A GENETIC STUDY OF LEAF SHEATH BARBS, AURICLE HAIRS, AND REACTION TO STEM RUST AND "BLACK CHAFF" IN CROSSES OF (ND105×ND1) AND ND113 WITH CONLEY WHEAT

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Conley, a new variety of hard red spring wheat, was released from North Dakota Experiment Station in 1959. Because of its relatively fair resistant to stem rust (*Puccinia graminis tritici*) and excellent milling and baking quality, it has served as the basic variety for crosses in the North Dakota hard red spring wheat improvement program.

The wheat varieties used in crosses with Conley were (ND105×ND1) and ND113. They were so used because they were derivatives from the 15B rust program. They happened also to have two distinctive botanical characters, *i. e.* leaf sheath barbs and hairy auricles, as well as reaction patterns to 15B stem rust and "black chaff". All these were contrasting characters with respect to those of Conley.

Material and Methods

The parental varieties used in this study were Conley, (ND 105×ND 1) and ND 113. Conley was a descendant from RL 2526×Lee maturing about 105 to 110 days. One of its ancestors was variety McMurachy which was assumed to be the main source of its 15B stem rust resistance. However its weakness, susceptibility to "black chaff" was considered to be the drawback of this good variety. (ND 105×ND 1) and ND113 both were unreleased varieties derived from a cross between Lee and ND 34. The contrasting characteristics in the parental varieties are as follows:

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Characters	Conley	ND 113 or (ND 105×ND 1)
Leaf sheath	Smooth	Barbed
Auricle	Smooth	Villous
Stem rust	Resistant	Resistant
"Black chaff"	Susceptible	Resistant

Leaf sheath barbs were dense stiff hairs on the leaf sheath which was most noticeable on the sheaths of lower internodes. These "barbs" pointed downward whereas "barbs" on the awn pointed upward. It was known that auricle hairs were extensions of some of the epidermal cells of the outer edge of the auricles. As the plants aged, auricle hairs were easily broken off by movements of the plants which were induced by wind. The expression "villous" was given to hairy auricle and "smooth" to hairless type. The F_2 plants were given a gennotypic classification based on the phenotypes observed in F_3 progenies.

Since stem rust infection was simply too light for the mature plant in the field, the reaction of the F_3 progenies was determined by seedling tests during the fall of 1959. Inasmuch as a mixture of biotypes might cause a more confused host reaction, only a single culture of rust was used. This was stem rust 15B subrace 32-S-15. Seeds of parental varieties and F_3 progenies of these crosses were planted for the seedling rust reaction test. About 12 to 15 seeds were used to grow seedling plants of each progeny in a 3½ inch pots. From seven to eight days after planting under a temperature of 75°F, these seedlings had a single leaf about three inches in length. This was the suitable stage for inoculation. The inoculation was performed by the mobilsol oil method. The seedling pots were left 24 hours in the inoculation chambers, under 100 percent relative humidity and 68°F temperature. Then they were transferred to the greenhouse where the temperature was maintained at 72° to 75°F. Generally, 10 to 12 days after inoculation, the optimun stem rust reaction was ready for reading. Notes were taken on pustule types which were described by Stakman (1944).

"Black chaff" disease of Conley wheat might affect various parts of a plant. The first stage was the dying of the leaf-tip and leaf necrosis. Dark discolorations of stems below the nodes were characteristic. Usually, dark discoloration appeared also on the rachis, lemma and other glumes. When Conley plant was severely affected by "black chaff", kernels might be shrunken and the yield of grain was reduced accordingly. The classification of "black chaff" reaction followed the system which was suggested by Ebeltoft (1957). In the greenhouse, the reaction was induced by raising the temperature 90-100°F for 48 hours about two weeks after first heading. A week after the high temperature treatment, the symptoms of this disease showed up on leaves, stems and peduncle. However, the symptoms on the stem, mostly below the nodes and rachis showed up later.

Experimental Results

Inheritance of Leaf Sheath Barbs

Leaf sheath barbs have not been extensively reported in the literature. Vazquez (1958) studied the inheritance of barbs in a cross of ND20×N. 2350. He determined that there was only a single genetic factor pair controlling the barb character in that cross. Barbed was dominant over barbless.

Two crosses were studied for leaf sheath barbs, (ND105×ND1)×Conley (two population), and Conley×ND113. The study of these crosses was based on F_3 progenies. F_1 plants were recorded as having barbs. F_3 progenies of the crosses were classified into barbed, segregating and smooth. Table 1 shows that the classification of F_3 progenies fit a single factor hypothesis very closely. This analysis strongly supported the hypothesis that a single genetic factor pair controlled leaf sheath barbs in these crosses.

Table 1. Segregation for Leaf Sheath Barbs in F_3 Progenies of Three Crosses

Cross	F_3 Progenies			X^2	P
	Barbed	Segregating	Smooth		
Ratio	1	2	1		
(ND105×ND1)×Conley (summer, 1959)	28	44	28	1.44	0.50 to 0.25
(ND105×ND1)×Conley (spring, greenhouse, 1960)	35	87	36	1.63	0.50 to 0.25
Conley×ND113 (spring, greenhouse, 1960)	10	26	16	1.38	0.75 to 0.50

Figure 1 shows the contrast in parents for this character.

Inheritance of Auricle Hairs

Wu (1953) reported that hairy auricle of Mida was differentiated from the non-hairy auricle of Lee by a single factor. Dawson (1958) made a similar observation in crosses involving Maria Escobar derivatives. He concluded that the inheritance of auricle hairs was determined by a single factor pair with hairy dominant over smooth. The dominant allele was derived from Selection I and recessive from ND81.

The inheritance of auricle hairs was studied first in the progenies of two crosses, (ND105×ND1)×Conley (two population) and Conley×ND113. The F_1 plants all showed villous auricles. For this phenomenon, the villous factor would be considered as a dominant factor. The F_3 progenies of these crosses

Table 2. Segregation for Auricle Hairs in F_3 Progenies of Three Populations

Crosses	F_3 progenies			X^2	P value
	Barbs	Segregating	Smooth		
Ratio	1	2	1		
(ND 105×ND 1)×Conley (summer, 1959)	23	47	30	1.34	0.75 to 0.50
(ND 105×ND 1)×Conley (Jan.-Apr., greenhouse, 1960)	38	75	45	1.02	0.75 to 0.95
Conley×ND 113 (Jan.-Apr., greenhouse, 1960)	14	26	12	0.15	0.95 to 0.90

Figure 2 compares the villous and smooth auricle of ND 105×ND 1 and Conley respectively.

were classified into villous, segregating and smooth. Table 2 shows the classification of F_3 offsprings fit a single factor hypothesis very well.

Inheritance of 15B Stem Rust Reaction

Previous genetic studies on the resistance of Conley to stem rust race 15B, have been made by several graduate students at North Dakota State University. Ebeltoft (1957) found that one major factor pair, Sr^c Sr^c, controlled resistance in Conley×P. I. 26219-12. Dawson (1958) studied the (ME×E-T)×Conley cross and found that both parents carried different and independent major factors controlling 15B stem rust reaction. Sheen (1958) made a cross to combine the major resistance genes from CT 231×Conley. He found that CT 231 carried a resistance factor Sr^a Sr^a, and Conley carried a different resistance factor, designated Sr^b Sr^b. Among the progenies of that cross, he identified both transgressive resistant and transgressive susceptible recombinations.

In this study, the analysis of data on stem rust depended only on F_3 seedling tests in the greenhouse. The examination of cross Conley×ND 113 in relation to parental reactions, revealed that some progenies were more resistant and some more susceptible than either parent. The simplest hypothesis to explain such a phenomenon was that the parents each contributed a different factor for stem rust resistant, and that these factor were additive in effect.

Based on average seedling stem rust reaction, the fifty two F_3 lines of the cross, Conley×ND 113, were classified for supposed genotype and the results fitted the ratio expected from the two factor hypothesis. The genotypes and phenotypic reactions are shown in Table 4.

Table 4. Hypothetical Average Numerical Rust Values for Genotypes Expected, Based on Observed Reaction of the Parents in the Cross Conley×ND 113 (72-75°F)

Frequeney	F_3 progenies	F_3 progenies Ave. Num. Value	Average Rust reaction	F_2 Phenotypes
1	Sr^c Sr^c Sr^x Sr^x	7.5	0; to 1	Super-resis.
2	Sr^c Sr^c Sr^x sr^x	6.5	1 to 2−	Highly-resis.
1	Sr^c Sr^c sr^x sr^x (ND 113)	5.5	2− to 2	Resistant
2	Sr^c sr^c Sr^x Sr^x	4.75	2 to 2+	Resistant
4	Sr^c sr^c Sr^x sr^x	3.75	2+ to 3−	Resistant
2	Sr^c sr^c sr^x sr^x	2.75	3−	Resistant
1	sr^c sr^c Sr^x Sr^x (Conley)	2.00	3 to 3+	Moderate-res.
2	sr^c sr^c Sr^x sr^x	1.00	3+	Semi-susc.
1	sr^c sr^c sr^x sr^x	0.00	3+ to 4	Susceptible

The P value of the test was found to be between 0.90 and 0.75, supporting the hypothesis that each parent contributed a gene for stem rust resistance and that they are inherited independently and had an additive effect. There appeared to be no dominance.

A slightly different approach to identifying F_2 genotypes was made by classifying all F_3 progenies into five classes (1) ranging more resistant than ND 113, (2) like ND 113, (3) intermediate between the parents or segregating widely, (4) like Conley and (5) more susceptible than Conley. The test also gave a P value of 0.90 to 0.75 indicating support of this hypothesis. According to above analysis, Conley had been shown to carry one resistance gene derived from McMurachy. ND 113 was presumed to carry at least one other stem rust resistance gene derived from Kenya AA. The recovery of transgressive resistant and transgressive susceptible types suggested that the rust resistance genes were additive in effect. This is encouraging that higher types of resistance may be created by combining genes already known. Figure 3 shows the progenies showing transgressive stem rust reaction in comparion with the parents.

The Inheritance of "Black chaff" Reaction

Bamberg (1936) in studying bacterial black chaff disease, stated that the symptoms of this disease may differ with different hosts. Hope and H-44 showed discoloration symptoms near the lower nodes of the stem, while other varieties showed symptoms on the necks and floral parts. McFadden (1939) concluded that the so-called "black chaff" of Hope and H-44 wheats was reaction to infection by *Puccinia graminis tritici*. Dawson (1958) studied two crosses between(ME×E-T) ×Conley, and Selection I×Conley. He observed a good fit to a 1:2:1 ratio in both crosses, suggesting a single genetic factor difference for "black chaff" reaction. Sheen (1958) studied the cross CT 231×Conley, for the inheritance of "black chaff" reaction. His results indicated that a single partially dominant factor pair controlled the inheritance of "black chaff" reaction in this cross.

The inheritance of "black chaff" in this study was based on the behavior of F_2 plants and F_3 progenies. The F_2 behavior to this disease in two crosses, (ND 105×ND 1)×Conley (three populations) and Conley×ND 113, showed a satisfactory, fit to a 1:2:1 ratio. Behavior of F_3 progenies was tested in the greenhouse with artifically induced symptoms, and P values were acceptable. Table 5 shows the segregating F_2 and F_3 progenies to a 1:2:1 ratio for "black chaff" reaction.

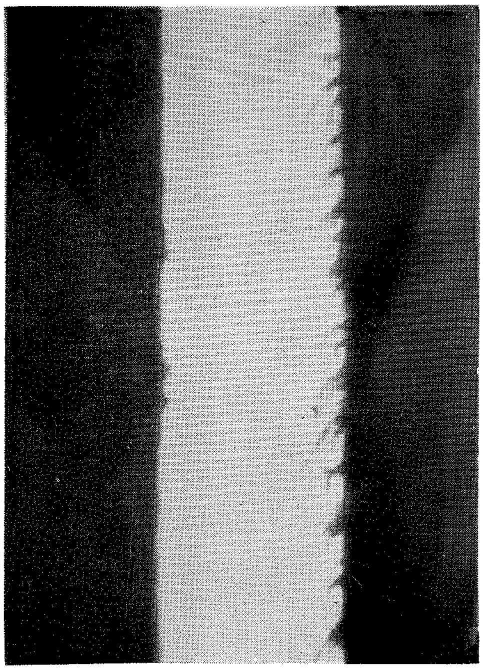

Fig. 1. Comparison of Somoth and Barbed Leaf Sheath.
Left, Conley (smooth)
Right, ND113 (barbed)

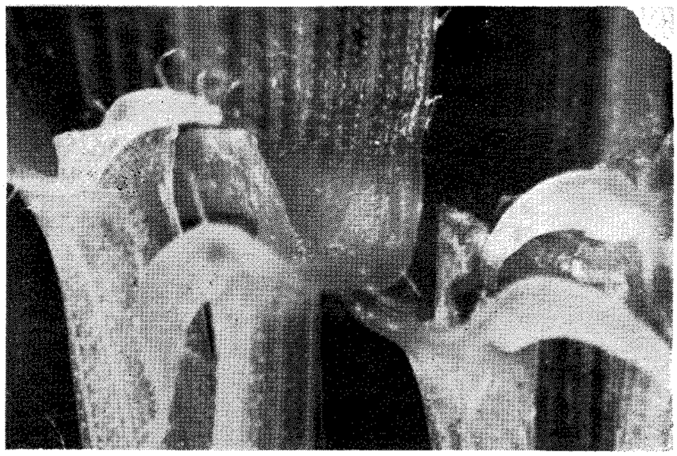

Fig. 2. Comparison of Villous (left) and Smooth (right) Auricle.
Left, ND 113 (villous)
Right, Conley (smooth)

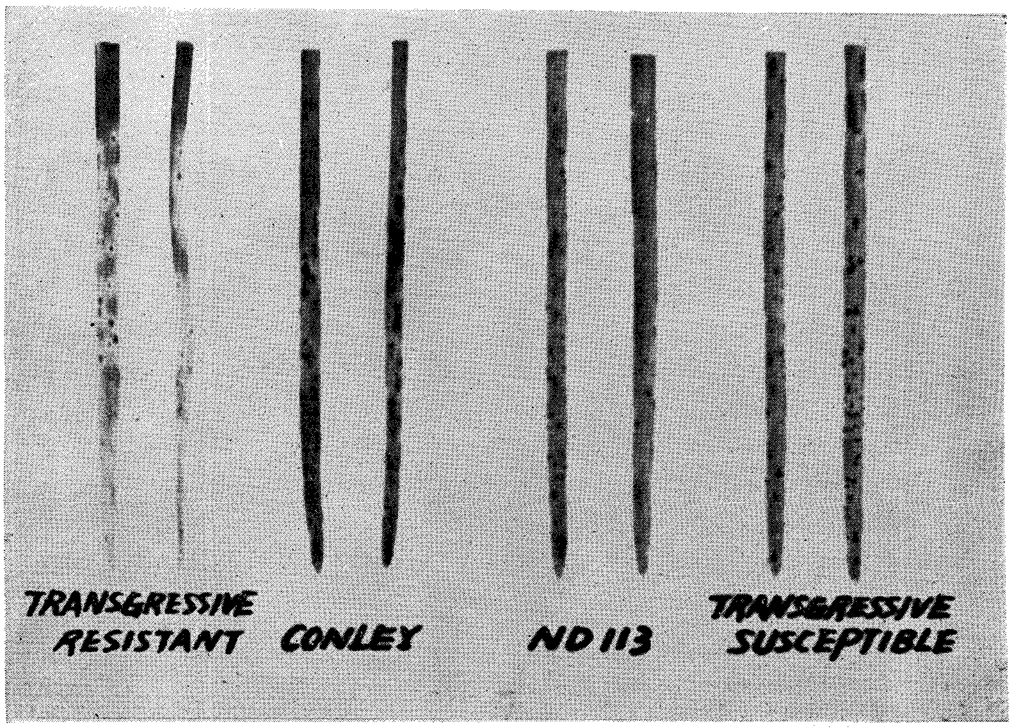

Fig. 3. Comparison of 15B Stem Rust Reactions on Conley, ND113 and Transgressive Resistant and Susceptible Lines.

Table 5. Fit of Segregating F_2 and F_3 Progenies to a 1:2:1 Ratio for "Black Chaff" Reaction

F_2	Black chaff classification			X^2	P value
	Resistant	Intermediate	Susceptible		
Ratio	1	2	1		
(ND 105 × ND 1) × Conley	16	33	20	0.710	0.75 to 0.05
(ND 105 × ND 1) × Conley	35	83	41	0.760	0.75 to 0.05
(ND 105 × ND 1) × Conley	5	14	7	0.769	0.75 to 0.05
Conley × ND 113	10	29	13	1.098	0.75 to 0.50
F_3	Resistant	Segregating	Susceptible	X^2	P value
(ND 105 × ND 1) × Conley	23	28	18	3.23	0.25 to 0.10
(ND 105 × ND 1) × Conley	44	81	34	1.314	0.75 to 0.50
(ND 105 × ND 1) × Conley	9	13	4	1.923	0.50 to 0.25
Conley × ND 113	17	22	13	1.846	0.50 to 0.25

Association of Leaf Sheath Barbs and Auricle Hairs

The only association was found between leaf sheath barbs and auricle hairs. The parents (ND 105×ND 1) and ND 113 had hairy auricle and barbed stems whereas smooth phase of each, as found on Conley, had been proved recessive in the F_1 plants. According to the maximun likelihood method for coupling phase, cross-over value of 39.18, 29.69 and 25.27 were found for three different crosses. It was possible that the differences in cross-over values represented errors of classification associated with two characters which were difficult to observe, even under microscope, for both hairs and barbs were fragile in adult plant. However, there seemed to be of no doubt that the controlling genes were located on the same chromosome.

Summary

1. The inheritance of leaf sheath barbs, auricle hairs, stem rust reaction and "black chaff" disease in wheat was dealt with in this paper, using the variety Conley and two promising strains in test, ND 113 and (ND 105×ND 1), as crossing parents.

2. Conley had a smooth leaf sheath and amooth auricle. It was resistant to stem rust race 15B and was susceptible to "black chaff" disease. The other parents ND 113 and (ND 105×ND 1) had barbed leaf sheath, villous auricle, different stem rust resistance gene and "black chaff" resistance.

3. Barbed leaf sheath was dominant over smooth leaf sheath and proved to be controlled by a single genetic factor pair (Bb).

4. Hairy auricle (villous) was also found to be dominant over smooth auricle and was controlled by a single genetic factor pair (Vv).

5. Stem rust reaction was controlled by two genetic factor pairs in the cross Conley×ND 113, one factor contributed by each parent. Transgressive segregation was observed.

6. "Black chaff" reaction was controlled by a single genetic factor pair as in former studies (Bc Bc).

7. Linkage was indicated between auricle hairs and leaf sheath barbs. Three differing cross-over values were obtained from three related crosses 39%, 29%, and 25%. These differencs might be attributed to errors in classifying these minute characters.

美國康利小麥和北達哥他州二種春小麥之四種遺傳因子之研究

吳 旭 初　　葛倫・史密斯

利用二種比較早熟的春小麥，(ND 105×ND 1) 和 ND 113 分別和康利小麥雜交，研討葉鞘剛毛，葉耳剛毛，抗桿銹病及抗黑潁病四種因子的遺傳習性。

康利小麥的葉鞘和葉耳都是光滑沒有剛毛，對於桿銹病 15 B 具有抗病性，但是不能抵抗黑潁病，另外二種雜交親本 (ND 105×ND 1) 和 ND 113 它們的葉鞘和葉耳都具有剛毛，對於桿銹病和黑潁病都具有抗病性。根據分析的結果，葉鞘和葉耳的剛毛是受一對顯性因子所控制，它們的第一代雜種都具有剛毛，第二代雜種，剛毛和光滑分離的比例是 3:1。

桿銹病的抗病性是根據幼苗(四吋至五吋) 接種所得到的結果，接種的方法是用桿銹病菌 15 B 的夏孢子在溫室中完成的，為了容易做遺傳分析起見，祇用一種單純亞小種 32-S-15。分析的結果發現康利和 ND 113 小麥對於 15 B 銹病菌都有不同的抗病因子，這二種來源不同的因子，可以集中在一個後代，俾使抗病能力能够因抗病因子數目的增加而增强，此種集中不同因子數目，使後代的抗病性超過它的父母本的現象稱為超越抗病性(Transgressive resistance).

黑潁病的遺傳習性，根據田間和溫室處理的結果，是由一對遺傳因子所控制，第一代雜種的感染性是顯性，第二代感染對不感染的比例是 3:1。

親本 (ND 105×ND 1) 和 ND 113 它們的葉鞘和葉耳全部都生有剛毛，並且在雜種第二代裏，發現葉鞘有毛的植株，大多數的葉耳亦都生有剛毛，因為這種相連的現象便發現這二個因子的確是排在同一條染色體上，從三個雜交組合得到 39, 29 和 25 三個略為不同的交叉百分率，祇能歸於調查誤差的結果，不能做眞正的差異。

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