Dr. V. A. Johnson

UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

Crops Research Division

and cooperating

STATE AGRICULTURAL EXPERIMENT STATIONS

in the Hard Red Winter Wheat Region

# REPORT

# of the

# EIGHTH HARD RED WINTER WHEAT WORKERS CONFERENCE

Stillwater, Oklahoma
February 11-13, 1958

(NOT FOR PUBLICATION WITHOUT PERMISSION)[1/]

Agronomy Department
Agricultural Experiment Station
Lincoln, Nebraska
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FOREWORD

Ninety-three workers attended the Eighth Hard Red Winter Wheat Conference held at Stillwater, Oklahoma, February 11-13. All sessions of the $2\frac{1}{2}$-day conference were held in the Small Grains Building on the Oklahoma State University Campus. Thirteen states, Canada, and the U. S. Department of Agriculture were represented.

The conference was sponsored by the Hard Red Winter Wheat Improvement Committee composed of 25 members from 11 hard red winter wheat producing States. Members of the committee met on February 10, prior to the opening of the conference, to discuss future policy and objectives of the committee. Seventeen committee members representing seven states were present. Dr. L. E. Hawkins, Director of the Oklahoma Agricultural Experiment Station and Dr. L. P. Reitz, Head of the Wheat Section, U.S.D.A., also were in attendance and participated in the committee deliberations. Dr. A. M. Schlehuber, Chairman of the committee, will continue in that capacity until the next conference.

Objectives of the conference were to review and evaluate the regional research program and to make plans for research to be undertaken in future years. Regional nurseries, disease, and insect problems, environmental hazards, wheat quality, genetics and cytogenetics were among the many phases of wheat research included on the conference agenda. In order to allow adequate time for discussion at each session, consideration of the various topics on the agenda was largely limited to their implications in breeding work.

This report includes abstracts of presentations, informal statements, and other commentary as recorded by the conference secretary. In those instances where abstracts were not submitted or the record is otherwise incomplete, this report does not adequately reflect the excellent discussions and deliberations that occurred. Numerous editorial changes have been made in the interest of brevity and uniformity. It is hoped that the more important points have been accurately retained.

A word of thanks and recognition is due Miss Ione Rischling of the Nebraska Crop Improvement Association who served ably as conference recording secretary and assembled the material for this report. My thanks are extended also to the several session leaders who assisted me in editing the material. A special word of appreciation is due Dr. Schlehuber and his co-workers at Oklahoma State University who made the many preparations that contributed to the smooth functioning of the conference. Last but not least, the Oklahoma Wheat Research Foundation and the Oklahoma Crop Improvement Association are recognized for their sponsorship of the banquet and other evening activities that contributed to the relaxation and enjoyment of the conferees.

V. A. Johnson
Regional Wheat Improvement Leader

CONFERENCE PROGRAM

Tuesday A.M., February 11, 1958
8:00-Noon

Registration

Opening Remarks - A. M. Schlehuber, Chairman, Hard Red Winter Wheat Improvement Committee

The Regional Hard Red Winter Wheat Program - V. A. Johnson, Discussion leader

Regional Nurseries
- Yield evaluation
  - Field plots - - - - - - - - - - - - - - - - - - - - - - - - - D. E. Weibel
  - Uniform yield nurseries - - - - - - - - - - - - - - - - - - - E. G. Heyne
  - Uniform winterhardiness nurseries - - - - - - - - - - - - - E. R. Hehn
  - Relationship of uniform yield and uniform winterhardiness nurseries - - - - - - - - - - - - - - - - - - - - - - - - - V. A. Johnson
- Observation
  - Supplementary winterhardiness nursery - - - - - - - - - - - V. A. Dirks
- Disease
  - Uniform bunt nursery - - - - - - - - - - - - - - - - - - - - T. E. Haus
  - Uniform and internation rust nurseries - - - - - - - - - W. Q. Loegering
  - Screening winter wheats from world collection for rust resistance - - - - - - - - - - - - - - - - - - - - - - M. C. Futrell
  - Winter wheat soil-borne mosaic nursery - - - - - - - - - R. O. Weibel
  - Regional streak mosaic nursery - - - - - - - - - - - - - - R. C. Bellingham

Reporting of Data
- The annual regional report - - - - - - - - - - - - - - - - - - - A. M. Schlehuber
- Use of Biometrical Services at Beltsville - - - - - - - - - E. J. Koch

Tuesday P.M., February 11
1:15-3:15

Diseases - H. C. Young, Jr., Discussion Leader
1. Tolerance vs. complete resistance or immunity from the standpoint of stability and the race picture
2. An evaluation of the facilities and breeding effort concerned with: (1) Septoria leaf blotch; (2) dwarf bunt establishment in the region; (3) loose smut; (4) soil-borne mosaic
3. Accumulation of different genetic factors conditioning resistance--the feasibility and practicality of accomplishment
4. Breeding implications of the study of genes for virulence in the rusts

3:35-5:20

Insects - C. F. Henderson, Discussion Leader
1. Resistance problems in wheat - - - - - - - - - - - - - - - R. H. Painter
2. Present status of developing commercially accepted varieties of wheat resistant to insects and mits

A. Greenbug
Resistance screening tests; sources of resistance; host preferences, antibiosis, etc. Contributions by - - - R. H. Painter
E. A. Wood
N. E. Daniels
D. E. Weibel
H. L. Chada
T. L. Harvey

Agronomic characteristics and genetics of resistant hybrids Discussion led by D. E. Weibel. Contributions by - B. C. Curtis
E. G. Heyne
K. B. Porter
R. H. Painter

B. Hessian fly
Resistance screening tests; importance of fly races; status of commercial releases; source of resistance, etc. - - - - - - - - - - - - - - - - - - - - - - - - - W. B. Cartwright

Agronomic characteristics and genetics of resistant hybrids. Discussion led by E. G. Heyne. Contributions by - - - - - - - - - - - - - - - - - - - - - - - W. B. Cartwright
R. H. Painter

C. Wheat curl mite - - - - - - - - - - - - - - - - - - - - H. W. Somsen
T. L. Harvey

3. Testing irradiated wheat for resistance
A. Greenbug - - - - - - - - - - - - - - - - - - - - - - - - E. A. Wood, Jr.
T. L. Harvey
B. Hessian fly - - - - - - - - - - - - - - - - - - - - - - W. B. Cartwright
C. Wheat Curl mite - - - - - - - - - - - - - - - - - - - - H. W. Somsen

4. Comparative importance of insecticides, biological control, cultural control, and resistance for controlling wheat pests - - - - - - - - - - - - - - - - - - - - - - - - - E. A. Wood, Jr.
W. B. Cartwright
H. W. Somsen

5. Problems involved with low levels of insect infestation, and with species that occur in outbreak numbers at infrequent intervals - - - - - - - - - - - - - - - - - - - - General discussion

6. What should be done with strains that have about the same yield potential as varieties currently grown, but which are resistant to insects that present infrequent harzards General discussion

SOCIAL HOUR - 6 to 7 P.M., President's Suite, Union Club
BANQUET - (Courtesy Okla. Wheat Research Foundation) 7 P.M., Student Union

Wednesday A.M., February 12
8:15-10:15

Environmental Hazards - I. M. Atkins, Discussion Leader

| | |
|---|---|
| Shattering - - - - - - - - - - - - - - - - - - - - - - - - | K. B. Porter<br>R. W. Livers |
| Drought - - - - - - - - - - - - - - - - - - - - - - - - | V. A. Dirks<br>B. J. Kolp<br>R. W. Livers |
| Winterhardiness - - - - - - - - - - - - - - - - - - - - - - | V. A. Dirks<br>A. W. Pauli<br>R. E. Atkins |
| Vernalization - - - - - - - - - - - - - - - - - - - - - - - | D. E. Weibel |

10:25-12:10

Climate-Plant Relationship Laboratories - E. R. Hehn, Discussion Leader

1. Problems to be attacked by Climate-Plant Relationship Laboratory
   a. Production hazards resulting from weather extremes
   b. Genotype-environment interactions within the normal weather pattern range.
2. Possible approaches to genotype-environment interaction responses
   a. Uniform nurseries accompanied by detailed nicro and macro climate observations.
   b. Selection of a confined geographic area with wide climate variations for interaction observations
   c. Identification of primary response factors in climate areas of similar climatic patterns.
3. Degree of development of techniques for selecting for favorable responses to the primary climatic factors
   a. Limited to identification of factors
   b. Clarification of plant processes involved, possibly leading to rapid laboratory tests
4. Organizational nature of regional plant-climate relationships laboratory
   a. Central laboratory
   b. Central laboratory with sub-stations or contacts with experiment stations
   c. Dispersion of laboratory throughout the region with a feasible divirsion of areas of research

Wednesday P.M., February 12
1:30-3:15

Quality - John Shellenberger, Discussion Leader

| | |
|---|---|
| 1. Criteria of good quality wheat from the breeder's stand-point - - - - - - - - - - - - - - - - - - - - - - - - | K. F. Finney |
| 2. Implications of recent developments in turbo milling - - | J. W. Meyer |
| 3. Relationship of mineral content to flour quality - - - | R. K. Bequette |
| 4. Quality of irrigated wheat - Panel discussion - - - - - | I. M. Atkins<br>K. B. Porter<br>S. N. Vilm |

3:25-5:00

Miscellaneous Topics - E. G. Heyne, Discussion Leader

1. Use of multiline varieties or varietal mixtures
2. Breeding wheats for special environments - irrigation, high fertility, etc.
3. Use of dwarf or semi-dwarf wheats.
4. Value of high test weight wheats
5. Other miscellaneous subjects.
6. Current status of wheat genetics nomenclautre - - - - - E. G. Heyne

Thursday A. M., February 13
8:15-12:00

Genetics, Cytogenetics, and Irradiation - John W. Schmidt, Discussion Leader

A. Genetics of protein quantity and quality. Discussion initiated by K. F. Finney. Contributions by - - - - - - - - - - - J. E. Andrews
I. M. Atkins
E. G. Heyne
V. A. Johnson
R. Morris
A. M. Schlehuber

B. Gene accumulation for quantitative characters. Discussion initiated by V. A. Dirks. Contributions by - - - - - - E. R. Ausemus
E. R. Hehn
D. E. Weibel

C. The use of selective gametocides.

D. Cytogenetics in relation to:

1. Wheat aneuploids
   a. Use of common wheat aneuploids. Discussion initiated by L. A. Snyder
   b. Status of development of aneuploid stocks of hard red winter wheat - - - - - - - - - - - - - - - - - - - - J. E. Andrews
   E. R. Hehn
   E. G. Heyne
   I. V. Holt
   R. Morris
   L. A. Snyder
   c. Substitution of individual chromosomes into genetic background to study contribution of genes of individual chromosomes - - - - - - - - - - - - - - - - J. E. Andrews
   E. R. Hehn
   I. V. Holt
   R. Morris
   L. A. Snyder
   d. Summary of gene locations by chromosomes - - - - R. Morris
   e. Need for chromosome marker or tester genes - - - L. A. Snyder
   J. W. Schmidt
2. Irradiation
   a. Effect on the monosomic series - - - - - - - - - - E. G. Heyne
   b. Use to delete undesirable gene loci
   c. Use in gene transfer
3. Agrotricums, wheat-rye hybrids, and other intergeneric hybrids. Discussion initiated by A. M. Schlehuber. Contributions by - - - - - - - - - - - - - - - - - - - - - - - - J. E. Andrews
   I. M. Atkins
   I. V. Holt
   E. E. Sebesta
   C. O. Johnston
   E. McCracken

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## Tuesday A. M., February 11

**Opening remarks** by A. M. Schlehuber, Chairman, Hard Red Winter Wheat Improvement Committee

This conference will be one in which we will have an opportunity to think about and discuss our problems. Oftentimes we gather together to listen to a series of papers and then go home and forget them. This conference was planned with the idea of giving us something to think about. It is sponsored by the Hard Red Winter Wheat Improvement Committee appointed by the Experiment Station directors of the eleven States in the hard red winter wheat region.

### THE REGIONAL HARD RED WINTER WHEAT PROGRAM

V. A. Johnson, Discussion Leader

The hard red winter wheat regional program was initiated 25 years ago. This program has served us well. Will it serve us as well in the future? Perhaps some changes are needed in the organization of existing nurseries. Perhaps we are neglecting to do some things on a regional basis that need to be done. This session was organized in order that we might take a thorough look at our program, to evaluate it, and to make the changes that seem necessary to improve it.

To facilitate our deliberations on the regional testing program, I have asked certain people to initiate the discussion of the various nurseries and other topics on our agenda.

#### Field Plots

D. E. Weibel

Uniform plot tests vary from station to station in plot size and number of entries. Prior to 1953 most of the stations used large size field plots. Since then the majority of locations have used nursery plots. The number of replications has varied from 3 to 10. Agronomic, disease, and insect data are reported annually by the cooperator. Samples of grains are submitted to the Hard Wheat Quality Laboratory at Manhattan, Kansas, in 6 to 10 pound lots where they are milled and baked individually and in composite.

The region is organized by districts for uniform plot testing. These are the southern, central, northeastern, and northwestern. Check varieties for long-time comparisons are designated for each district. Stations generally grow and report on more strains than are included in the uniform list. Most of the stations growing the uniform plots also grow the uniform yield nursery.

The varieties grown uniformly in each district for 1957-58 are listed below. Permanent checks for each district are indicated with an asterisk.

| Southern | Central | Northeastern | Northwestern |
|---|---|---|---|
| Kharkof* | Kharkof* | Minturki* | Kharkof |
| Early Blackhull* | Pawnee* | Minter | Minter |
| Comanche | Comanche | Nebred | Yogo |
| Concho | Concho | | |
| Crockett | Bison | | |
| CI 12871 | CI 12871 | | |
| CI 13023 | | | |

Weibel: I would suggest that in the future we report data for the uniform varieties only.

Heyne: We should look to these uniform tests for regional information. They could serve for certain studies that might be of considerable value to us in this region.

Lowe: Information on plot varieties grown in other States have much value. It is helpful to have information on new varieties relative to their adaptation, etc. They should be included in the report for this information.

Walter: The same information is available from the uniform nursery in an earlier period of testing.

Atkins: Perhaps the field plots have served their purpose and we are at the place where we could drop them from the regional programs. I move that we drop the plot series as it is now constituted. Seconded by Heyne.

Johnson: I would like to hear whether other regions grow a plot series.

Ausemus: We still grow field plots in the spring wheat region. Different varieties are grown in the various sections. Varieties are not included in the plot series until after they have been tested in and are dropped from the uniform yield nursery.

Briggle: In the soft wheat region we do not have regional field plots. Some States grow large plots, but they are not a part of the regional program.

Curtis: If this motion is passed, would information on plot varieties still be included in the regional report?

Johnson: No.

Finney: If the regional plots are discontinued, we would have different varieties submitted for quality evaluations from each State and it would be impossible to make regional comparisons.

Schmidt: I suggest that we table the motion until the other nurseries are discussed.

## Uniform Yield Nursery

E. G. Heyne

Much of what Weibel said about the field plots also applies to the uniform yield nursery. It is grown in rod-row plots at 19 stations in the southern and central part of the region. Permanent check varieties are Kharkof, Blackhull, and Early Blackhull. Long time entries are Pawnee, Comanche, and Concho. The number of entries varies from 18 to 30. We all look to this nursery as a screening nursery for our advanced materials. The nursery provides a rapid method of evaluating materials. It supplies much valuable information on new things that are coming along. How long should varieties stay in the nursery? There should not be a hard and fast rule on this. We get adequate information on some varieties in three years. It is difficult to make a decision on other varieties in three years.

This nursery should be called the "uniform performance" "nursery instead of "uniform yield" nursery because it supplies much other information as well as information on yield. We should make more use of the nursery than we have in the past. We certainly should continue the nursery and perhaps consider using it for additional studies such as maturity, elevation, and temperature relationships.

Loegering: If you want to study the relationship of maturity and altitude, it would be far better to set up a separate nursery for this purpose. If you try to get too much information from one nursery, you will run into trouble. It is difficult to superimpose new objectives on an old nursery.

Young: If the uniform yield nursery can be used for additional objectives, why not use it?

Ausemus: We set up our spring wheat uniform yield nursery with the idea of getting pathological notes on it also. It serves well for both agronomic and pathological purposes.

Sill: To attempt to get other information from this nursery will mean nothing but trouble for those involved.

Heyne: These other factors can be studied if they are planned for in advance.

Finney: Assuming the field plots are discontinued, what quantity of seed of each variety would be available from the uniform yield nursery for quality testings?

Johnson: There would continue to be the usual one-pound lot of each variety from each location.

Atkins: I think we have too many checks in the uniform yield nursery. I recognize that we need some range in quality and maturity, however.

Heyne: This is a screening nursery. If we want to study long-time performance of varieties, let's set up a nursery for this purpose. We are evaluating new things in comparison with currently grown varieties. Therefore, checks should shift and should represent if possible a range of types.

Livers: The interest in specific varieties as checks will vary from station to station.

D. Weibel: If a State is interested in a particular variety on a long-time basis, it could be grown in a State nursery.

Shellenberger: Perhaps we are oversimplifying the purposes of the nursery. Testing of varieties and strains involves a great deal so far as the public is concerned. We should think beyond what is good for just the plant breeder.

Heyne: Regional tests provide information on the agronomic and quality characteristics of a variety and they provide research information from a regional standpoint.

## Uniform Winterhardiness Nursery

E. R. Hehn

This nursery provides information on winterhardiness as well as yield and other agronomic characteristics. Records on the nursery go back to 1948. Varieties that have been in it since the beginning are Minturki, Kharkof, Minter, Yogo, and Nebred. None of these has been designated as a check variety although that is what they are. Nursery locations are Laramie, Archer, and Sheridan, Wyoming; Alliance, Nebraska; Ames, Iowa; St. Paul and Waseca, Minnesota; Brookings, South Dakota; Dickinson, North Dakota; Havre, Montana; and Lethbridge, Alberta.

I would suggest that entires in this nursery be kept to a minimum. Each State should screen its material well before entering it in the regional nursery. We should have "indication" varieties for winterhardiness if we can find them. Agreement between stations in a single year is generally poor. We also should carry permanent check varieties.

## Relationship between the Uniform Yield and Uniform Winterhardiness Nurseries

V. A. Johnson

You have just heard discussions of both nurseries. What should be the relationship between them? In the beginning there was little relationship other than that both were replicated yield nurseries each containing a uniform but different set of entries. Acceleration of winter wheat research in South Dakota, Wyoming, and Montana increases the need and importance of the uniform winterhardiness nursery. Winter wheat acreage is increasing in these States. Nebraska and Iowa, because of their location in the region, submit material for evaluation in both nurseries. However, an entry usually goes into one or the other of the nurseries. The question arises as to how a variety grown only in the uniform winterhardiness nursery should be handled prior to release and distribution. Should it be included in the uniform yield nursery for a year or two and vice-versa in the case of materials originally in the uniform yield nursery? Actually, at present the uniform winterhardiness nursery is the northern counterpart of the uniform yield nursery. Its name is a misnomer, since winterhardiness is only one of several important characteristics on which data are taken.

Schmidt: Varieties in the uniform yield nursery should also be entered in the uniform winterhardiness nursery after three years of testing in the former.

Johnson: What shall we do with the tabled motion concerning the uniform plot series?

Reitz: I am very much concerned about the total implications of this motion. I suggest we drop the plot series in the northern districts and that this be the only change that we make in the uniform plots at this time.

Atkins: I withdraw my motion.

Heyne: I withdraw my second to the motion made by Atkins.

Weibel: It seems that everyone is concerned about the quality angle, I move that the plot series as it is now set up be dropped and that a uniform quality series be initiated for each district. (Motion seconded by Schmidt. Motion carried.)

Lowe: I move that the uniform yield nursery be designated the uniform performance nursery. (Seconded by Heyne. Motion carried.)

Schmidt: I move that the uniform winterhardiness nursery be redesignated as the northern uniform performance nursery and what was formerly the uniform yield nursery be designated as the southern uniform performance nursery. (Seconded by Heyne. Motion carried.)

## Supplementary Winterhardiness Nursery

V. A. Dirks

Analysis of survivals in the supplementary winterhardiness nursery together with other information was presented by Dirks. His data indicated that the low-surviving and high-surviving materials in the nursery could be identified easily, but that materials falling in the intermediate range of survival were very difficult to classify at a location in any one year. On the basis of his analysis, Dirks suggested that three key stations be set up for the supplementary winterhardiness nursery, approximately 200 miles apart, with 3 or 4 replications at each location. A usable level of winterkilling would be expected to occur at one of the three stations in any year, and over a period of years better information would be acquired than from the present 2-replication nurseries at several locations.

After some discussion, Reitz moved that Dirks' suggestion be referred to a committee composed of representatives from each area and the regional leader -- the committee to be appointed by the chairman. (Motion seconded by Dirks. Carried.) V. A. Dirks and I. M. Atkins were appointed to serve with Dr. Johnson on the committee.

Schlehuber: In view of our action on renaming the other nurseries, I move that the supplementary winterhardiness nursery be renamed the Uniform Winterhardiness Nursery. (Seconded by Schmidt. Motion carried.)

## Uniform Bunt Nursery

T. Haus

This nursery is grown in two replications at Denton, Stillwater, Manhattan, Lincoln, North Platte, Ft. Collins, Bozeman, and Spring Hill. Selections are evaluated for bunt resistance before they are entered in regional yield nurseries. Bunt inoculum used by each State represents as nearly as possible the types of bunt that occur in that State. Relief, Hussar, and Oro serve as resistant check varieties. Cheyenne and Red Chief are susceptible checks.

It was recommended that the nursery be continued at all locations except Spring Hill, Montana. It was further recommended that new entries in the uniform bunt nursery be sent to the Regional Smut Laboratory at Pullman, Washington, for evaluation of resistance to dwarf smut. Length of rows in the nursery will continue to be 10 feet except where land limitations require them to be shortened.

## Winter Wheat Rust Nurseries

W. Q. Loegering

Three nurseries for making rust tests on winter wheats are coordinated from Beltsville. They are the International Winter Wheat Rust Nursery, the Uniform Winter Wheat Rust Nursery, and the Seedling Test Nursery. The purpose of all these is to study the wheat rusts, but each nursery has somewhat different objectives.

### International Winter Wheat Rust Nursery

The International Winter Wheat Rust Nursery is maintained from the plant breeder's point of view and furnishes a means of obtaining adequate tests on rust resistance of winter wheat. It has two major objectives:

1. To find and prove new sources of resistance to leaf and stem rust. New sources of resistance are mostly obtained through screening of plant introductions in the World Collection. However, the plant breeder's own program is another little explored source of materials. Breeders and plant pathologists are urged to watch for lines of **highly** resistant winter wheats in their plots, without regard to agronomic characteristics, particularly in crosses of winter wheats with rust-resistant spring wheats.

2. To make tests on breeders' selections to determine if satisfactory resistance has been transferred to potential varieties. This is a selection test, and there is no set limit to the number of entries from any single breeder. Common sense will determine the total number of entries in the nursery. Under special circumstances the nursery may have up to 400 entries, though 2 to 3 hundred is more reasonable. While it is expected that all entries will have shown some resistance before they are entered in the nursery, the idea is to include new materials to learn if their resistance is good - not because it is known to be good.

The idea of international testing is to obtain tests with as many different race populations as possible. To do this it is both cheaper and safer to take the wheats to the rust than to bring the rust to the wheat in this country. The cooperation which the plant pathologist and plant breeders of the several countries give in helping us test our wheats is too often taken for granted, but it should be remembered that the large amount of valuable information at present on rust resistance in winter wheats could not be obtained without the aid of the many cooperators in other countries.

The nursery is planted in about 10 countries at latitudes north and south of the Tropics, as it has been found that winter type wheats generally do not head normally in the torrid zone regardless of altitude. A total of 32 nurseries are prepared each year during the first week of September. Five grams of seed of each entry are put up for each nursery. Therefore, about 150 grams of seed of each entry are needed at Beltsville by the end of August.

### Uniform Winter Wheat Rust Nursery

The Uniform Winter Wheat Rust Nursery is operated primarily from the plant pathologist's point of view. Its objectives are to study the distribution and prevalence of rust, to furnish a source of rust collections for race identification, and to test parental materials, commercial varieties, and advanced generation material to the rust populations occurring in the United States. Attempt is made to limit the number of entries in this nursery to less than thirty. About half the entries are included to assist in studies of rust itself. The other half is material being tested for plant breeders, but no variety should be entered for testing unless it has been screened through the International Winter Wheat Rust Nursery or has promise of becoming a commercial variety. The Uniform Nursery is included in the International Nursery, and approximately 300 grams of seed of each entry are needed by the end of August. A detailed discussion of the objectives and methods to be used with this nursery will be distributed with the 1957 Uniform Rust Nursery Report.

International Seedling Test Nursery

The tests made in the International and Uniform Winter Wheat Rust Nurseries are on adult plants in the field to populations of rust races. This furnishes valuable information on the general resistance of varieties. The objective of the Seedling Test Nursery is to obtain data on specific seedling resistance against prevalent races of rust and potentially dangerous but non-prevalent races. The principal purpose of this is to prove the value of given lines as rust-resistant parents in a breeding program. Entries for this nursery should in general be breeding materials - both those in use and those of potential value. Usually this nursery is assembled about every other year. It will have two sections in the future - one for tests with stem rust races and the other for tests with leaf rust races. The next nursery will be assembled in tha fall of 1958. Tests are conducted at locations throughout the world where an active race identification program is in progress.

## Soil-borne Mosaic Nursery

R. O. Weibel

The Soil-borne Mosaic Nursery is a naturally infested area located on the Agronomy South Farm at Urbana. It is an area roughly 115 by 300 feet. Each year one-half of the area is used for testing winter wheat material, and the remaining half is seeded to alfalfa (fall seeding following the wheat). Duplicate single rows 4 to 6 feet long and one foot apart are used for determining the reaction of the material planted. The variety Illinois #2 has been planted as the check variety. It is used as border and also at 20-foot intervals across the field. This provides a means of checking the uniformity of infestation over the entire area.

Mosaic readings are taken about the last week of April or the first week of May. Rosette reaction readings are based on estimates of plants rosetted. Mottled reaction readings are based on estimates of leaves mottled. Severe mottling refers to plants which are definitely stunted by the disease and which do not recover. Mild mottling can be quite high and the plant recover if growing conditions are favorable.

The area was first used as a disease nursery during the 1954 crop season. Material other than that from Illinois has been tested in the nursery starting with the 1955 crop. There were 118 entries of hard red winter wheat included in 1955. Only three showed a high type of resistance to both the rosette and the mottling type of reaction. They were C.I. 12517 (Concho), C.I. 12871 (Med-Hope-Paw x Oro-Ill-Com) and K49-422 (Quivira-Tenmarq x Marquillo-Oro).

In 1956 there were 187 entries, 110 submitted by Virgil Johnson and 77 by Elmer Heyne. Three entries from Johnson, C.I. 12517 (Concho), C.I. 12804 (Ea.Blkh-Tq x Oro-Med-Hope), and C.I. 13115 (Cheyenne-Chiefkan x H44-Minturki), showed a high type of resistance to both rosette and mottling. There were a number of resistant lines in the material from Heyne. In 1957, Virgil Johnson submitted 127 entries and Lee Briggle 22. Seventeen of these entries were highly resistant to both rosette and mottling. They were:

| | |
|---|---|
| C.I. 12517 | Concho |
| C.I. 13023 | Kanred-H.Fed.-Tenq. x Med-Hope x Cimarron |
| C.I. 13024 | Cimarron-Hope-Chey.-Comanche |
| C.I. 13187 | Blackhull-Oro x Pawnee |
| STW 536633 | Concho x Triumph |
| STW 536937 | Concho x Triumph |
| STW 536671 | Triumph x Concho |
| TK 55R454 | Ponca Selection |
| TK 55R455 | Ponca Selection |
| TK 55R456 | Ponca Selection |
| 531538 | Wichita x Nebred |
| KIN2 | McM-Exch.-Redman$^3$ x Chey. |
| K. 22 | Pawnee Sel. 136 |
| 52-277-42 | Triumph x Marq.-Oro-Comanche |
| 53-633-212 | Pawnee-Marq.-Oro x Red Chief-Nebred |
| 53-491-54 | Pawnee-Marq.-Oro x Chiefkan-Ea. Blackhull-Tenq. |
| 55603 (201 Rep.2) | Chey.-Red Chief x Pawnee-Marq.-Oro |

There were approximately 750 entries from Illinois material tested each of these years. Of interest in this material are several highly resistant lines involving Pawnee and Comanche. The crosses involved Pawnee 9 x Ill. 37-1146 and Ill. 37-1146 x Comanche. Ill. 37-1146 is a selection out of the cross Kanred-Red Rock x Purdue 21-2-11. The 1958 nursery includes 21 entries submitted by Briggle, 109 by Johnson, 181 by Indiana, 50 by Texas, and 870 by Illinois.

## Regional Streak Mosaic Nursery

R. C. Bellingham

This nursery was established in 1957 and grown at 10 locations in Oklahoma, Kansas, Nebraska, Colorado, and Montana. Disease data were obtained from five of the locations. The nursery is seeded in 5-foot rows in two replications. One-half of each row is inoculated in the fall. Local inoculum is used in each State. This is an observational nursery in which selected wheat strains representing the range in varietal reaction to streak mosaic will be evaluated at several locations to ascertain the extent to which strains of the virus and environment condition varietal response. The nursery also will allow future uniform screening of mosaic-tolerant materials derived from breeding work now in progress.

It was suggested that in the future BlueJacket, Pawnee, and Kansas Sel. 462666 be used as check varieties instead of Stafford and Pawnee. The use of a single virus strain at all locations was discussed. Several people objected to this. The establishment of a uniform system of note-taking was discussed at an evening meeting of pathologists and agronomists concerned with streak mosaic. In 1958, the nursery will be rated on the basis of 5 classes with 1 the best and 5 the poorest. The extreme classes are to be described verbally. Separate ratings will be made for stunting and yellowing or mottling.

## Regional Reporting

A. M. Schlehuber

A questionnaire in which five questions were asked concerning the usefulness of the annual regional report of cooperative investigations was sent out to 42 people in the region. Twenty-six were returned. Answers to the questions were summarized as follows;

1. Should these reports be continued?

   All 26 answered yes.

2. No changes needed . . . . . . . . . . . . . . . . . . .18

   Some change needed . . . . . . . . . . . . . . . . . 8

   Major changes needed . . . . . . . . . . . . . . . . 0

3. Which portion of the report is of most use?

   Summary tables . . . . . . . . . . . . . . . . . . . 7

   Uniform yield nursery data . . . . . . . . . . . . . 6

   Uniform and supplementary winterhardiness nursery data . . . . . . . . . . . . . . . . . . . . 5

   Uniform plot data . . . . . . . . . . . . . . . . . . 2

   Miscellaneous information (new C.I. numbers, new varieties, personnel, etc.) . . . . . . . . . . . 4

   All seem important . . . . . . . . . . . . . . . . . 2

4. What portion of the report could easily be eliminated?

   All 18 said "None".

5. What portion of the report should be enlarged?

   10 said none

   10 suggested an index on key data

   One person suggested more statistical data

A report on the Biometrics Laboratory established at Beltsville, Maryland, in 1953, was given by James Koch, a representative of the laboratory. The availability of the laboratory for analyses of regional data and other data collected by A.R.S. employees in the field was discussed.

The need for a standard set of varietal abbreviations in wheat was discussed briefly. Heyne reported that Kansas was attempting to develop such a set for use by Kansas workers. The question was asked as to whether an attempt should be made to develop a set of abbreviations on a regional or national basis.

Futrell moved that the chairman appoint a committee to study the problem and develop a set of abbreviations in wheat for regional use after consultation with wheat workers in other regions. (Motion seconded by Loegering. Carried.)

The suggestion was made by Loegering that the committee contact the Rockefeller Foundation for information on work they have done in developing uniform abbreviations for varieties.

Tuesday P. M., February 12

DISEASES

H. C. Young, Jr., Discussion Leader

The session on diseases was a group discussion without formal presentation of papers. Two general topics were discussed as follows: (1) Tolerance versus complete resistance or immunity from the standpoint of stability and the race picture, and (2) evaluation of the facilities and breeding effort concerned with Septoria leaf blotch, dwarf bunt, loose smut, and soil-borne mosaic.

<u>Tolerance Versus Complete Resistance</u>

Christensen led off the discussion by saying that in his opinion tolerance was a substitute for resistance. Johnston stated that when certain varieties were compared, some could be termed tolerant and others not, and that the word tolerance might indicate a certain degree of resistance. Loegering then stated that in the final analysis the tolerance or resistance of a plant is determined by the reduction in green surface area of the plant affected. Tolerance might be indicated by a delay in the onset of necrosis. Johnston confirmed that there was a definite relationship between resistance or tolerance and the reduction of chlorophyll in the active tissues. Young brought up the question of whether or not what we have been calling tolerance is actually an inherent capacity for yield, or does tolerance mean yielding in spite of the presence of some disease or diseases? Caldwell mentioned that perhaps some varieties yield the same whether or not they are affected by disease.

V. Johnson questioned whether enough attention was being paid to the measurement and utilization of tolerance. Ausemus indicated that they were not breeding specifically for tolerance at Minnesota, but that if it appeared they were grateful!

Loegering suggested that perhaps in other diseases tolerance was more important than in the work with rusts. Sill said that in the work with yellow streak mosaic virus they grew the best plants and strains, whether they were called tolerant or moderately resistant. He thought that with tolerant varieties there was less chance for new strains or races of disease to develop rapidly. He felt that there was abundant evidence to indicate that when true resistance or immunity was used new strains or races would develop rapidly and cause considerable crop loss. Young questioned whether Sill was using disease symptom severity or yield to measure tolerance, and Sill replied that they considered a variety tolerant which yielded better than another in spite of susceptibility.

Schlehuber asked what difference it made whether a plant was called tolerant or resistant, and Fellows added that we did not have the knowledge requisite for making such a decision now. He felt that more basic research was needed before we could differentiate between tolerance and resistance.

He then brought up the question of how losses could be measured. Loegering said loss measurements could be made on the basis of leaf infestation. Fellows indicated that there were other factors involved besides the loss of chlorophyl, and pointed out as an example the loss of water. Johnston said that he had removed all the leaves from wheat plants once and found little difference in the yield.

The discussion then turned to the need for basic research and the possibilities of getting support. Hawkins challenged the group to submit a project with proper justification for the use of funds and he was sure that such worthwhile projects would be approved. Sill stated he thought there was a need for less formalized types of projects and suggested that a researcher be allowed much latitude in the choice of what was done on a particular problem. The idea of post-doctoral study and research was injected here. Reitz said that they have never turned down projects because of the fundamental research element. He thought much of the limitation on fundamental research was in the minds of the investigators themselves.

Bringing the discussion back to the question of tolerance, Reitz asked if the leaf rust workers had any variety for measuring tolerance to rust. Johnston answered that they used the variety Blackhull. Reitz indicated that more attention should be devoted to tolerance to leaf and stem rust in the tests we have. Atkins said that in oats the Red Rustproof variety was a standard of tolerance and that farmers in the south Plains returned to this variety when the newer varieties became susceptible to disease because of new races or strains.

Young then asked if this tolerance could be recognized so that it could be transferred and used in the present breeding programs. Sill stated that they were using the tolerance they had to yellow streak mosaic and were trying to improve upon it by combining different sources of tolerance.

V. Johnson closed out the discussion of tolerance by stating that in this region we could not afford to overlook tolerance - whatever it is or however we define it - nor could we afford to take it lightly. He thought perhaps we should be more concerned with how a plant performed than how it looked with respect to disease infection.

## Evaluation of Facilities and Breeding Effort Concerned With:

### Septoria Leaf Blotch:

The discussion was started with a question by Young concerning the effort that was being made to develop resistance to Septoria leaf blotch. Caldwell stated that they had done some work on this in Indiana. They found that

Lerma 50, a spring wheat from Mexico, had a high degree of resistance and were in the process of transferring this resistance to the soft red winter wheats. He also stated that in 1957 losses due to this disease measured 22 to 26 percent in plots that had been treated with a fungicide, and in check plots the loss was as high as 37 percent. Since Septoria leaf blotch is a cool-weather disease, he said, infection comes early and causes more damage on the early varieties. Fellows said he thought most agricultural experiment stations had facilities for studying Septoria leaf blotch. However, in Kansas they were making no direct effort to breed for resistance to Septoria. Futrell asked how important it was to control Septoria leaf blotch. Roland Weibel answered by saying that they had a severe epidemic in 1957 and that he thought they needed to devote considerable effort to developing resistance to this disease. He said that in Illinois many fields were defoliated before they headed out. He also indicated that the disease was quite prevalent during the current season in Illinois. Futrell asked how often Septoria would defoliate the plant before blossoming time, and Johnston's answer was that it depended upon the variety. Futrell replied that in Texas the variety Triumph was very susceptible and that in 3 years out of 8 defoliation occurred before flowering.

Loegering asked about the effect of rainfall upon the development of Septoria leaf blotch. Futrell replied that tests had shown less development of Septoria in years of light rainfall. Fellows stated that it took 72 hours of wetting period for the infection process with Septoria, and that the complete incubation time was about 27 days. Compared with rust, this is a very long incubation period. Young added that with at least some strains of Septoria infection could be obtained with 48 hours of wetting period and that the complete incubation period could be as short as 10 to 14 days. He also stated that total rainfall may not always be directly associated with Septoria development, since long periods of light rainfall are more effective in Septoria infection than shorter heavy showers.

<u>Dwarf Bunt Establishment in the Region</u>:

Johnson said that Nebraska was carrying along dwarf bunt resistant material in their program, and that they were using some of this material in crosses with hard red winter wheats. Hansing stated that they had not found any dwarf bunt in Kansas and he thought there was a good possibility that it would never become established in our region. However, they were using dwarf bunt resistance sources as well as sources with resistance to other bunt races in their breeding work. He indicated that they had on hand supplies of as much as 2 bushels of seed of certain dwarf bunt-resistant selections. He said they were not as high yielding as the varieties now grown commercially, but they would serve as stop-gap varieties in case of dwarf bunt epidemic. Caldwell said they had never found dwarf bunt in Indiana, but there were some records which indicated it had been found there as early as 1900. Since it has not been a problem there, they were not devoting any breeding effort toward resistance.

The discussion then turned to the problem of testing for dwarf bunt resistance. Hehn said he thought it would be better if the dwarf bunt nursery were planted somewhere else in place of the planting at Spring Hill, Montana. Johnson said that the laboratory at Pullman, Washington, had always been available for testing or screening dwarf bunt material. Reitz added that the workers at Pullman were working with new techniques for developing dwarf bunt in nurseries and he thought the testing could be done there more precisely than has been possible at Spring Hill. Johnson suggested that the Spring Hill planting be discontinued and that new entries in the bunt nursery, or other material which anyone desired to have tested, be so designated and he would see that it was sent to Pullman, Washington, for testing.

Loose Smut:

Hansing said they were interested in developing a high level of resistance to loose smut in the program in Kansas, but so many factors for resistance were involved it was almost impossible to combine them all in one variety. He felt that, even though they did not attain the high degree of resistance evident in varieties such as Pawnee, progress in the control of loose smut with moderately resistant varieties was being made. Schafer said that they had a serious loose smut problem in Indiana, and that they, too, had had great difficulty in transferring resistance to the desirable wheat types.

Young then raised the question of methods of inoculation and said in Oklahoma they had not had very satisfactory results with any of the methods in common use. Christensen said that the spray blast method developed by Moore was giving excellent results in Minnesota. Weibel said they had good results with the spray method in Illinois, but Hansing said in Kansas they had better results with the vacuum method, applied early, than they had with the spray method. Heyne thought they were getting satisfactory results in Kansas simply by carefully weeding out the selections in their breeding nurseries which showed any loose smut.

Discussion then turned to control of loose smut by treatment of the seed. D. Weibel said that the soak treatment used in barley loose smut control would not work with wheat. He said that soaking wheat for 4 hours at 70-75° F., draining off the water, and then holding the seed in an air-tight container for 4 to 5 days gave fairly good control of loose smut and that the germination was good. Loegering said that in their tests they found no reduction in germination, and that there was a correlation between the temperature and the length of time the grain must be held in the container to get control.

Soil-borne Mosaic:

Sill said that in Kansas they had good results controlling this disease with resistant varieties. Fellows said they were not devoting much breeding effort to developing resistance to this disease because it was very easy to find resistant selections within susceptible varieties. Sill added, however, that the selections might be offtypes or mixtures and that all such selections had to be rigidly tested to determine if they were the same as the varieties from which the selections came. Caldwell said that very few of the soft red winter wheats were susceptible to soil-borne mosaic, but that most of the breeding material from other areas was susceptible. Therefore, they subjected their breeding material to tests for resistance.

# INSECTS

C. F. Henderson, Discussion Leader

## Teamwork Essential in Development of Resistant Varieties

C. F. Henderson

The development of wheat varieties resistant to insect and mite attack requires the services of a well organized team of entomologists, plant breeders, agronomists, and cereal chemists. The entomologist searches for resistant germ plasm for use in the breeding program by screening lines of wheat from such sources as the World Collection. The plant breeders then evaluate the resistant lines and cross the more promising ones with commercially acceptable varieties in order to transfer the resistance to high quality wheats. The hybrids are then planted in the field and observed for agronomic qualities such as plant type, winter hardiness, stiffness of straw, yield, etc. During this process the hybrids are screened for resistance, so that the more resistant types may be selected early in the breeding program and the susceptible ones discarded. Finally, the cereal chemist is called upon to test the acceptable varieties for milling and baking quality.

## Resistance Problems in Wheat

R. H. Painter

Wheat as a crop is unique in the number of varieties that have been distributed partly because of their resistance to insects. The only competitor for this distinction is corn, where the information is blurred by the presence of secret pedigree hybrids. In wheat, seven varieties have been distributed that carry resistance to hessian fly and three that carry resistance to the wheat stem sawfly. Definite progress has been made in breeding for resistance to the greenbug.

Hessian fly-resistant wheat is also notable in the measurable effect secured in California and Kansas in control of that insect.

The three insects mentioned were possibly the major insect hazards to wheat production in the Great Plains region. The most important breeding for resistance that remains to be done involves grasshoppers and mites. Both must be studied on an insect species basis. Possibly resistance to head clipping by grasshoppers is on a separate genetic basis from leaf feeding.

In both these groups what is badly needed is a satisfactory method for studying large numbers of individual plants, as has been done with hessian fly, sawfly, and greenbug resistance. It is important to find and utilize against all these insects the maximum number of genes for resistance.

Under drought conditions greenbugs or mites have frequently been the final blow that killed the wheat plant. It has been difficult to breed for drought resistance, but if one can breed for aphid or mite resistance it should be possible to alleviate this part of the hazard of wheat growing in the western Great Plains.

## Greenbug Screening Tests and Agronomic Characteristics of Resistant Hybrids

Painter: The search for additional sources of resistance to greenbugs in wheat is important: (1) to find higher levels than present in Dickinson; and (2) to find additional genetic factors for resistance as a possible defense against biotypes of the aphid. At Manhattan, the following foreign plant introductions have been screened:

| Kind | Number screened | Number saved | Record numbers more resistant sel. |
|---|---|---|---|
| Winter wheats from U.S.D.A | 1,118 | - | testing not complete |
| Spring wheats from U.S.D.A | 1,023 | 2 | P.I. 94558; 94734-1 |
| Mexican spring wheats from Rockefeller Foundation | 1,200 | 3 | 367, 883, 502 (?) |
| | 3,341 | | |

Screening of these wheats has been based on the tolerance reaction as already described (Painter & Peters 1956). The basis of tolerance may be complex; the genetics will be discussed Thursday. The resistant selections named are apparently no more resistant than Dickinson; the Mexican wheats are less resistant but may carry different genetic factors.

Antibiosis and non-preference are both present in resistant material studied, but differences appear to be small and difficult to use in a breeding program with methods now available. Tolerance has been so used successfully.

Wood: We have screened over 7000 lines of the World Collection and have found no common winter wheats with any degree of resistance. We have found two spring vulgare lines which show a very high degree of tolerance. These are Dickinson Sel. 28-A and C.I. 9058, which are capable of producing seed under a heavy, sustained greenbug attack. Of the 7000 lines tested, 111 showed enough tolerance for re-screening. Nineteen of this group, 14 durum and 5 vulgare lines, have been saved as a source of resistant germ plasm. Resistant varieties will give us a permanent type of control as compared to the temporary and often expensive type of control obtained with insecticides.

Daniels: Crosses between the greenbug-resistant Dickinson selection and several commercial wheat varieties were made in 1955. The $F_1$ plants were grown in the greenhouse in 1956. The $F_2$ progenies from the crosses were screened during the period September 1956 to March 1957 in order to discard the susceptible segregates. Results of this study suggest a difference of one major factor for controlling resistance between the Dickinson selection and the commerical varieties tested, although modifiers may be present. Dominance relationships were not clearly defined. A relatively small number of $F_1$ plants tested tended to be intermediate to the parents, which indicates a lack of dominance. The $F_2$ distributions indicate that dominance of susceptibility is not complete, although the larger percentage of the $F_2$ populations was placed in the more susceptible classes. When the data were fitted to a 3 to 1 ratio they gave a chi-square value which would confirm the ratio of three susceptible to 1 resistant. Approximately 200 $F_3$ lines of the above wheat hybrids were tested in 1957 and 1958 for greenbug resistance. Twenty-eight of the $F_3$ lines were from the above tested $F_2$ plants and the remaining $F_3$ lines were from unselected $F_2$ plants (not tested for greenbug resistance). The 28 $F_3$ lines from the selected $F_2$ plants showed more resistance than those from the unselected $F_2$ plants. This indicates that the testing and selecting for greenbug resistance has been of value. It is obvious that the length of time tests are conducted and the severity of the infestation will influence the results of resistance studies. The hybrids were: Dickinson x Kanred, Dickinson x BlueJacket, Dickinson x Crockett, and Dickinson x Vaughn Turkey.

Weibel: $F_2$ plants in the field at Denton in 1955 from crosses with Dickinson Sel. appeared vigorous and developed normally without differences between spring- and winter-type plants being observed. $F_3$ lines in the 1956 field tests, however, showed that there was a predominance of spring-type plants. Greenbug reaction was the only basis used for selection, however, in the 350 rows grown. Only a very few rows appeared to have good agronomic characteristics and usually these were susceptible to greenbugs in the insectary tests.

This past year it was impossible to tell much about agronomic type in our plantings of the $F_4$ at Denton. In general, all 1500 rows were very poor. They seemed to be very susceptible to *Septoria tritici* and/or to some other defoliating diseases or troubles.

Our present thinking is that two or more cycles of breeding will be necessary to produce acceptable agronomic types with resistance to greenbugs. Backcrosses have been produced. Approximately 2600 head rows in the field at the present time will be screened carefully (conditions permitting) for winter-types with greenbug resistance for use as donor parents in additional crosses.

Chada: Most of our resistance studies at Denton are in connection with barley and oats, although some work has been done recently on wheat. Our resistance studies were primarily to find resistant germ plasm for use in the breeding program. We have found resistant plasm and this is being transferred to acceptable varieties. Since none of the domestic varieties of oats had any degree of resistance, we went to the World Collection where some resistance was found. Much of the work at Denton is the testing of lines made by Dr. Dale Weibel. We need to do a lot of basic research to determine why certain lines are resistant. We think that it is physiological. There seems to be a direct correlation between ascorbic acid content and high resistance.

Wood: As resistance is an inherited quality, it is practical to make selections of plants which survive insect infestation and use these plants as a source of resistance. Occasionally a mutation occurs which is unlike the parent in many respects. With this idea in mind, a large amount of Concho wheat seed was subjected to irradiation in an attempt to select mutants showing some degree of greenbug resistance.

Approximately 170 Concho $X_2$ lines were planted in flats in the greenhouse and subjected to a heavy infestation of greenbugs. All plants tested, with the exception of one, were found to be as susceptible as non-irradiated Concho plants growing in the same flats. This plant was saved for seed and planted in a subsequent test. All the progenies of this plant were found susceptible. However, in a large scale operation, it is possible that a desirable mutation may be found.

## Inheritance of Greenbug Resistance in Wheat

Weibel: The greenbug (*Toxoptera graminum*) is one of the most serious pests of small grains in the Central and Southwestern States. Severe outbreaks of these insects causing losses estimated at more than 50 million bushels of grain occurred in 1907, 1942, 1950, and 1951. Lesser damage has resulted in other years.

Insecticidal control of greenbugs is possible but is expensive and may not be practical in areas of low average yields. Greenbugs thrive when it is too cold for natural parasites and predators to develop.

In 1954 workers at Stillwater discovered a highly resistant selection in Dickinson durum. This Dickinson Selection is a spring-type common wheat with 21 pairs of chromosomes. It was after this break-through that efforts began in earnest to breed resistant adapted varieties. Since then other good sources of resistance have been discovered.

At Denton the first crosses were made in the spring of 1954. One of these was Hopei (C.I. 11059) x Kan-HF-Tq x Med-Hope-Cim (Sel. 274-50-1). C.I. 11059 is one of several oriental wheats tested at Denton in 1953 and 1954. Certain ones were considered to have some resistance to greenbugs when compared to Pawnee. This was before the days of Dickinson selection. C.I. 11059 was sown in the greenhouse along with several others and happened to match up for the above cross. C.I. 11059 is somewhat of a winter type.

The material was classified into damage classes as follows: Class 1 to 3 = 41 to 60, 4 = 61 to 80, and 5 = 81 to 100 percent of leaf area damaged in controlled insectary tests.

C.I. 11059 fell into classes 2 and 3 in these tests, while 274-50-1 piled up in the 3 class giving the impression of having a low level form of resistance to greenbugs. $F_1$ plants were rated intermediate or 3's. The $F_2$ population was classified largely into the 2, 3, and 4 classes. By grouping classes 1, 2, and 3 as resistant and 4 and 5 as susceptible, a ratio of 9:7 was a plausible explanation. This would mean two factors, both necessary to give resistance. This is not quite consistent with the observed reaction of the parents and $F_1$.

Tests of $F_3$ lines resulted in the resistant, segregating, and susceptible classifications that fit a 1:8:7 ratio very well and is what would be expected from a 9:7 classification of $F_2$ plants. First generation backcross plants fell into classes 2 and 3, as might be expected from the original hypothesis.

In the second cross Dickinson Selection was combined with 256-50-7. The latter is a selection from the cross Cimarron x Hope-Cheyenne (C.I. 13022). Dickinson Selection gave mostly class 1 plants, but a few were rated as susceptible; and selection 256-50-7 rated largely as 5 plants, but a few were considered resistant. $F_2$ data when grouped as before fit a ratio of 3:1. The $F_3$ lines did not fit a ratio. The resistant class was too small for a 1:2:1, but strangely enough the second generation backcross lines had resistant lines when they were not expected.

The third cross was Dickinson Selection x 274-50-1; the latter being the same parent used in the first cross, a selection from Kan-HF-Tq-Med-Hope x Cimarron. The Dickinson Selection parent rated mostly resistant and the 274-50-1 had some plants in the 3 class, again suggestive of the possibility of a low level form of resistance. However, the grouping of classes 1 to 3 and 4 to 5 as before did not fit a 9:7 ratio, as might possibly be expected, because there were too many resistant plants. Neither did it fit the 3:1 ratio, but this was because there were not enough resistant plants. $F_3$ lines classified into resistant, segregating, and susceptible groups fit a 1:2:1 ratio and the second generation backcross lines fit a 1:1 ratio, indicating a single factor inheritance of resistance.

A different cross gave plants in more resistant classes than might have been expected. Again the $F_2$ data fit neither the 9:7 nor 3:1 ratio and, for the same reasons, too many resistant plants for 9:7 and too few for 3:1. Grouping classes 2, 3, and 4 as an intermediate group would not fit a 1:2:1 ratio, as would be expected if there were no dominance. The $F_3$ lines, however, fit the 1:2:1 ratio nicely, indicating a simple factor inheritance.

Since data from $F_3$ lines are usually considered more critical than data from $F_2$ plants in inheritance studies, the tendency would be to accept the single factor hypothesis for Dickinson Selection. Enough conflicting evidence is present, however, to cast some doubt on the simplified explanation.

Porter: The inheritance of greenbug resistance was studied in the $F_1$, $F_2$, and backcross populations of the cross Dickinson durum Sel. x Concho. The test was conducted in flats under greenhouse conditions. Resistance ratings of 1 to 10 were used to rate all populations. Plants damaged from 0 to 10 percent were rated as 1's, while those showing 90 to 100 percent damage were rated as 10's. The means of the $F_1$ and $F_2$ populations were nearly equal to the mid-parent value. The mean of the backcross to the resistant parent was intermediate to the mean of the resistant parent and the mid-parent value, while the mean of the backcross to the susceptible parent was only slightly greater than the mean of the susceptible parent. This study indicated partial dominance of factors influencing susceptibility. Estimates of the minimum number of effective factor pair differences ranged from 1.4 to 3.5. Estimates of heritability gave values of .33, .34, and .66. The mode of inheritance of greenbug resistance in this cross was believed to be relatively simple but more complex than a single factor pair difference.

Curtis: Two greenbug resistant strains, Dickinson Sel. 28-A and C.I. 9058, have been crossed with each of the greenbug susceptible varieties, Ponca, Concho, and Crockett, to study the inheritance of greenbug resistance. Also, Dickinson Sel. 28-A was crossed onto the entire monosomic series of Chinese Spring. The results of these studies indicate that a single recessive factor is responsible for the resistance shown by Dickinson Sel. 28-A. The inheritance of resistance in C.I. 9058 is more complex than that of Dickinson Sel. 28-A; however, it has been determined from $F_1$ data that the resistance is controlled by a recessive mechanism. The $F_2$ data indicate that probably 2 genes are involved. Greenbug reaction tests of monosomic $F_1$ hybrids of Chinese Spring x Dickinson Sel. 28-A failed to reveal the critical chromosome involved. In other words, the greenbug-resistant gene in a hemizygous condition failed to cause resistance. These tests will be continued in $F_2$ populations.

Painter: In crosses between Dickinson and Pawnee, Concho and Bison, it has been reported by Painter and Peters (1956) that a single recessive factor controlled survival of wheat plants under greenbug attack. Over 800 $F_2$ plants were studied. In $F_3$ and $F_4$ differences between resistant and susceptible lines and plants were generally clear cut in Pawnee, Concho, and Ponca crosses but less so in Bison hybrids.

In the $F_1$ plants the chlorosis caused by greenbugs was less than in the susceptible parents. Genetic results may depend on the parents used, with a possibility of transgressive segregation for resistance when Bison was the winter wheat parent.

## Hessian Fly Screening Tests and Agronomic Characteristics of Resistant Hybrids

W. B. Cartwright

Screening tests: The entomologist as one member of the team of research workers interested in producing improved wheats is fortunate in having hessian fly resistance in several wheats controlled by simple Mendelian factors. They fly-resistant derivatives fall into few categories and are easily separated by genotypic behavior in both field and greenhouse tests. Several thousand low generation and advanced wheats selected by our cooperators can be tested and rated each year on a purely routine basis. The greenhouse especially makes possible a rapid turnover of work.

Over a long period of years we have tested and rated a large proportion of the domestic and foreign wheats and now have confidence in our screening processes and the selection of parental stocks in use today. There is no doubt that our techniques for testing will improve and that we will find quicker ways of handling the increasing amount of test work. We need to control or understand more fully the variabilities due to environment and to fly races, to understand the relationship between the fly and its host, the feeding processes of the fly - its secretions and excretions, the systemic disorders observed in wheat plants soon after fly attacks, and lastly to know if differences of fly races and of resistant wheats are related to the presence or absence of free amino acids.

Resistance in advanced wheats. Our most usable and advanced wheats for hessian fly resistance are held by the wheat breeders in our winter wheat region. Experimentally tested, they are meeting our economic requirements as now known. A few of these wheats are listed below.

Parental Stocks for Resistance

| C.I. or Sel. No. | Name | Resistant parent |
|---|---|---|
| Sel. 6179 | Dawson x $Poso^4$ | Dawson |
| Sel. 6232 | Dawson x $Poso^4$ | Dawson |
| 12128 | Ponca | Kawvale-Marquillo |
| 12804 | Med-Hope-Pawnee x Oro-Ill. 1-Com. | Illinois No. 1 |
| Ks. 472941 | IVCL.-Com. x Med.-Hope-Pawnee | IVCL |
| Ks. 52400 | Chief.-H.F.-Kaw. x PI 119344-7 | PI 119344-7 |
| 12858 | Mq-Oro x Triunfo | Marquillo and Triunfo |
| Ks. 52381 | Paw. x PI 119358 | PI 119358 |
| Ks. 52382 | Pawnee x PI 94547-1 | PI 94547 |
| Ks. 52383 | Pawnee x PI 94379-7 | PI 94379-7 |
| 13083 | Dual | W38 |
| Purdue 3678 | PI 94587-Fultz Sel.-Hung. | PI 94587 |
| Purdue 4217 | Vigo x Ribeiro | Ribeiro |
| Purdue 4419 | Fultz Sel.-Hungarian-S633 | S633 |

In addition there are excellent progressive fly-resistant wheats representing one or more of the original parents in the wheat nurseries in Kansas, N Nebraska, Missouri, Arkansas, Wisconsin, Indiana, Michigan, Virginia, Maryland (Beltsville), and Georgia. There are still other resistant wheats from Argentina, Australia, Mexico, Portugal, and other countries which have not been used in the breeding programs in the winter wheat region. Yaroslav emmer from Russia and the Tremez varieties of durums from Portugal are examples and are likely the closest approach to immunity to the fly that we have. We are continuing the search for resistant material from foreign introductions for use in our studies on geographical and local populations of the fly.

Commercially acceptable varieties. Of our old line wheats which are resistant to the hessian fly and reported seeded in certain areas the following may be named: California, Big Club 43; Colorado, Pawnee and Ponca; Illinois, Pawnee; Iowa, Pawnee and Ponca; Kansas, Pawnee and Ponca; Kentucky, Pawnee; Michigan, Pawnee; Minnesota, Pawnee and Marquillo; Missouri, Pawnee and Ponca; Montana, Pawnee; Nebraska, Pawnee and Ponca; New Jersey, Pawnee; New York, Pawnee; Ohio, Pawnee; Oklahoma, Pawnee and Ponca; Pennsylvania, Pawnee; South Dakota, Pawnee; Washington, Pawnee; and Wyoming, Pawnee. Marquillo had an estimate 1,053 acres in 1949; Pawnee 6,798,140 acres in 1954; and Ponca 447,570 acres in 1954. Later estimates are not at hand.

Dual, released in 1955 in Indiana, has been recommended for Illinois, Indiana, Kentucky, Michigan, Jew Jersey, Ohio, and Pennsylvania. The acreage seeded is not known. Todd, recently released in Kentucky, is limited mostly to seed increases.

In 44 entries of soft winter wheats in regional tests, Dual and 13 advanced unnamed lines were resistant to hessian fly in tests at Lafayette, Indiana.

Specialized races. We recognize geographical populations of the hessian fly for California, western Kansas and Nebraska, and for the soft red winter wheat region or eastern fly. We feel that the eastern fly likely differs within the area - differences due to varying proportions of intermixing and dominating local races.

In the studies on races at Lafayette, Indiana, Mr. R. L. Gallun has isolated and maintained four races and many interracial crosses. The races are providing material for genetic studies on the fly itself, and providing populations for use in the economic program where our cooperating wheat breeders are combin one or more fly-resistant genes in a single wheat strain.

Since the races are separated on their capability to infest resistant wheats, we choose differentials from the known parental stocks. At present W38, Purdue 39153, and Ribeiro, and a susceptible wheat are differentials for the four races at Lafayette, and Dawson and a susceptible wheat for geographical races.

Populations and Races

| | Susceptible check | Dawson | W38 | Purdue 39153 | Ribeiro |
|---|---|---|---|---|---|
| California | S | R | R | R | R |
| Western | S | R | R | R | R |
| Indiana: | | | | | |
| Race A | S | S | R | R | R |
| Race B | S | S | S | R | R |
| Race C | S | S | R | S | R |
| Race D | S | S | S | S | R |

Tests of irradiated wheats

A list of lines tested follows:

| No. lines | Source | Variety | Remarks |
|---|---|---|---|
| 169 | Schlehuber (Okla.) | Concho | 10 MR (X2) |
| 120 | " " | Concho | 15 MR (X1) |
| 274 | " " | Concho | 15 MR (X3) |
| 3 | Poehlman (Mo.) | - | 15 MR |
| 3 | " " | - | Foil 110A |
| 1 | " " | - | Foil 114A |
| 3 | " " | - | Foil 115A |
| 1 | " " | - | Foil 122A |
| 10 | Powers (Beltsville) | - | 4 hrs. T-N (N2) |
| 10 | " " | - | 5 hrs. T-N (N2) |
| 10 | " " | - | 20 MR (X2) |
| 4 | Sunderman (Minn.) | Lee | T-N |
| 1 | Weibel (Ill.) | Ill. 45-553 | (X2) |
| 1 | " " | Ill. 45-553 x Knox | (X2) |
| 1 | " " | Knox | (X2) |
| 1 | " " | Newcastle | (X2) |
| 1 | " " | Pawnee | (X2) |
| 1 | " " | Prairie | (X2) |
| 1 | " " | Royal | (X2) |
| 1 | " " | Saline | (X2) |
| 1 | " " | Vigo | (X2) |
| 1 | " " | Webster | (X2) |
| 1 | " " | Dual (R) | (X2) |
| 1 | " " | Ponca (R) | (X2) |
| 1 | " " | Todd (R) | (X2) |
| 2200 | Wells (Miss.) | Anderson | (N4) |

Inheritance of Hessian Fly Resistance in Wheat

Heyne: A number of sources of hessian fly resistance have been transferred to Kansas adapted hexaploid wheats. These include I V CL, PI 94547-1, PI 119358, PI 119344-7, and Illinois No. 1, and were crossed among themselves and with known testers.

These five sources were similar to the $H_3$ gene. The fly populations used indicated that the $H_3$ gene and $h_4$ gene could not be distinguished in Kansas tests and were either alleles or the same factor. The Ribeiro crosses had the $H_5$ gene. A selection of the cross Pawnee x Ribeiro was more resistant than the $H_5$ tester, suggesting that Pawnee was contributing resistance.

PI 94587 resistance in hexaploid types reacted as a single major factor response and was designated as $H_6$. There appear to be other modifiers, but no factorial analysis could be made.

Ponca appears to have three recessive factors for resistance differing from the genes $h_1$ to $h_6$.

Pawnee appears to have two factors for resistance to the "western" race of Kansas flies perhaps different from the $h_1$ and $h_2$ factors, as the $h_1$ and $h_2$ factors of Dawson gave a susceptible reaction to Kansas flies.

Two previously described factors $H_3$ and $H_5$, one unpublished factor $H_6$, possibly three undescribed factors from Ponca and two from Pawnee, are being used in the Kansas breeding program for resistance to hessian fly.

Cartwright: The empirical data obtained to date indicate that simple Mendelian factors control hessian fly resistance in the wheat varieties Dawson, Java, W38, and Ribeiro. We have some data also to indicate simple factors in the common derivatives of PI 94587 and Yaroslav emmer. It is of interest to note that the resistance in barleys follows the same pattern as wheats. Of the five identified genes, two occur in Dawson ($H_1$, $H_2$), one each in W38 ($H_3$) in Java ($h_4$) and Ribeiro ($H_5$).

We find that Dawson, W38, Ribeiro, and a PI 94587 derivative are useful differentials for geographical and local populations and races of the fly. For this reason our attention is being focused on obtaining further differentials, and later using these in inheritance studies.

## Screening Tests for Resistance of Wheat to Aceria Tulipae

Somsen: During 1956 approximately 1,500 entries of the World Collection were screened for resistance against the wheat curl mite, *Aceria tulipae*. Of these entries 118 lines were worthy of future testing. When these lines were re-tested, 23 had lower mite populations than the others and were saved. Of these, only one line survived a third test. This was a fast growing spring-type wheat, P.I. 8765. It was saved not because of any apparent resistance to mite development but because it resisted leaf trapping and curling and seemed to be quite tolerant to wheat streak mosaic. This line will probably be very favorable for development of the mite under field conditions.

In 1956 resistance studies were confined to checking individual plants or very small numbers of plants of each variety in the greenhouse. A suitable testing and rating method has not been developed which will allow large scale tests to be undertaken. No resistant plants are available to serve as check plants in any testing program. About 10,000 irradiated Concho seeds were given individual testing. None of them showed any measurable resistance to the mite, and all were highly susceptible to wheat streak mosaic.

Harvey: Approximately 3,000 entries from the World Collection were observed for resistance under mite infestation in the greenhouse and field. All of the World Collection entries appeared to be susceptible. Nearly 100 wheat x rye hybrids supplied by Dr. Painter were tested and several appeared to be resistant. A wheat x rye hybrid supplied by Dr. Jensen of Cornell was of special interest since it had resistance to the curling and trapping of the leaves which is normally caused by the mites. This hybrid is described as wheat-like in nearly all morphological respects, and it is fully compatible in crosses with other wheats. If resistance to leaf curling occurs in the field, it could make conditions unfavorable for mite increase.

Wednesday A. M., February 12

ENVIRONMENTAL HAZARDS

I. M. Atkins, Discussion Leader

## Inheritance of Shattering in Wheat

K. B. Porter and I. M. Atkins

The inheritance of shatter reaction was studied in the $F_1$, $F_2$, and $F_3$ generations of the three possible crosses among the varieties Cimarron, Blackhull, and Wichita. Shatter reaction determinations were made on individual plants in the laboratory with a brushing device which, in effect, gave a relative measure of the breaking strength or persistency of the glumes and other floral parts. A correlation of 0.66 was obtained between field and laboratory ratings of 138 $F_4$ lines of the cross of Cimarron x Wichita.

The shatter resistance of Cimarron and Blackhull was dominant to the susceptibility of Wichita. There appeared to be at least a 4-major factor pair difference between Cimarron and Wichita, and a 2-factor pair difference between Blackhull and Wichita. Cimarron and Blackhull differed only slightly in resistance to shattering, and distinct segregation was not obtained in the $F_2$ generation; however, significant differences among the means of $F_3$ lines were obtained in this cross. Estimates of heritability were extremely low where the regression of $F_3$ means on the $F_2$ parental measurements was used. However, estimates of heritability based on variances of the means of $F_3$ lines ranged from 0.35 to 0.69.

## Evaluating Wheat Varieties for Shattering in the Field

R. W. Livers

It has been possible to evaluate wheat varieties at Clovis for tendency to shatter by a brief field examination of fully ripe material. Consistent differences between varieties have been apparent in the degree to which spikelets and heads break up when crushed in the hands, rolled between the hands, or when standing heads are stripped through the fingers. The latter technique, that of stripping heads through the fingers with moderate pressure applied, can be developed so that repeatability of results is excellent.

Reference to check varieties with rather well established performance with respect to shattering is necessary to keep the readings standardized. Under Clovis conditions RedChief has been rated 1; Blackhull 2; Kharkof, Comanche, and Concho, 3; and Westar, Wichita, and Pawnee consistently rate 4. No commercial varieties studied have rated 5, but some new lines which shatter that badly have been observed.

Evaluation of varieties and breeding material by the method described is quite rapid. About 100 plots per hour has been the usual rate for two workers. Results so far have been in very good agreement with known varietal histories on shattering. Even in years when actual shattering in the field has been insignificant, distinct differences among the check varieties have been apparent upon examination.

## Drought Resistance Work in South Dakota

V. A. Dirks

Drought resistance studies in winter wheat were undertaken in South Dakota in 1957. Drought is a major consideration with us, since farmers may grow a non-winterhardy variety in order to take advantage of its drought resistance or other characteristics. We have found it very difficult to persuade our growers to plant certain varieties. Fall drought is a problem, since the farmer has to decide if there is enough moisture to plant wheat. The fall-sown crop is usually less susceptible to injury from spring drought. Summer drought and high temperatures also are major factors in our wheat production.

This past year we opened a new station in the winter wheat area of the southern part of the State and have initiated a breeding program for the area. So far as the farmer is concerned, drought resistance is determined by the ability of a variety to produce a crop of grain despite lack of moisture. Test weight is a very important measure of drought resistance in the drier portions of our State.

## Coleoptile Growth in Relation to Wheat Seedling Emergence

R. W. Livers

Difficulty in obtaining a good stand of wheat in the semi-arid production areas frequently is due to drying of the surface soil before seedlings have had time to emerge and become established. A response to this problem has been deep planting, in the range from 2 to 3 inches. With this common planting practice there have been a number of farmers' reports of failure to get good stands with certain varieties, notably Westar and Comanche.

In the fall of 1954, in an off-station yield trial, deep planting followed by rain resulted in stand differences among varieties. The extremes were a 25% stand for Westar and 85% for Blackhull. Further tests in the greenhouse, using only these two varieties, have consistently produced similar results. The difference in emergence between these two varieties has also been demonstrated in deep planted field experiments. However, such experiments in the field frequently fail to differentiate among varieties in emergence ability.

In digging the first greenhouse tests it was apparent that the deeper plantings of Westar usually failed to come up because the leaves emerged from the coleoptiles too far below the soil surface. These leaves, lacking ability to penetrate through soil, often were found folded "accordion fashion". The direction of growth of these emerged leaves might even be downward, apparently being along lines of least resistance.

These first tests demonstrated the relation between emergence and coleoptile length. It was postulated that genetic differences among varieties in coleoptile length might be demonstrated in a dark germinating chamber permitting maximum coleoptile growth. A test of this sort with Blackhull and Westar indicated little difference in coleoptile length in the absence of resistance to elongation imposed by a soil medium. However, it appeared that Blackhull shoots grown in this manner had much more turgidity and strength than those of Westar. This matter was studied by splitting coleoptiles with a razor blade, separating coleoptile tissue from other shoot tissue, and weighing the two component parts of the shoots. On an oven-dry weight basis there was generally no difference between the two varieties in total shoot growth. In coleoptile growth on the same basis, Blackhull was greatly superior to Westar.

The data which follow show the decided superiority of Blackhull over Westar in emergence, coleoptile length, and oven-dry weight of coleoptiles under deep planting conditions. In this and related tests the seed of the two varieties was produced in the same nursery. Seed was carefully selected for soundness and size, each seed lot of 36 seeds being adjusted to 1.2 grams and treated with Arasan.

Results from a wheat seedling emergence test in a greenhouse soil bench, February, 1946. Figures given are averages of two seed sources and two replications.

| | Av. planting depth, millimeters | Av. no. plants emerged | Average coleoptile length, mm. | Av. dry wt., 20 coleoptiles, milligrams |
|---|---|---|---|---|
| Blackhull | 50.2 | 32.00 | 54.9 | 45.0 |
| Westar | 48.6 | 32.25 | 50.6 | 36.7 |
| Blackhull | 84.8 | 27.25 | 79.8 | 70.7 |
| Westar | 83.8 | 18.25 | 66.2 | 59.5 |
| Blackhull | 107.3 | 23.00 | 89.4 | 78.2 |
| Westar | 107.5 | 4.00 | 67.7 | 66.7 |
| L.S.D., .05 | ----- | 5.50 | 5.7 | 4.3 |

The difference between Blackhull and Westar which has been consistent under all conditions so far explored has been that of coleoptile strength as indicated by oven-dry weight. That difference in strength appears to be the cause of differences in coleoptile length and seedling emergence, both of which can be demonstrated under appropriate conditions.

Preliminary tests indicate that several of the Blackhull group of wheats have superior emergence ability; that the Turkey types are intermediate; and that Comanche and Westar are poor in this respect. Blackhull derivatives appear to fall at all points on this observed range.

## Drought Studies in Wyoming

B. J. Kolp

In our present drought studies, we are concerned with the question of whether we are measuring what we want to measure. We are studying three groups of varieties separated according to osmotic pressure responses. Germination tests were made and the materials were planted at two locations. We hope to answer the questions of whether there are actually emergence differences among these varieties and whether such differences bear any relationship to winter-hardiness. We made stand counts following emergence last fall and in the spring will determine the percentage of plants surviving the winter. We determined last fall that there was no difference in the emergence of the varieties where moisture was adequate. Thus, varieties that will germinate under high osmotic tension are also as good as other varieties under low tension. Questions that confront us are whether this characteristic is a function of the embryo or endosperm and whether it expresses itself at stages later than the seedling stage.

Another experiment initiated at Laramie involves the study of wheats with difference osmotic pressure responses in a field test. Applications of water will be made next spring when soil moisture reaches certain osmotic tension. We plan to establish three different water treatments.

## Winterhardiness Studies in Kansas

A. W. Pauli

Our work has been done primarily with artificial freezing in cold chambers and in field nurseries. Both are valuable tools in winterhardiness studies. Plant breeders have been able to select lines with improved cold resistance, using either artificial freezing or field tests. Such tests tell whether a strain is winterhardy, but they tell nothing about why it is winterhardy. Methods of determining why a plant is winterhardy have proceeded along two lines. They involve the comparison of lines known to different in winterhardiness or the study of hardy and non-hardy plants of the same variety. We have been studying the water soluble protein and amino acids in field and greenhouse tests of winterhardy material. For years workers in this field have emphasized the association between certain carbohydrates and winterhardiness. Perhaps there is an association of protein and winterhardiness.

If we had some idea why a winter wheat plant is winterhardy, we might be able to explain many unusual behavior patterns such as the large survival differences observed in some years. We need to know much more about the role of moisture in winterkilling and its relationship to temperature.

## Winterhardiness Observations in South Dakota

V. A. Dirks

We have studied the effect of soil organisms on the survival of wheat in the north central part of the State. Winter survival on non-fumigated soil was 83 percent; on fumigated, 96 percent. No differences in yields on non-fumigated land were found, but where fumigation was practiced only phosphorus was able to offset the lack of normal soil organisms. This was in an area where phosphorus is not deficient. We believe it is beneficial to apply phosphorus even where some is present in the soil. Nitrogen fertilizer in the fall is not desirable for winter survival.

I. M. Atkins: This has been observed frequently in winter oats. Phosphorus increases hardiness. Nitrogen tends to make the plants succulent and more subject to injury.

## Vernalization of Immature Winter Wheat Embryos

D. E. Weibel

Immature spikes with culms attached of Comanche winter wheat were brought into the laboratory at periods varying from 3 days after anthesis to maturity. With their culms in water, the spikes were placed in a refrigerator at 32 to 40° F. for periods varying from 10 to 55 days. Following this treatment the spikes were dried rapidly at room temperature.

Plants grown from seed from spikes brought in 8 to 12 days after anthesis and chilled 40 to 50 days showed that the immature embryos had been vernalized. Seed from spikes brought in sooner than 8 or 9 days after anthesis were vernalized, but they had low germination. Plants from seed of spikes brought in later than 12 days after anthesis were not vernalized.

It was proposed that a method may be developed by which the winter grain breeding programs might be expedited.

## CLIMATE-PLANT RELATIONSHIP LABORATORY

E. R. Hehn, Discussion Leader

The Great Plains Agricultural Council has initiated discussion and planning directed towards a concerted attack upon plant-climate relationships. It has been proposed that these investigations be undertaken as a regional Great Plains Project with emphasis upon those problems particularily important to this region. However, basic knowledge gained would certainly recognize no geographical boundaries.

During the latter part of 1956 a committee appointed by the Great Plains Council met in Lincoln, Nebraska, and prepared a statement of justification for such a regional project, research areas, and budgetary needs. Following the report of this committee, Dr. Kelso appointed a sub-committee consisting of H. H. Laude, T. J. Army, and E. R. Hehn to draw up a more complete statement on "characterization of biological responses to weather variables."

In the report of this committee to Dr Kelso, three main research phases were suggested:

1. Studies of crop yield records and weather data;
2. Research to determine the effects of specific weather factors on crop responses;
3. Research on hardiness of crops to cold, heat, drought, and other weather extremes and hazards.

Will these fields of investigation meet the needs of the plant breeder in the Great Plains area? It is my personal feeling that we are overemphasizing the response of plants to available moisture and the effect of climatic extremes upon crop plants. Because moisture is a major growth factor and because it can be measured with relative ease, we already have voluminous information on the biological responses to this weather variable. Contrast this with our information on such variables as: Air movement, radiation, diurnal soil and air temperatures, etc. Except from an economic viewpoint, I see no great value in establishing yield level probabilities for various crop areas. Had the area of grain sorghum adaptation been accepted by the plant breeders as absolute 40 years ago, it would have remained a Southern Great Plains crop.

It is questionable whether as plant breeders we will ever develop a winter wheat capable of withstanding the extremes of weather, such as severe drought, hail storms, tornadoes, and floods. Amelioration of the hardships suffered by Great Plains people due to such catastrophes, I fear, lies in other realms. Could we not accomplish more by emphasizing investigations leading to an understanding of the genotype-environment interactions within the normal range of weather variables?

If funds become available for such a regional project, I believe the nature of its organization concerns us as plant breeders. Two basic alternatives present themselves, either a centralized laboratory or a subdivision into several laboratories. The advantages of centralization need not be enumerated. It is, however, disturbing to contemplate where the 75 scientists necessary to staff this laboratory would be recruited. What would be the effect of this drain in personnel upon the existing research institutions? Sub-division of such a laboratory would permit utilization of existing staffs and equipment at established institutions. Location of such sub-divisions at teaching research institutions also would facilitate the training of future scientists.

A. Problems to be attacked by a climate-plant relationship laboratory

1. Production hazards resulting from weather extremes, such as drought, hail, windstorms, and temperature extremes.
2. Genotype-environment interactions within the normal weather pattern range.

Hehn: Everyone is familiar with these extremes hazards. They will attract strong support. On the other hand, what are the plant characteristics that give so much variation in the growth response of varieties in an average year? What is the cause of these genotype-environment interactions? Should we go along with the idea that the extreme weather conditions are a primary concern, or should we try to get the laboratory to consider as well these other plant-climate interactions which we know so little about?

Andrews: From the point of view of developing hardiness to a higher degree than we have now, I think that such a study would provide the necessary information on which to plan a breeding program for winterhardiness. About the only approach we have now is to cross varieties that we think might have different genes for hardiness and to select for the end product. The suggested studies would put breeding on more of a planned basis than it is now.

Hehn: There are at least three major factors involved in the loss of spring stands.

Schlehuber: Are we concerned more with the violent or the more normal weather hazards? I believe we need to work within the normal weather pattern.

Schmidt: When we talk about normal or extreme, are we saying that these are entirely different?

Schlehuber: Our average conditions are the mean of the extremes.

Livers: In the central portion of our region the extremes occur less frequently. As one goes to the far north, winterhardiness is a paramount problem. In the West drought is the principal problem. We are not so concerned with extremes in the central area. We see variations in yield in the absence of weather extremes. We need to study some of the climatic factors that we may not even be seriously considering today.

3. Nature of disease and insect resistance.

Painter: Very high losses from winterkilling occurred during the time when Turkey was the commonly grown wheat. Turkey has been replaced by varieties such as Tenmarq and Comanche, which are less winterhardy. On the other hand, Turkey was more susceptible to hessian fly than are Tenmarq and Comanche. I am quite certain that many of the early reports of winter injury in Kansas were not winter injury but primarily hessian fly injury. We should consider insects as one of the factors of environment that should be studied in the proposed laboratory.

I would like to point out that insects are extremely sensitive to some of the other factors. There will be new cultural practices recommended, and some of these will affect insect populations. We think, for example, that summer fallow reduces insect populations. Stubble mulch and strip cropping undoubtedly have an effect. For these reasons, I believe that the entomologists and pathologists will be very much interested in the proposed laboratory.

Hehn: If we are going to increase the ability of plants to produce, we must better tailor them to the climatic pattern. As plant breeders we will have difficulty in effecting improvement unless we know what the climatic factors are.

B. Possible approaches to the study of genotype-environment interaction responses.

1. Plan a series of nurseries over the region accompanied by detailed micro and macro climate observations. This might enable us to detect and evaluate those factors which are responsible for differences in crop variations from year to year.
2. Select a confined geographic area with wide climatic variations. With detailed instrumentation, this could yield as much information as the first approach and lead to the identification of the factors for further detailed study.
3. Identify the primary response factors in controlled climate chambers. Establish areas of similar climatic patterns in which to test laboratory findings.

Johnson: All three of these approaches would have value for the identification and study of the genotype-environment interaction. However, the first two methods are largely an extension of an approach we are already using and would eventually require the utilization of growth chambers for more detailed and precise study. It seems to me that the third approach has considerable merit over the first two, but all should be utilized.

Schlehuber: Does anyone here feel that the agronomist and physiologist have enough information on micro climate to start studies in a carefully controlled laboratory?

Hehn: Most of our observations have been extremely crude, and I doubt whether the recorded data are going to be of any great value. The data give a very general picture, but nothing very specific.

We must first identify the forces that produce the differences in the performance of genotypes within a very small area. Even if we could identify these climatic factors, it still would not aid us greatly in our selection program unless we could grow many plants under these same conditions.

Miller: Perhaps the biochemist could make a significant contribution here. We are studying the biochemistry of hessian fly resistance. Other characteristics also could be studied, but facilities are frequently not adequate. What we are doing in Kansas is not being done at many other places. Some work of this nature is under way in Wisconsin and some in Germany. It seems incongruous that more of this type of work is not being done.

Hehn: The identification of climatic factors that contribute to the performance of a wheat variety is not sufficient. We must ascertain whether it is possible to establish climatic pattern areas. If we could reach the point where winter, summer, and drought conditions could be duplicated in the laboratory, much time would be saved in our study of these factors. Thus, far, there has been little opportunity to study the plant during its entire life cycle.

C. Organizational nature of a regional climate-plant relationship laboratory

1. Central laboratory
   Points in favor -- Economy through sharing of equipment, etc., and coordination of effort.
   Points against -- Difficulty of staffing, drain on personnel of existing institutions, standardization of thinking, lack of training of future research workers.
2. Central laboratory with sub-stations or contacts with experiment stations.
   This approach would implement the efforts of existing staffs. It would serve to stimulate and support existing staffs. It would allow the use of already available institutional equipment.
3. Dispersion of the laboratory throughout the region with a feasible division of areas of research.
   This would facilitate correlated field studies and would make good use of existing staffs and facilities. In addition, it would aid in the training of research workers.

Reitz: I would like to comment on the subject you have outlined so very well. There seldom is just one way to do a thing. If the establishment of a central laboratory would cause the individual research as it is now organized and carried on to dry up, it would be a catastrophe. We should reject the establishment of a central laboratory if we think it would do this. There has developed in ARS of the U.S.D.A. the philosophy of pioneering research. Research in one area is projected into new fields that are not now being investigated for lack of funds, personnel, etc. I think your idea of a central laboratory or central laboratory with sub-stations falls under the pioneering research philosophy. This field of research is very deserving of attention and support.

Wednesday P. M., February 12

QUALITY

J. A. Shellenberger, Discussion Leader

## Criteria of Good Quality Wheat from the Breeders' Standpoint

J. A. Shellenberger substituting for K. Finney

Quality means different things to different groups. From a farmer's standpoint it could mean freedom from diseases and insects, good color, plump grain, etc. To the grain merchant it could mean moisture content, storing ability, etc. Freedom from foreign matter, good test weight, high protein labels might be among the processor's criteria of quality. Still other criteria would be used by the consumer. As we attempt to appraise wheat from the standpoint of the breeder, we must consider all of these groups. For example, unless the wheat we recommend is acceptable to the farmer, he will not grow it.

Most of the wheat quality work has been handled in this region by the Hard Winter Wheat Quality Laboratory. A good job has been done. The laboratory makes every effort to process the material submitted and to give the wheat breeders the information that will help them in their programs.

However, I believe that in the future the wheat breeders will need to take into consideration some factors about which they are not presently concerned. For example, I do not believe that processors are going to be satisfied indefinitely with the shape of the wheat kernel as it is now. I believe also that breeders eventually will have to pay attention to the actual cell structure of the wheat kernel. I cannot tell you when this may come about, but it may be sooner than you think.

Quality of wheat from the processor's point of view can be determined only in relation to how it is to be used. The export picture may change drastically in the years ahead. While we do not need to market wheat comparble to that from Canada in order to maintain our market, we must have greater uniformity of our product than heretofore.

The implications of recent developments in turbo-milling were discussed by John Meyer of Pillsbury Mills. Mr. Meyer point out that air classification or impact grinding at the present time supplements normal milling operations. He discussed the range of separations based on particle size that are possible with the equipment, the protein characteristics of the various particle sizes, the possibilities for reconstituting the material to obtain the desired types of flours, and the implications of these and other aspects of the process for the wheat industry.

## Mineral Composition of Gluten, Starch and Water-Soluble Fractions Of Wheat Flour and its Relationship to Flour Quality

R. K. Bequette, B. S. Miller, J. A. Johnson and W. G. Schrenk

The influence of environment and variety on the total ash and elemental composition of gluten, starch, and water-soluble fractions separated from forty hard red winter wheat flours and the relationships of these data to flour quality were investigated. Many of the samples contained protein with abnormal quality due to adverse environmental conditions during the growing season. This was indicated by the abnormally low correlation coefficient of +0.54 between flour protein and loaf volume. Location was more important than variety in determining flour quality and mineral composition of the flour and flour fractions.

Correlations between adjusted loaf volume and mineral contents calculated as percent of the fraction ash or between gluten quality score and the concentrations of ash or elements in the ash from the fractions were of low order. The best correlations were those based on data which involved a consideration of ash composition and total quantity of the fraction recovered. Correlations between adjusted loaf volume and between elemental composition of the three flour fractions indicated that the adjusted loaf volume and the ash of the gluten were negatively correlated. Phosphorus, potassium, iron, sodium, manganese, and magnesium but not calcium contributed to this relationship.

Correlations between adjusted loaf volume and total ash of starch or water-solubles were non-significant. The amounts of phosphorus, potassium, manganese, and calcium in the starch and the amounts of phosphorus and potassium in the water-solubles were each correlated significantly with adjusted loaf volume. All except phosphorus in the starch and water-solubles were correlated positively.

Phosphorus, the major component of gluten ash (35-49%), apparently was the main element affecting gluten quality. The high correlations of adjusted loaf volume with either the ash content of the gluten (-0.818), phosphorus content of the gluten (-0.844), or the amount of crude dry gluten extracted from the flour (-0.808), suggested that any of these factors was more reliable than flour protein or loaf volume alone for predicting the breadmaking quality of these flours. A correlation of +0.963 was obtained between the amounts of ash and phosphorus in the gluten. It is postulated that the combination of various elements, and phosphorus in particular, with the protein as it is being formed in the kernel has an important bearing on the quality of the resulting flour.

## Quality of Irrigated Wheat

K. B. Porter

Winter wheat quality characteristics may be affected by irrigation and fertilization practices. Irrigation may influence baking characteristics a great deal in years of near-normal or below-normal rainfall when low irrigation treatments limit the yield. During years of above-normal rainfall there will be less influence on baking characteristics from irrigation.

In 1956 and 1957, an irrigation water management study on winter wheat was conducted at the Southwestern Great Plains Field Station, Bushland, Texas. The experiment consisted of six irrigation treatments, each having six fertilizer treatments as subplots. All treatments were replicated four times. Quality analyses were made on all 36 combinations of treatments. Concho wheat was used both years.

The results indicate that baking score decreased as yields increased. Baking score also increased with the straw-grain ratio and decreased as more wheat was produced for each inch of water used. Nitrogen fertilizer increased proteins, but protein content affected baking quality only slightly. Correlations and regression equations of these and other quality characteristics as they were related to growth characteristics were calculated.

It was concluded that a study of how irrigation practices affect quality may enable a farmer to improve the quality characteristics of irrigated wheat by varying his irrigation practice. This would be especially desirable when premium prices are paid for good quality wheat. Present irrigation practices are aimed primarily at higher yields of grain. When premium prices justify such practice, irrigation for quality may become more important than quantity.

S. N. Vilm (Producers Grain Corporation Quality Laboratory, Amarillo, Texas)

We have received many samples of wheat in our laboratory, both pure and mixed, and from most areas in the Southwest. The samples from irrigated wheat consistently have given poor farinograph curves and have shown poor baking quality. This has been true even for strong gluten varieties. This led us to cooperative work with the experiment station at Bushland. From our tests on the 1956 and 1957 irrigated and fertilized plots of Concho grown on the station, we have concluded the following:

1. Irrigated wheat generally has heavier grain than dryland wheat. The protein is usually lower and the ash higher.
2. It mills well and has a fair cleanup with good protein recovery.
3. The Farinograph curves show a lower hydration, mixing peak and stability with a higher M.T.I. than dryland wheat.
4. The absorption is always lower and the baking qualities are poor.
5. The mixing time is short and fermentation has to be shortened considerably to make a fair loaf of bread.

## Quality of Hard Red Winter Wheats

K. Finney
(Presented at the Wednesday morning session)

The term "quality" has been misused on many occasions and has led to much confusion. In talking about milling and baking quality, it is essential that the class of wheat and the use to which it is to be put are defined. For example, is it to be used for the baking of crackers, cookies, cake, or bread? Hard red winter wheat is used almost entirely for bread making. Therefore, we define its milling and baking quality in terms of the properties that determine its excellence for bread making purposes.

A variety of hard red winter wheat to be of good milling quality must have normal sifting and bolting properties. If the wheat is too hard, more time will be required to mill it with the result that the cost of the product will be increased. If, on the other hand, the wheat is too soft, its milling characteristics are such that milling delays will occur and extra time will be required. If a wheat variety meets these requirements and, in addition, gives a normal yield of flour with normal ash content, it will almost always be given a good milling rating. To say the wheat has "good" or "poor" milling quality is not adequate. The specific milling characteristic in which it is inferior should be indicated. Poor milling quality may mean grain that is too hard or too soft or it may mean low flour yield or ash content that is too high.

Similarly, when we talk about baking quality we should be specific. High water absorption, medium to medium-long mixing time, good loaf volume potentialities, and satisfactory internal crumb characteristics are specific criteria of good overall baking quality. Wheats with medium to medium-long mixing time usually will have good mixing tolerance, satisfactory dough-handling properties, and will remain stable during the entire baking process. To say that a flour is of poor baking quality tells nothing of the specific characteristic or characteristics that make it so. In some instances "poor" quality may be concerned with the hardness of the grain or short mixing time or perhaps low protein. If quality is not up to par because of low protein, why not state that the protein content is too low rather than make a vague reference to "poor" baking quality.

The term "quality" need not be confusing if we define it in terms of specific milling and baking characteristics with reference to the end product.

Vilm: In our tests, we have not been able to get good flour from irrigated wheat.

Finney: Irrigated wheats generally will be lower in protein and, therefore, may have poorer baking characteristics than dryland wheat.

Livers: Will dryland-produced wheat have a longer mixing time than irrigated wheat?

Finney: Not necessarily.

## MISCELLANEOUS TOPICS

E. G. Heyne, Discussion Leader

### Use of Multiline Varieties or Varietal Mixtures

Heyne reported on a Kansas experiment involving related $F_4$ lines that were leaf rust resistant as well as leaf rust susceptible. Despite heavy leaf rust in 1957, significant yield differences between the mixtures and component lines were not demonstrated.

Schmidt discussed the initiation of multiline experiments in Nebraska in 1958. Two different 4-line composites are being tested at three locations in the State, together with the individual component lines and all possible combinations of them. One of the composites involves related experimental Nebraska strains, while the second contains regional strains. Each composite contains two winterhardy strains and two strong gluten types. All of the component strains have the same approximate maturity.

Schlehuber reported on work conducted in Oklahoma by Raymond Peck in which the reaction of four hard red winter wheat varieties in a composite was studied. Yield superiority of the composite over the mean of the four varieties grown separately could not be demonstrated at locations in western Oklahoma, whereas in central Oklahoma the composite yield was somewhat superior to the average of the varieties.

A recently initiated multiline experiment with hard red winter wheat in South Dakota was described by Dirks.

Dwarf or Semi-dwarf Wheats

V. A. Johnson reported on Nebraska work with semi-dwarf wheats. The objective of this work is to develop varieties better adapted to irrigation than the currently grown dryland varieties. Several lines derived from 1948 crosses of Seu Seun, Norin 16, and Norin 10 with Nebraska 60 x Med.-Hope have been yield tested under irrigation and on dryland in the last three years. Several have been consistently superior to Pawnee, Nebred, and Cheyenne under irrigation as well as in dryland tests. They appear to have a yield potential well above that of the currently grown varieties. However, several have lodged severely under high fertility and moisture. Their plant height also varies widely depending upon fertility and moisture availability.

Question: What has been the height of these semi-dwarfs under droughty conditions?

Johnson: The shortest ones failed to exert fully the spikes under severe drought and have been as short as 10 inches.

Hehn: The semi-dwarfs we are testing in Montana have had a rather constant height. I believe that we can select for constancy of height under variable conditions.

Schmidt: We are crossing our Nebraska semi-dwarfs with RedChief derivatives for short and stiff straw.

I. M. Atkins: We are interested in the semi-dwarfs for the western part of Texas where forage is the main consideration. We don't know, however, whether they will produce as much forage as the taller growing wheats.

Livers: We get considerable depression of height due, I believe, to high light intensity. The dwarfs that we have grown frequently have attained a height of only 8 inches -- too short to harvest easily.

Johnson: We have underway in Nebraska a study to evaluate the various yield components of the semi-dwarfs in relation to taller growing varieties in order to learn what is responsible for the high yields of the semi-dwarfs.

Dr. Caldwell reported on work underway at Purdue involving Norin 66 derivatives. At harvest time this year they were the only strains in the nursery not lodged by the excessively wet weather prior to and during harvest.

Dr. Heyne discussed briefly the work in progress in Kansas in which Norin 33 and Norin 10 are the principal sources of short stature.

Thursday A. M., February 13

GENETICS, CYTOGENETICS, AND IRRADIATION

J. W. Schmidt, Discussion Leader

Genetics of Protein Quantity and Quality

Finney reported on experiments over the region in which the soft red winter wheat varieties Atlas 50 and Atlas 66 were compared with Wichita and Comanche. The results of these studies showed conclusively that these two Atlas varieties were capable of laying down considerably greater amounts of protein than Wichita and even as much as 2 percent more than Comanche. Because of this information, these varieties have been included in the breeding programs in this region with the idea of producing wheats that would be inherently higher in protein content.

Johnson pointed out that, while there was no question about the grain of the Atlas wheat being higher in protein content than the hard red winter wheats, they often did not outproduce the hard red winter wheats in pounds of protein per acre. This is due to the fact that they generally do not yield as many bushels of grain per acre. However, in a few instances where the Atlas wheats were equally as productive as the hard red winter wheats, they still produced grain with a higher protein content. Experiments are now underway in Nebraska to study this relationship of grain yield to protein content, as well as to study the inheritance of levels of protein content, in crosses of the Atlas wheats with Wichita and Comanche. Study is also being given to the relationship of nitrogen availability in the soil and protein content of the grain produced on soils of varying nitrogen levels. In another study individual plants of the parental Atlas 66, Wichita, and Comanche varieties and $F_2$ plants of Atlas 66 x Comanche and Atlas 66 x Wichita were analyzed for protein content. A summary of the data obtained are shown below.

Summary of the results of protein analyses of seed from individual parents and $F_2$ plants grown in a space-planted block at Lincoln, Nebraska, 1957. (Planted October 1 and 2, 1956; harvested July 10, 1957.)

| Variety | C.I. or cross no. | No. of plants | Mean protein | Variance ($S^2$) | Standard error of a mean | C.V. | Range |
|---|---|---|---|---|---|---|---|
| | | | % | | | % | % |
| Atlas 66 | 12561 | 48 | 20.8 | 1.8511 | 0.1964 | 6.5 | 18.1-25.3 |
| Comanche | 11673 | 43 | 15.6 | 0.9626 | 0.1496 | 6.3 | 13.7-17.9 |
| Wichita | 11952 | 33 | 13.7 | 0.7069 | 0.1464 | 6.1 | 11.7-16.2 |
| Atlas 66 x Comanche | 5310 | 160 | 17.7 | 1.9447 | 0.1102 | 7.9 | 14.6-23.2 |
| Atlas 66 x Comanche | 538 | 151 | 17.5 | 1.9151 | 0.1126 | 7.9 | 14.4-22.0 |
| Atlas 66 x Wichita | 537 | 114 | 16.9 | 2.1126 | 1.3613 | 8.6 | 13.7-20.1 |

In reply to a question, Finney stated that the samples studied had not been sufficiently large to carry out baking tests in order to determine what the relationship was in Atlas 66 between protein content and loaf volume.

Ausemus commentated that in some of their material they did not get as high a loaf volume, comparatively, for the higher protein content.

Reitz stated that the Atlas wheats grown in eastern States performed well in baking tests and that the protein did not appear to be inferior.

M. Atkins described some of the Texas work with isogenic lines and suggested that the technique might be valuable in a study of the relationship of protein content with baking quality.

Heyne reported that the $F_2$ progeny test for quality evaluation had been used effectively in Kansas and should be useful in other studies of protein quantity and quality.

Morris reported that a project had just been initiated in Nebraska where the inheritance of the dough handling properties of the Cheyenne wheat variety will be studied. The study will be by means of substitution of chromosome pairs from Cheyenne, a long mixing time variety, into Chinese Spring, a short mixing time variety.

Reitz: How are you going to get comparable results?

Schmidt: We are expecting some difficulty in regards to certain substitution lines being winter types. We have no idea of what magnitude some of the other interactions may be, but we expect to learn about those from this study.

Schlehuber reported on Oklahoma work regarding attempts to obtain early maturing varieties with strong gluten properties. C.I. 12406, Mqo-Oro x Oro-Tenmarq, is being used as the strong gluten parent in crosses with early wheats such as Triumph. In the first attempts, the early maturity of Triumph has not been recovered. Additional crosses are being used in further studies. C.I. 12406 is also being used in crosses with the very weak gluten agroticums.

## Gene Accumulation for Quantitative Characters

Dirks reported that work has been underway in South Dakota for obtaining greater winterhardiness in winter wheats. An attempt is being made to accumulate genes for winterhardiness from various sources by using many varieties in the crosses and intercrosses. The germ plasm has not been restricted to very winterhardy types alone, such as Minturki, but has included also such less winterhardy varieties as Pawnee. These less winterhardy varieties may contain factors for winterhardiness quite different from those of the most winterhardy wheat and, therefore, contribute to an increase in winterhardiness. By making these wide crosses and many intercrosses of surviving materials, it may be possible to break existing linkages and obtain superior recombinants. The biggest problem is one of recognizing the potentially useful genotypes. An environment must be set up that is favorable for the identification of the best combinations. Of interest in this connection is the winter barley winterhardiness work initiated by Dr. G. A. Wiebe and continued at Nebraska, among other places. Many crosses of diverse germ plasm representing possible different sources of winterhardiness were made at Beltsville. Many additional crosses between good lines were made at Lincoln by the late Charles Pulham, and new combinations were obtained. Some of the better ones from this work were grown at Brookings in 1956-57 and appear to represent new levels of winterhardiness in winter barley.

<u>Ausemus</u>: I might say a few words on the winterhardiness question, since I have been at it for 30 years now. We started out in 1917 with Turkey x Odessa crosses and we needed a lot of winterhardiness. The three most winterhardy wheats we were able to obtain were Minhardi, Minturki, and Minter. We have never been able to obtain derivatives of other crosses which are any more winter-hardy than these.

<u>Andrews</u>: In Canada we started a program about 6 years ago and the limitations soon became evident -- that is, how to recognize the superior combinations. The big problem is not how to combine genes but how are we going to recognize them. One of our tests is based on the handling and freezing of seedlings.

<u>D. Weibel</u>: What is the possibility of using some chemical tests to identify varying levels of winterhardiness?

<u>Hehn</u>: We are trying to identify the superior combinations by exposing them to various stresses. We are using different depths of seeding and different dates of seeding for this purpose.

## Possible Use of Selective Gametocide in Wheat Research

<u>Schmidt</u>: A recent article appearing in Science discusses the use of a chemical on cotton that acts as a selective gametocide causing male sterility. Has anyone tried it or is planning to try it on wheat? If workable, it would facilitate some of the studies discussed today. It would be useful for obtaining randomly mating populations in wheat.

<u>Briggle</u>: This has come up on some of our discussions at Beltsville. There are a lot of people working on different crops that are interested in it. The question there came up whether some concentrated investigations could be made by one group.

<u>Reitz</u>: I feel that this is something worth taking up. I would like to suggest that we have someone start on this and report on it in the next wheat newsletter a year from now.

R. Weibel stated that some work in this area had been planned at Illinois. They were waiting to try it on wheat and report their results, as suggested.

## Cytogenetics in Relation to Wheat Aneuploids

A. Use of common wheat aneuploids.

Snyder reviewed the cytological behavior of the wheat monosomics and nullisomics and related this to their usefulness in genetic analyses and chromosome transfer or substitution. The presence of homoeologous series in wheat indicates that broad chemical functions are distributed over the whole chromosome complement. This is reflected in duplicate, triplicate, or polymeric genic inheritance. It is in this area that the wheat aneuploids have their greatest usefulness because the genetic contribution of any specific chromosome can be accentuated and defined by aneuploid methods.

Snyder stressed the importance of the following points if aneuploid work is to be carried on successfully:

1. A constant genotype must be maintained for the variety being studied both by the monosomic method and by chromosome substitution. This necessitates bagging of spikes to prevent outcrossing both in variety being studied and in the cytogenetic stocks.
2. Critical cytological analyses must be made in every generation if any significance is to be attached to the results obtained. This requires the services of a trained cytologist.
3. Aneuploid transfers, and especially chromosome substitutions, should be made in duplicate so that if aberrations occur in one line another will be available to carry forward.

B. Status of development of aneuploid stocks of hard red winter wheat.

Andrews reported the monosomic set in Kharkof MC 22 has been nearly completed by Dr. Jenkins at Winnipeg. Additional backcrosses need to be made in two lines (chromosome XI and XIX).

Hehn reported that Montana is initiating a program of establishing the monosomic series in Yogo wheat.

Heyne stated that the nearly complete monosomic set in Pawnee was lost in the summer of 1957 when East Waters Hall burned at Kansas State College. A partially completed set in Wichita wheat was lost also.

Morris reported that Wichita wheat monosomics were in various stages in the backcross program and a new series in Cheyenne wheat was just being started in Nebraska.

C. Chromosome substitution lines.

Andrews reported that substitution series had been completed and used for the varieties Thatcher, Hope, and Timstein and that others were being developed in Canada. Chinese Spring is the recipient variety.

Morris reported that in Nebraska the transference of Cheyenne winter wheat chromosomes to Chinese Spring is in the initial stage.

At Minnesota, Snyder is transferring Marquis, Mida, and Kenya Farmer chromosomes to Chinese Spring. Snyder, also, reported that Sears has substituted Thatcher, Hope, Timstein, and Red Egyptian into Chinese Spring.

D. Summary of gene locations by chromosomes

Morris presented information obtained from published data or from personal correspondance relative to the rapidly accumulating knowledge of chromosomal location of genetic characters in wheat. The data by chromosomes are as follows:

Locations of Genes for Wheat Characters by Chromosomes
(Revised May, 1958)

Chromosome I

Plant height (3) by substitution lines.
Tillering (11) by nullis (reduced tillering).
Lodging resistance (3) by substitution lines.
Earliness (3) by substitution lines.

Chromosome I (cont'd)

Yield (3) by substitution lines.
Spike density (11) by nullis (laxer spikes), (3) by substitution lines.
Inhibition of stiff glumes (11) by nullis (stiffer glumes) and telos.
Red or brown glumes (14) by nullis (white glumes) and monos, (11) by telos.
Fertility (11) by nullis (low fertility) and telos.
Kernel weight (3) by substitution lines.

Chromosome II

Plant height (11) by nullis (reduced height).
Tillering (11) by nullis (reduced tillering).
Leaf size (11) by nullis (shorter, broader leaves).
Culm diameter (11) by nullis (larger culms).
Weak inhibition of solid culm (4) by aneuploids.
Lodging resistance (3) by substitution lines.
Earliness (3) by substitution lines, (11) by nullis (delayed maturity).
Spike density (3) by substitution lines.
Anther size (11) by nullis (larger anthers).
Yield (3) by substitution lines.

Right arm
Glume toughness (11) by nullis (thin, papery glumes), telos and isos.
Awn promotion (8) by nullis (awnless), (11) by telos and isos.
Normal synapsis (11) by nullis (asynaptic), telos and isos.
Female fertility (11) by nullis (female-sterile), telos and isos.

Left arm
Normal internode length (11) by nullis (short internodes), telos and isos.
Non-reduplication of spikelets (11) by nullis (reduplicated spikelets), telos and isos.

Chromosome III

Plant height (11) by nullis (reduced height), telos and isos (left arm), (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Solid top internode of culm by monos. (Larson, by correspondance).
Earliness (3) by substitution lines
Yield (3) by substitution lines.
Neatby's virescent (11) by telos and isos (left arm).
Necrotic leaves (11) irradiation-induced.
Leaf development (11) by nullis (narrower, shorter, stiffer leaves) and telos (left arm).
Spike density (3) by substitution lines.
Normal spike length (11) by nullis (short spikes), telos and isos (left arm).
Awn expression (3) by substitution lines, interaction with genes on VIII and X.
Normal synapsis (8) by nullis (reduced synapsis), (11) by telos and isos (right arm).
Seedling resistance to stem rust (13) by substitution lines (complementary gene on XIII).

Chromosome III (cont'd)

Adult stem rust resistance (Loegering by correspondence), by monos (McGinnis and Campbell, 1957 Wheat Newsletter, Vol. IV, p. 7, by permission - complementary to genes on VIII and XIII).
Stripe rust resistance (Loegering by correspondence).
Brown necrosis susceptibility (Loegering by correspondence).
Leaf rust resistance (C. O. Johnston by correspondence).

Chromosome IV

Plant height (11) by nullis (reduced height).
Earliness (3) by substitution lines.
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Lodging resistance (3) by substitution lines.
Spike density (3) by substitution lines.
Awn expression (3) by substitution lines, interaction with genes on VIII and X.
Male fertility (11) by nullis (male-sterile), telos and isos.
Kernel weight (3) by substitution lines.
Yield (3) by substitution lines.
Seed shape (11) by nullis (longer, shallower seeds).

Chromosome V

Plant height (11) by nullis (reduced height), telos and isos (long arm).
Leaf width (11) by nullis (narrower leaves), telos and isos (long arm).
Culm thickness (11) by nullis (thinner culms), telos and isos (long arm).
Solid lower internodes of culm by monos (Larson, by correspondence).
Earliness (11) by nullis (later maturing), (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Spike density (3) by substitution lines.
Spike size (11) by nullis (smaller spikes), telos and isos (long arm).
Glume size (11) by nullis (smaller glumes), telos and isos (long arm).
Male fertility (11) by nullis (male-sterile), telos and isos (long arm).
Kernel weight (3) by substitution lines.
Yield (3) by substitution lines.
Protein content (3) by substitution lines.
Normal synapsis (Okamota, Wheat Information Service No. 5, p. 6, by permission) by pentaploid hybrids.

Chromosome VI

Plant height (11) by nullis (reduced height).
Tillering (11) by nullis (reduced tillering).
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Earliness (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Spike density (3) by substitution lines.
Spike length (11) by nullis (shorter spikes).
Outer glume development (11) by nullis (narrow, spreading outer glumes).
Kernel weight (3) by substitution lines.
Yield (3) by substitution lines.
Male fertility (11) by nullis (low male fertility), telos and isos.
Seedling stem rust resistance (13) by substitution lines.

Chromosome VII

Plant height (11) by nullis (slightly reduced height), (3) by substitution lines.
Leaf width (11) by nullis (narrower leaves).
Earliness (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Spike density (3) by substitution lines.
Spike length (11) by nullis (shorter spikes).
Yield (3) by substitution lines.
Leaf rust resistance (C. O. Johnston by correspondence).
Protein content (3) by substitution lines.

Chromosome VIII

Plant height (11) by nullis (reduced height), (3) by substitution lines.
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Solid culm (4) by aneuploids.
Tillering (11) by nullis (increased tillering).
Earliness (11) by nullis (delayed maturity), (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Spike length (11) by nullis (shorter spikes).
Spike density (3) by substitution lines.
Awn inhibition (7) by monos, (14) by monos.
Hooded awns (8) by nullis (longer, straighter awns).
Male fertility (11) by nullis (male-sterile), telos and isos.
Yield (3) by substitution lines.
Seedling stem rust resistance (13) by substitution lines.
Adult stem rust resistance by monos. (McGinnis and Campbell, 1957 Wheat Newsletter, Vol. IV, p. 7, by permission complementary to genes on III and XIII).
Stripe rust resistance (Loegering by correspondence).

Chromosome IX

Plant height (3) by substitution lines.
Solid lower internodes of culm by monos. (Larson, by correspondence).
Lodging resistance (3) by substitution lines.
Earliness (8) and (11) by nullis (delayed maturity), (3) by substitution lines.
Male fertility (11) by nullis (male-sterile).
Yield (3) by substitution lines.
Protein content (3) by substitution lines.
Hairy node (6) by linkage studies.
Hairy leaf (6) by linkage studies.

Long arm

Leaf width (11) by nullis (narrower leaves) and telos.
Culm thickness (11) by nullis (thinner culms) and telos.
Pubescent nodes (8) by nullis (non-pubescent nodes), (11) by telos and isos.

Chromosome IX (cont'd)

Speltoid suppression and squareheadedness (8) by nullis (speltoid and non-squareheaded), (11) by telos and isos.
Awn inhibition (7) by monos, (14) by monos, (11) by telos and isos.
Spring growth habit (14) by monos, (11) by telos and isos (duplicate genes).

Chromosome X

Suppression of leaf necrosis (11) by nullis (necrotic leaves), telos and isos (right arm).
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Earliness (3) by substitution lines.
Normal outer glumes (11) by nullis (narrow, spreading outer glumes), telos and isos (left arm).
Awn inhibition (7) by monos, (14) by monos, (11) by telos and isos (left arm).
Spike density (3) by substitution lines.
Suppression of pistillody (11) by nullis (pistillody), telos and isos (right arm).
Kernel weight (3) by substitution lines.
Yield (3) by substitution lines.
Seedling leaf rust resistance (2) by monos. (complementary genes).
Mature leaf rust resistance (1).
Stem rust resistance (2 linked complementary genes) (12) by nullis, (13) by substitution lines.

Chromosome XI

Plant height (3) by substitution lines.
Spike density (3) by substitution lines.
Suppression of pistillody (11) by nullis (pistillody), telos and isos.
Red coleoptile (11).
Mildew resistance (11).
Seedling stem rust resistance (13) by substitution lines.

Chromosome XII

Plant height (11) by nullis (reduced height), (3) by substitution lines.
Leaf development (11) by nullis (narrower, shorter, stiffer leaves).
Earliness (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Spike density (3) by substitution lines.
Spike length (11) by nullis (shorter spikes).
Awn expression (2) by monos, (3) by substitution lines (interaction with genes on VIII and X).
Fertility (11) by nullis (low fertility) and telos.
Yield (3) by substitution lines.
Seed lethality in combination with Neatby's virescent on III (Sears, Wheat Information Service #6, p. 1 by permission).

Chromosome XIII

Plant height (11) by nullis (reduced height).
Tillering (11) by nullis (reduced tillering).
Leaf development (11) by nullis (shorter, narrower leaves).
Solid culm inhibition (4) by aneuploids.
Spring growth habit (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Earliness (11) by nullis (delayed maturity).
Basal spikelet development (11) by nullis (basal spikelets poorly developed).
Glume development (11) by nullis (thin, papery glumes).
Seedling stem rust resistance (13) by substitution lines. (complementary gene on III).
Adult stem rust resistance by monos (McGinnis and Campbell, 1957 Wheat Newsletter, Vol. IV, p. 7, by permission - complementary to genes on III and VIII).

Right arm
Normal spike-internode length (11) by telos and isos.
Awn promotion (11) by nullis (awnless), telos and isos.
Female fertility (11) by nullis (female-sterile), telos and isos.

Chromosome XIV

Plant height (11) by nullis (reduced height).
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Spike length (11) by nullis (shorter spikes).
Pubescent glumes (10) by nullis (non-pubescent glumes).
Fertility (11) by nullis (low fertility).
Leaf rust resistance (Heyne by correspondence).

Chromosome XV

Plant height (11) by nullis (reduced height).
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Earliness (3) by substitution lines.
Spike length (11) by nullis (shorter spikes).
Male fertility (11) by nullis (male-sterile).
Protein content (3) by substitution lines.
Stem rust resistance (one of 2 genes) (Loegering by correspondence).

Chromosome XVI

Leaf development (11) by nullis (narrower, shorter, stiffer leaves).
Tillering (11) by nullis (reduced tillering).
Root development (11) by nullis (reduced root development).
Earliness (11) by nullis (delayed maturity).
Lodging resistance (3) by substitution lines.
Culm and spike development (11) by nullis (twisted culm and spike).

Chromosome XVI (cont'd)

Solid top internode of culm by monos (Larson, by correspondence).
Spike density (3) by substitution lines.
Spike length (11) by nullis (shorter spikes) and telos (left arm).
Sphaerococcum characters (8) by nullis, (9) by monos.
Fertility (11) by nullis (low fertility),
Kernel weight (3) by substitution lines.
Yield (3) by substitution lines.
Protein content (3) by substitution lines.
Modification of bunt resistance (14) by monos.
Seed lethality or lowered viability in combination with Neatby's virescent on III (Sears, Wheat Information Service No. 6, p. 1, by permission).

Right arm

Plant height (3) by substitution lines, (11) by nullis (reduced height) and telos.
Awn inhibition (11) by nullis (longer awns), telos and isos, (2) by monos.
Red seeds (8) by nullis (white seeds), (11) by telos and isos.

Chromosome XVII

Plant height (11) by nullis (reduced height).
Tillering (11) by nullis (reduced tillering).
Procumbent tillering (5) by pentaploid hybrid offspring.
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Awn suppression by monos (McGinnis and Campbell, 1957 Wheat Newsletter, Vol. IV, p. 7, by permission - complementary to gene on IX).
Earliness (3) by substitution lines.
Spike length (11) by nullis (shorter spikes).
Fertility (11) by nullis (low fertility), telos and isos.
Yield (3) by substitution lines.
Seedling stem rust resistance (13) by substitution lines.

Chromosome XVIII

Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Solid lower internodes of culm by monos. (Larson, by correspondence).
Tillering (11) by nullis (reduced tillering).
Spring growth habit (3) by substitution lines.
Earliness (3) by substitution lines, (11) by nullis (delayed maturity) and monos.
Spike size (11) by nullis (smaller spikes).
Glume size (11) by nullis (smaller glumes).
Male fertility (11) by nullis (male-sterile).
Seed size (11) by nullis (smaller seeds).
Yield (3) by substitution lines.

Chromosome XIX

Plant height (11) by nullis (reduced height).
Leaf width (11) by nullis (narrower leaves).
Culm thickness (11) by nullis (thinner culms).
Solid culm inhibition (4) by aneuploids.
Earliness (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Outer glume development (11) by nullis (narrower, more spreading outer glumes).
Spike density (3) by substitution lines, (5) by pentaploid hybrid offspring.
Kernel weight (3) by substitution lines.
Yield (3) by substitution lines.
Seedling stem rust immunity (13) by substitution lines.

Chromosome XX

Plant height (11) by nullis (reduced height).
Tillering (11) by nullis (reduced tillering).
Solid culm inhibition (4) by aneuploids, (5) by pentaploid hybrid offspring.
Earliness (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Compactum or club spike (14) by monos.
Spike density (3) by substitution lines.
Spike-internode length (11) by telos and isos (left arm).
Glume development (11) by nullis (thin, papery glumes).
Stem rust resistance (2 dominant genes) (15) by monos.

Right arm

Suppression of spikelet reduplication (11) by nullis (spikelet reduplication), telos and isos.
Awn development (8) by nullis (awnless), (11) by telos and isos.
Female fertility (11) by nullis (female sterile), telos and isos.

Chromosome XXI

Plant height (11) by nullis (reduced height).
Leaf width (11) by nullis (narrower leaves).
Solid culm inhibition (4) by aneuploids.
Earliness (3) by substitution lines.
Lodging resistance (3) by substitution lines.
Spike density (3) by substitution lines
Spike length (11) by nullis (shorter spikes).
Awn expression (2) by monos, (3) by substitution lines (interaction with genes on VIII and X.)
Yield (3) by substitution lines.

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## Irradiation Effect on the Monosomic Series

The work done by Mr. Tsunewaki at Manhattan was reviewed by Heyne. Seed of the Chinese monosomics were irradiated with 1500 r units of X-ray. The material was then studied from germination through maturity. Some of the results obtained were as follows:

Mono. XIII had greatly reduced germination.
Monos. III and XVI were affected in early developmental phases.
Monos. VIII and XV had depressed numbers of tillers.

## Cytogenetics of wheat-rye hybrids

Sebesta reported on his study of the Cornell rust-resistant wheat-rye strain. Resistance is assumed to have come from the rye parent. The resistant lines have 44 chromosomes, and resistance is dependent on the presence of the extra pair of chromosomes or telos. It may be possible to transfer the resistance from the telo to a wheat chromosome by irradiation.

# REPORT OF THE COMMITTEE ON WHEAT NOMENCLATURE AND SYMBOLS

E. G. Heyne

The committee on wheat nomenclature and gene symbols appointed by the Crops Section of the American Society of Agronomy and consisting of E. G. Heyne, L. P. Reitz, J. W. Schmidt, E. R. Ausemus, I. M. Atkins, and R. J. Metzger presented the following statement and resolutions to the conference.

A committee was appointed of United States and Canadian wheat research workers by the American Society of Agronomy to develop a "uniform standardized system of nomenclature and symbols for genetic factors" in wheat (Amer. Soc. Agron. Jour. 34:1154. 1942). A summary of genetic studies in hexaploid and tetraploid wheats with recommended symbols was prepared and published in the Amer. Soc. of Agron. Jour. 38:1082-1099. 1946. This committee was disbanded in 1952.

Four people, two from Canada, Ruby Larson and B. C. Jenkins, and two from the United States, E. R. Sears and E. G. Heyne, were asked by a group of the wheat research workers to serve as a committee to continue this activity as an independent unit without further sponsorship of the American Society of Agronomy.

In 1953, the Japanese National Committee of Genetics recommended a new set of symbols for wheat characters in which they followed closely the rules set up by the International Genetics Congress pertaining to designation of genetic symbols. In general, there is agreement with the suggestions published in the Amer. Soc. of Agron. Jour. in 1946 and the Japanese system of 1953. The major difference is that the Japanese system attempts to set up the variety *Triticum vulgare* Vill. *graecum* Korn as the "so-called" wilt type, that is, the characters of this variety would be designated by + and the symbols be designated on an adjective-noun basis instead of merely the noun.

In 1954, a committee was appointed by the International Union of Biological Sciences held in Zurich to make recommendations for the standardization of symbols and adoption of common rules for their use with all biological organisms, which will make a report at the 10th Internation Genetics Congress in August, 1958. A motion was made and adopted at the last meeting of the Crops Section of the Amer. Soc. of Agron. at Atlanta to reorganize a committee on nomenclature and gene symbols for wheat. This committee has met and presents the following resolutions for your consideration:

We resolve that the Hard Red Winter Wheat Conference held at Stillwater, Okla., Feb. 11-13, 1958, go on record as favoring the adoption of the adjective-noun approach for establishing genetic symbols for genetic characters of wheat not yet published and that no "wild" type Triticum be recognized and that (this) viewpoint be presented at the 10th International Genetic Congress at Montreal. We further resolve that wheat research workers follow the international agreement on nomenclature as established by the International Genetics Congress. Furthermore, we recommend that an up-to-date published list of wheat genetic characters and symbols be prepared.

We resolve that the Hard Red Winter Conference held in Stillwater, Okla., Feb. 11-13, 1958, favor the immediate initiation of a plan to collect and maintain genetic stocks of wheat by encouraging or designating certain individuals at various locations to accept the responsibility for certain characters (smut genes, stem rust genes, aneuploid stocks, etc.); that the other organized wheat groups in the United States be invited to join with this group and to encourage workers on wheat genetic problems to cooperate on this project; that the maintenance of genetic stocks be worked out cooperatively with the Canadian wheat research workers; and that the committee of the Crops Science Society of America on Genetic Nomenclature of Wheat act as a temporary committee to initiate these objectives.

We resolve that a National Wheat Improvement Committee be organized to coordinate the over-all activities of the four designated wheat regions. The committee would be made up of two members from each of these four regions with the head of the Wheat Section of the USDA automatically a member and the secretary of the group. We suggest the representatives from each of the regions be the secretary and chairman of the respective regional committees. A national committee so constituted would appoint such committees as might be needed to carry out effectively the needs of the national wheat program, such as genetic nomenclature and maintenance of genetic stocks, and preparation and publication of the Wheat Newsletter.

The resolutions were unanimously adopted by the conference and the secretary was instructed to transmit them to the proper people in the other wheat regions.

# REPORT OF THE RESOLUTIONS COMMITTEE

We, the participants in the 1958 Hard Red Winter Wheat Conference, hereby resolve that -

SINCE the successful completion of this conference has in a large measure been the result of the services and planning performed by the staff of the Oklahoma State University, particularly members of the small grain section of this institution -

We wish to express our sincere gratitude for the facilities and services which have contributed in numerous ways to the success of this conference and to our own personal convenience.

We also wish to express our appreciation for the banquet and the periods of relaxation provided by the Oklahoma Wheat Research Foundation, for the Smoker provided by the Oklahoma Crop Improvement Association and for other support they have given this conference. We are indebted to the Nebraska Crop Improvement Association for the stenographic service they provided. We gratefully acknowledge this support.

We hereby also direct that the Secretary be instructed to express our appreciation by letter to the appropriate leaders of the organizations mentioned and that these Resolutions should become a part of the official records of this conference.

Kenneth B. Porter
Reginald H. Painter

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