one resistance gene. According to this classification, eight lines were homozygous resistant; eight were homozygous susceptible; eight were homozygous intermediate; twenty-one were double heterozygotes; and sixty were heterozygous for one gene pair. This appears to be a 1:2:4:8:1 ratio, and the $X^2$ test for goodness of fit showed a P value between 0.30 and 0.50 (See Table 5).

## Discussion

Dickinson Selection 28A is an important source of resistance to greenbugs. As pointed out earlier, the present investigation was undertaken with the following two objectives:

(1) To determine the reaction of Dickinson Selection 28A to the leaf rust races prevalent in this area.

(2) To study the pattern of inheritance of reaction to leaf rust race 9 in Dickinson Selection 28A x Ponca.

Dickinson Selection 28A was tested for its reaction to five individual races of leaf rust in the seedling stage. It was found to be susceptible to all the races, namely, 105A, 105B, 9, 21, and 5.

A cross between Dickinson Selection 28A and Ponca was available in the $F_3$ generation. For this purpose, only the families resistant to greenbugs were studied for their reaction to race 9. Since Ponca is resistant to race 9 of leaf rust, this material was used to study the pattern of inheritance of resistance to leaf rust race 9 in this cross. Of the 105 $F_3$ families, eight were resistant; eight were intermediate homozygous; twenty-one were segregating the full range and were assumed to be double heterozygotes; sixty were segregating through a lesser range and were assumed to be heterozygous for one gene; and eight were susceptible. Table 5 shows the assumed genotypes and the $X^2$ for goodness of fit.

If these assumptions are correct, then Dickinson Selection 28A has the genotype AABB, Ponca has the genotype aabb; and the effect of both A and B is cumulative. Thus, the two genes, on segregating, produce five types of reactions. Since the classification of reactions is somewhat inexact, not all genotypes could be identified, and some of the classifications may be in error. Since $F_1$ and $F_2$ data are not available and the $F_3$ families could be biased due to selection for greenbug resistance, no definite conclusion can be drawn.

Table 5. Reaction of Dickinson Selection 28A x Ponca $F_3$ lines to leaf rust race 9 at Stillwater, Oklahoma, 1956-1957

| Genotypes | O. | C. | O.-C. | (O.-C.)$^2$ | $\frac{(O.-C.)^2}{C.}$ |
|---|---|---|---|---|---|
| AABB (susc.) | 8 | 6.5625 | +1.4375 | 2.066 | 0.315 |
| aaBB<br>AAbb (inter.) | 8 | 13.1250 | -5.1250 | 26.266 | 2.001 |
| AaBb (seg.) | 21 | 26.2500 | -5.2500 | 27.563 | 2.000 |
| AaBB<br>AABb<br>aaBb<br>Aabb | 60 | 52.5000 | +7.5000 | 56.250 | 0.143 |
| aabb (res.) | 8 | 6.5625 | +1.4375 | 2.066 | 0.315 |
| Total | 105 | 105 | 0 | | $X^2$=4.774 |
| | | | | | P=0.30-0.50 |

# SUMMARY

1. Reaction of the greenbug resistant Dickinson Selection 28A was obtained from five individual races of leaf rust, namely, 105A, 105B, 21, 5, and 9. It was found to be susceptible to all of these races.

2. Although no definite conclusion could be drawn from this study regarding the genetics of reaction to race 9 in the cross Dickinson Selection 28A x Ponca, a possible explanation involving two equal additive genes is offered.

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# VITA

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