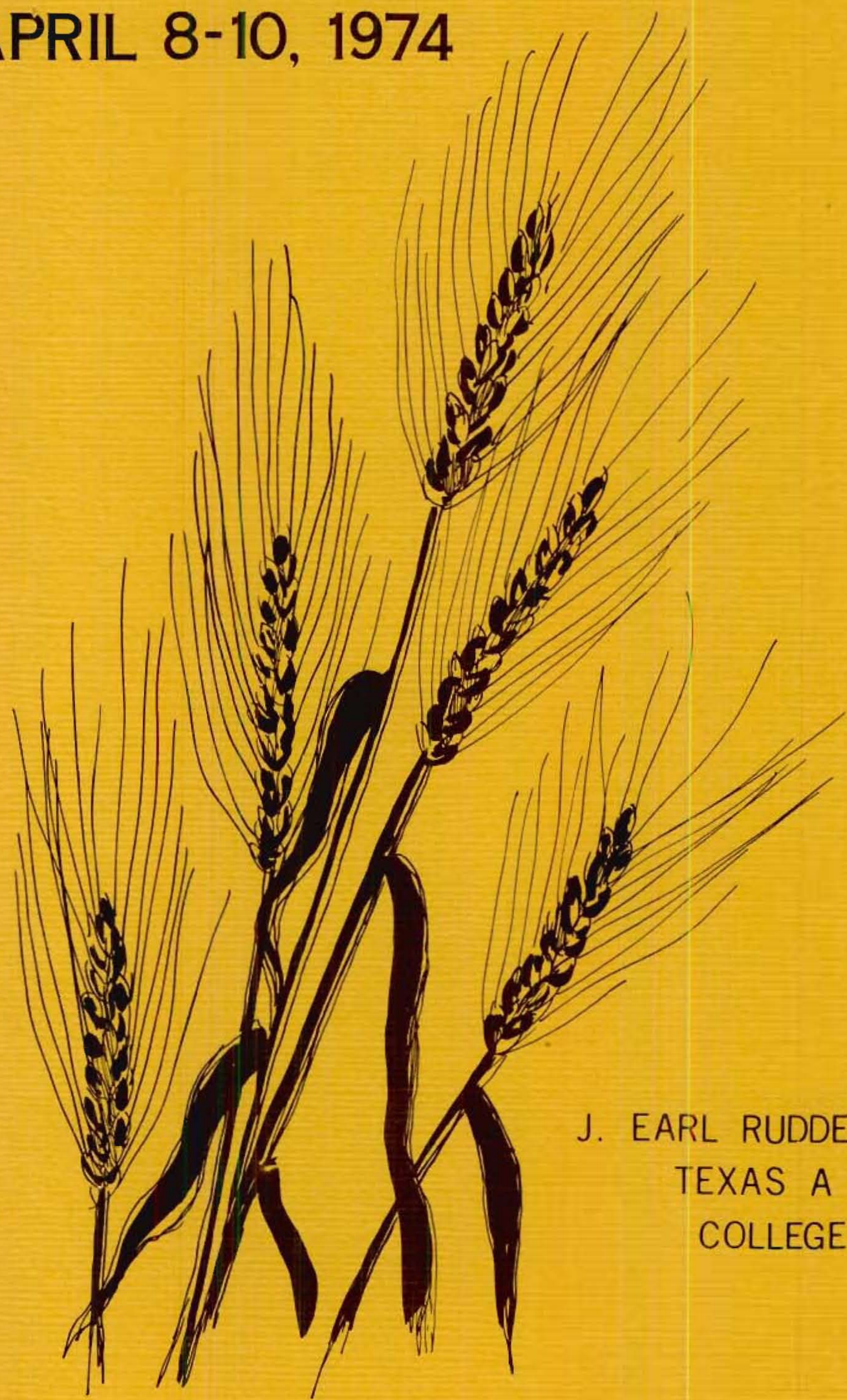
PROCEEDINGS

THIRTEENTH HARD RED WINTER WHEAT WORKERS CONFERENCE

APRIL 8-10, 1974



J. EARL RUDDER CONFERENCE CENTER
TEXAS A AND M UNIVERSITY
COLLEGE STATION, TEXAS

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Service

and

State Agricultural Experiment Stations, Cooperating

in the

Hard Red Winter Wheat Region

PROCEEDINGS

OF

THIRTEENTH HARD RED WINTER

WHEAT WORKERS CONFERENCE

Texas A & M University
College Station, Texas
April 8-10, 1974

Report not for publication[1]

Agronomy Department
Agricultural Experiment Station
Lincoln, Nebraska
April, 1975

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FOREWORD

This was the thirteenth time that workers in the hard red winter wheat region have met to review research and exchange information. Wheat workers from other wheat regions in the USA, Canada, and from the private sector of the wheat industry also participated. The conference was sponsored by the Hard Red Winter Wheat Improvement Committee.

This conference was a departure from prior regional conferences. The organizing committee elected to hold a relatively unstructured meeting in which several broad discussion topics dealing with wheat improvement in the region would be addressed. A discussion leader for each topic was selected but formal papers or presentations were not solicited. Well-chosen slides to convey ideas or to provide new research information were encouraged.

The committee recognized some risks associated with such an unstructured meeting but were convinced that the meeting could be most productive if the participants were willing to make it so. General discussion topics were identified prior to the meeting and participants were encouraged to think about them and come prepared to contribute information and ideas. The consensus among those who participated was that the conference was eminently successful and most participants indicated their desire to consider similarly unstructured foremats in future regional conferences.

In keeping with the unstructured makeup of the conference, participants were not required to submit written material for inclusion in this Proceedings. Many elected not to do so. Therefore, the material contained herein does not reflect the large and meaningful exchange of research information and ideas that occurred in the conference. The true value of the conference was in the stimulation afforded by vigorous and occasionally sharp exchange of information, ideas, and research philosophies and not in this partial record of the meeting.

-- V. A. Johnson
Winter Wheat Technical Advisor
and
Secretary, Hard Red Winter Wheat Improvement Committee

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CONFERENCE ORGANIZING COMMITTEE

E. L. Smith	Oklahoma State University (Chairman)
R. W. Livers	Fort Hays Experiment Station
H. C. Young, Jr.	Oklahoma State University
P. J. Mattern	University of Nebraska
G. A. Taylor	Montana State University
N. E. Daniels	Texas Agricultural Experiment Station
O. G. Merkle	ARS, Texas A & M University

PROGRAM

April 8

Morning: Welcome -- Dr. H. O. Kunkel,
Dean of Agriculture, Texas A & M University

Environmental Hazards
-- R. W. Livers, Leader

Afternoon: Public Plant Breeding
-- V. A. Johnson, Leader

Disease and Insect Pests
-- H. C. Young, Jr. and N. E. Daniels, Leaders

Evening: Regional Business Meeting
-- K. B. Porter, Presiding

April 9

Morning: Plant Architecture
-- E. L. Smith, Leader

Crop Management
-- K. B. Porter, Leader

Afternoon: Field Tour

Evening: Social Hour

April 10

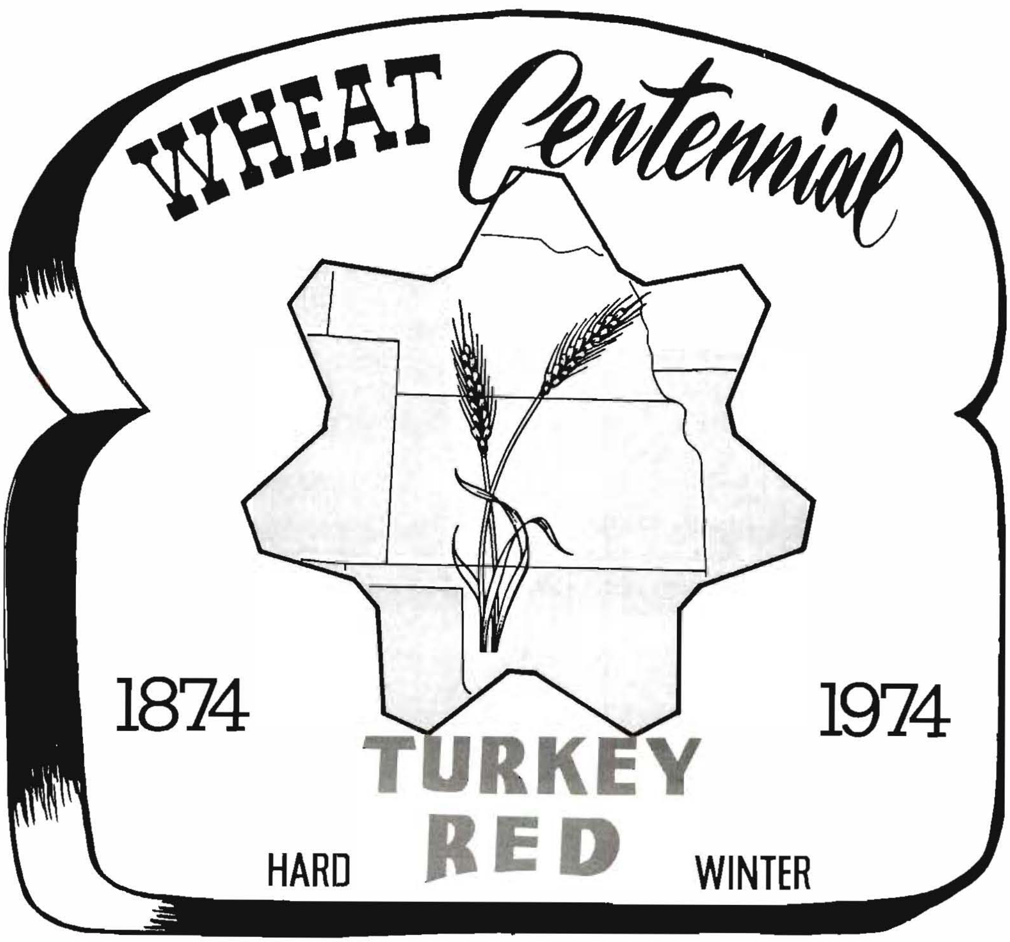
Morning: Nutritional Quality
-- P. J. Mattern, Leader

Genetic Analyses
-- J. R. Welsh, Leader

Hosted by: The Texas Agricultural Experiment Station
and
The College of Agriculture, Texas A & M University

TURKEY WHEAT CENTENNIAL

Nineteen seventy-four was the 100-year anniversary of introduction of Turkey Red Wheat into Kansas. Because of the contribution and significance of Turkey wheat to the hard red winter wheat region, material prepared by the Kansas Wheat Centennial Committee and provided by Mr. Tom Roberts of the Kansas Wheat Improvement Association is reproduced.



WHEAT GROWING IN EARLY KANSAS

The story of winter wheat raising in Kansas is older than statehood itself. The Shawnee Indian Mission, in Johnson County, reported sowing 100 acres of winter wheat in 1839. A Sac and Fox Indian farmer sowed 40 acres in 1850, and members of the Osage Tribe were reportedly sowing wheat in 1851. The early white settlers raised both spring and winter wheat of the softer types, together with a greater acreage of corn.

Wheat production increased in Kansas during these early years, along with the population gain, as more land was opened for crops. Corn occupied a major portion of the cropland. In 1875, corn production was still almost six times as large as the wheat yield.

Wheat production statistics were separated into the spring or winter types for the first time in 1870. That year spring wheat production was larger than that for winter wheat. In subsequent years, winter wheat acreage increased while spring wheat production declined. This trend continued: by 1886 winter wheat was harvested from 982,000 acres, and spring wheat was harvested from 83,500 acres.

T. C. Henry, a self-styled "winter wheat evangelist", planted 500 acres east of Abilene in 1873. He sowed the Early Red May and Little Red May varieties of soft winter wheat. By 1878 his operation covered 10,000 acres in Dickinson County. (Much of the above information is based on the article by Dr. Homer E. Socolofsky in MARKETING KANSAS WHEAT, 1959.)

Turkey Hard Red Winter Wheat was brought to Kansas by Mennonite immigrants from South Russia. Bernard Warkentin, a Mennonite miller, played an important role in introducing the hard winter wheat to Kansas. Warkentin and Peter Wiebe, together with German Mennonites from Summerfield, Illinois, reserved land near Halstead in Harvey County in 1873. In that same year eight vanguard Mennonite families from the Crimea and Molotschna areas of South Russia settled in Marion County.

The small groups of immigrants were reinforced by hundreds of Mennonite families from South Russia during the late summer and fall months of 1874. These 1874 immigrants brought small amounts of many agricultural seeds with them, including some Turkey Hard Red Winter Wheat. They settled on Santa Fe Railroad land in Marion, McPherson, Harvey, and Reno Counties.

Introduction of Turkey Hard Red Winter Wheat into Kansas in 1874 produced many changes in Kansas agriculture during the past century. Corresponding changes occurred in Kansas economic situation.

Prior to Turkey Hard Red Winter Wheat's introduction, Kansas tried producing soft winter wheats brought from eastern corn belt states. Wheat production was confined to less than one million acres and yielded but $7 to $8 million gross income annually. Twenty years after this introduction, wheat occupied 5 million acres and produced more than $50 million gross annual income.

Wheat achieved status as Kansas' most important crop during the period of World War I, a time of world wide food shortages. By 1914, value of the Kansas wheat crop was more than double that of corn, the previous leader among Kansas crops. In 1924, value of the wheat crop was more than $180 million and exceeded the combined value of all livestock produced in Kansas that year.

More than 40 years ago, Kansas wheat production exceeded 250 million bushels in a single year. The State had demonstrated its unqualified superiority as a Producer of Hard Red Winter Wheat -- having produced more of this class of wheat in a single year than any other political unit in the world.

Even during the depths of drought and depression, wheat stood in the forefront of Kansas agriculture. In 1934, for example, wheat contributed more than $70 million gross income -- more than that generated by any other individual crop or livestock commodity.

During each of the last five years, Hard Red Winter Wheat has established new records of yield efficiency and/or total production. Since the 1969 harvest, value of Hard Red Winter Wheat has exceeded $3.0 billion. The value of the 1973 crop alone will exceed $1.25 billion!

ENVIRONMENTAL HAZARDS

General Question: The region constitutes a harsh environment for wheat production. Variable precipitation patterns, relatively low water use efficiency, high winds, and great fluctuations in temperature are important climatic features. What effects do these constraints have on wheat breeding programs?

Topics Discussed:

- Seedling emergence
- Winterkilling
- Spring frosts
- Lodging
- Shattering
- Heat and drought effects
- Hail damage
- Sprouting in the field
- Tillering

ASSOCIATION OF CHARACTERISTICS OF FIELD AND GROWTH CHAMBER SEEDLINGS WITH WINTER SURVIVAL OF WHEAT

G. A. Taylor

We studied the relationship between morpho-developmental characteristics and winter wheat (Triticum aestivum L.) survival of six diverse cultivars planted at five depths in a growth chamber and one depth in the field.

Cultivars and planting depths differed significantly for crown node depth, emergence rate index (ERI), seedling height, adventitious root length and number, tiller number, and seedling foliar dry weight. The cultivar X depth interactions were significant for all characteristics except ERI and seedling height. 'Froid' and 'Yogo' developed the shallowest crown nodes followed by 'Cheyenne', MT 6928, 'Itana' and 'Crest' in that order. Froid and Yogo had the longest adventitious roots and the most adventitious roots and tillers. Shallow planting depths resulted in high ERIs, tall seedlings, shallow crowns, long adventitious roots, more adventitious roots and tillers and high foliar dry weights.

All characteristics were significantly correlated. Crown node depth was negatively associated with adventitious root length and number, tiller number and foliar dry weight. Adventitious root length was positively associated with number of roots and tillers, ERI and foliar dry weight. Growth chamber and field crown node depths and adventitious dry lengths were significantly correlated (.90* and .90*, respectively).

Shallow crowns were associated with increased winter survival. The negative correlation of adventitious root length with crown node depth (r = -.58**) and the positive correlation of root length with winter survival (r = .99**) further emphasize the importance of the winter wheat crown region relative to winterhardiness.

The identification of genotypes with shallow crown nodes, high adventitious root lengths and ERI should enhance selection for winter survival in winter wheat breeding programs functioning in environments similar to Montana.

Soil Water Depletion and Water Use Efficiency of Winter Wheats

Winter wheats are primarily grown in semiarid regions of the United States and the world. The most limiting production factor in these regions is moisture available for plant growth. The identification of winter wheat varieties which are efficient water users and the delineation of plant characteristics associated with this efficiency would contribute valuable information to wheat breeders in their variety development activities and to grain producers.

We designed a field study using ten winter wheat varieties, fourteen growth stages and eight soil depths to examine water use patterns and water use efficiencies of winter wheats and to identify major associated plant characteristics.

Under conditions of this study, we found the shorter, earlier maturing winter wheat varieties were the most efficient users of soil moisture. Those varieties which were most efficient water users (bushels of grain per inch of water used) also exhibited the highest yield. The shorter varieties 'Crest' and 'Nugaines' yielded 70 and 74 bushels per acre and averaged 6.0 and 5.9 bushels per inch of water used, respectively. Two tall late maturing varieties 'Froid' and 'Winalta' both yielded 54 bushels per acre, with reduced efficiencies of 4.6 and 4.1 bushels per inch of water used.

We also found that winter wheats removed water differentially when growth stages and soil depths were considered. Water use differences at the five, six, seven and eight foot soil depths were indicative of rooting pattern differences. The shorter wheats appear to have more intensive root systems primarily restricted to the top four feet.

When we averaged all winter wheat varieties we found that water use increased from the late tillering stage in May, to stem extension in June and peaked during heading and grain filling in July. Water use greatly decreased during the July-August maturation stage. Additionally, the averages showed that although significant amounts of water were used from the lower four feet, the upper four feet accounted for 88% of the total water used, with 54% coming from the top foot.

The information, from this and further studies, is beneficial to both wheat breeders and wheat producers. Wheat breeders can better determine the parental materials which will most likely result in superior progenies and varieties for the wheat grower. Also water use efficiency of winter wheat varieties is useful in the effective management and use of soil water.

PUBLIC WHEAT BREEDING

General Question: Will the role of the public wheat breeder remain unchanged in the next decade? If not, what kinds of changes will occur?

Lead-off remarks by V. A. Johnson:

Developments since 1962 --

Commercial seed companies entered the regional wheat breeding picture.

Some believed that this would lead to the phasing out of public breeding.

Situation today --

Public breeders continue to be very active in the major hard red winter wheat states.

Several seed companies have large breeding programs in the region.

Three hybrids and several varieties released by seed companies.

Variety Protection Law enacted.

Impetus for the Law came initially from the private sector.

Working relationships between public and commercial wheat breeders in the region have been established.

Evidence -- presence of many scientists from private companies at this conference and their involvement in regional affairs and activities.

Future --

It seems likely that both public and private sectors will continue to be involved in hard red winter wheat variety and hybrid development.

There continues to be some areas of concern among the public and the private sector breeders. This session is intended to provide a forum for examination of these concerns.

Have inappropriate germplasm releases been made by breeders? Is this a serious problem?

Have there been wheat releases by commercial companies of material obtained from State Experiment Stations without appropriate recognition and acknowledgement of their source?

Plant Variety Protection Law
- Acceptable.
- Interpretation of the law is needed.
- What are the implications and consequences of restriction of use of name to classes of certified seed?
- Perhaps there should be protection of name only.
- What about royalties?

Remarks by L. P. Reitz:

Leaders of wheat improvement programs are responsible for the direction their work is to go. Therefore, it is somewhat presumptuous of me to tell them what to do. Nevertheless, I must tell you that I am repeatedly alarmed when breeders and other wheat researchers appear to relax their efforts on exploratory probing for new knowledge and techniques. I am not talking about short-cuts and increased efficiency in breeding which everybody works at all the time. My concern is that basic inquiry be maintained on mechanisms of responses, the nature of resistance, how to bridge cross-breeding barriers, ways to avoid epiphytotics, enhancement of the predictive value of yield and plant performance trials, pathways to high nutritive quality and digestibility, avoidance of the many losses in production and storage, boosting the yield potential of wheat to match that of corn, and the genetic and cytoplasmic controls of all these processes. Public agency workers have a responsibility to keep this "front" of science moving forward.

Consequently, I think it highly appropriate for administrators to provide budget and employment opportunities for scientists to explore new horizons.

It is especially important to involve young scientists in these endeavors. I look at the crowd here in this conference and realize that the leadership in the hard winter wheat region has changed completely three times since the Parker-Kiesselbach-Quisenberry era. It is very nearly true on a state-by-state basis also. Who will replace you?

New ideas are frequently met with hostility, disdain, and "reasons why they won't work." I have fought this kind of bigotry all my life wherever I found it -- both in myself and in others. We must keep the way open for honest, well-thought-out, exploratory work. Somehow people with ideas must be supported, encouraged, and funded. Every program can plow back a little of its funds for this kind of work.

I am asked frequently whether industry breeders could take the major responsibility for variety development. The answer, of course, is "yes, whenever they want to put enough effort into it." In corn, the change was accompanied by a chorus of cries that corn research was doomed. Quite the opposite has happened. Corn research is still the finest in the land and, significantly, the lines and populations being released by public research teams are at the fore-front of the best combining germplasm available anywhere. I have only two fears about private breeders dominating wheat variety development: (1) that they won't put creative effort into it and will become merely "skimmers", and (2) that they may neglect areas of small acreage and minor needs. It is gratifying to me that this Workers Conference has been open to private breeders and I sincerely hope future conferences remain so.

DISEASE AND INSECT PESTS

General Question: There have been drastic and significant changes in management systems in the HRWW Region over the past decade. What effects have these changes had on disease and insect complexes important to wheat production and what can be done to reduce production losses to the pests?

Topics Discussed:

Disease Session

Influence of advanced planting dates in Southern Plains on:
- Rust development
  - Fall epidemics
  - Winter rust survival
- Root rot
  - *Helminthosporium sativum*
  - *Fusarium* species
  - *Rhizoctonia solani*
- Leaf blights
  - *Septoria tritici*
  - *Helminthosporium sativum*

Influence of minimum tillage practices on inoculum levels of:
- *Helminthosporium sativum*
- *Fusarium* species
- *Rhizoctonia solani*
- *Septoria tritici*

What should varietal life expectancy and adaptability be in relation to:
- Genetic diversity?
- Best use of resistance genes?

How can specific resistance be utilized?
How can non-specific resistance be utilized in an overall improvement program?
What do breeders want in terms of data from disease evaluations?
What will increased corn acreage in the western plains do to summer carry-over of western streak mosaic?
- Can the vector be controlled on corn economically?
- Will isolation serve as a control measure?

DEFINING AREAS OF NATURAL OVERWINTERING OF WHEAT STEM RUST

A. P. Roelfs

It is currently obvious that the major primary source of wheat stem rust inoculum in the north-central U.S. is from areas further south. The eradication of the barberry from the principle grain-growing areas has eliminated this source of primary inoculum from the wheat-growing areas. Most cultures currently identified from the few barberry aecial infections collected in the northern area are not *Puccinia graminis tritici*.

It has long been assumed that stem rust overwintered in northern Mexico and south Texas and then moved northward in the spring. In 1970, however, we observed the occurrence of extensive primary infection of stem rust in Kansas that could not be explained by this assumption and subsequently, race survey data showed that south Texas and Mexico was not the source of the race found in Kansas. In 1971, a severe drought in south and central Texas was unfavorable for rust development. Among the few collections from south Texas, no isolates of race 15B-2 were found. In 1972, no race 15-TN or -TL was found in south Texas or Mexico. Again in 1973, a similar pattern was observed. Race 15-TNM and -TLM was not recovered from collections from Mexico and south Texas, i.e., those countries completely south of the 30^{o} parallel. South of this line races 11-32, 17, and 151 were common. North of this line these races were found in trace amounts in collections made near harvest time. Collections from north and central Texas in late April consisted of race 15-TNM and -TLM. Races found in Louisiana nurseries were identical to south Texas except that race 15-TNM and -TLM was also present. In late April, traces of rust were found at Poplarville, Mississippi and it was identified as race 32-RKQ. On May 21 and June 24 two collections, also identified as RKQ, were made at Hartsville, South Carolina (Calvin Newton). A single collection from Freeport, Florida on April 25 (R. D. Barnett) yielded one isolate of TNM and two isolates of QFB. Stem rust was found at Stuttgart, Arkansas on April 30; however, it was probably artificially introduced as a contaminant in inoculum of leaf rust applied to these plots. The race identified was 151-QFB. No collections were received for identification from Missouri, Kentucky, Tennessee, Alabama, Georgia, or North Carolina. Thus, the failure to detect the race 15B group south of the 30^{o} parallel and its appearance in central and northern Texas suggest that this race group overwinters outside of the assumed overwintering area.

Rod impaction traps were used in rust trap plots during the early spring of 1973 to locate possible areas of wheat stem rust infections. These traps were known to detect trace amounts of rust near the trap but generally are ineffective for detecting the arrival of exogenous spores. Rust trap plots, 16 x 20 ft, were planted at Beeville, Texas (Lucas Reyes, cooperator), Chillicothe, Texas (B. R. Schuette, cooperator), and Quincy, Florida (R. D. Barnett, cooperator). The variety used in these plots was McNair 701, a soft red winter wheat susceptible to stem rust with 'Transfer' type leaf rust resistance. A fourth station was located in a breeding nursery at Atmore, Alabama (in cooperation with R. W. Romig and W. Caldwell of Northrup King). At Beeville our plot was separated from the small grain nurseries by about 1/4 mile. Stem rust apparently overwintered only in the breeding nursery and moved into our plot in early March. Rust was found in early May within 50 miles of Chillicothe at Seymour and Iowa Park. It could not be determined where the rust overwintered at Seymour; however, at Iowa Park the apparent overwintering source was a seed increase field. Apparently stem rust occurred in only one location in Florida where it either could have overwintered or could have resulted from an early spring infection. No stem rust developed on the trap plot at Quincy. Stem rust overwintered in Louisiana in the Baton Rouge wheat nursery; however, to my knowledge no commercial fields of wheat are present in that area. I have not found wheat stem rust on other grasses in Louisiana.

Observations on oat stem rust indicated that it overwintered in 1973 at Beeville, Texas and at Hope and Rohwer, Arkansas. Thus, it appears possible for rust to overwinter as far north as the 34° parallel.

In 1974, rust trap plots of McNair 701 were planted at Beeville, Chillicothe, Renner, and College Station, Texas; Hope and Rohwer, Arkansas; Quincy, Florida; and Atmore, Alabama.

THE POSSIBLE EFFECT OF CENTURK ON THE RACE DISTRIBUTION OF WHEAT STEM RUST

A. P. Roelfs

Historically, the dominant races in the major wheat-producing area of the Great Plains were those with virulence for most of the hard red winter wheats. First race 56, and later race 15B predominated during the past 40 years. Stem rust is now suspected to overwinter on hard red winter wheats north of the 30° parallel in Texas. The acreage planted to Centurk, a new hard red winter wheat variety, is increasing from Nebraska to Texas and is replacing varieities that were susceptible as seedlings to race 15-TNM. This increase in acreage of Centurk reduces the potential for race 15-TNM to overwinter and increase in the hard red winter wheat area. Centurk, however, is susceptible to race 151-QSH that predominates in southern Texas. Although this race has been present in trace amounts throughout the United States since 1965, it never has become abundant outside of southern Texas and Mexico. The northward spread of this race probably has been restricted by the moderate seedling resistance to race 151-QSH of the hard red winter wheats. The increasing acreage of Centurk weakens this barrier and could cause a shift in the race population. This shift probably will involve a reduction in the prevalence of race 15-TNM and -TLM and may result in an increase in race 151-QSH.

A potential hazard from race 151-QSH exists for the hard red spring wheats. Susceptible responses were obtained in a field trial in southern Texas with the commercially grown varieties Chris, Crim, Era, Fletcher, Justin, Manitou, Neepawa, Polk, Red River 68, and World Seeds 1809, as well as on the parental materials Frontana/Kenya 58/Newthatch and Kenya Farmer.

The hazard of race 151-QSH could be reduced by combining the moderate resistance of the older hard red winter wheats with the Centurk resistance in future varieties.

PROBLEMS IN BREEDING FOR SLOW RUSTING TO LEAF RUST OF WHEAT

Ralph M. Caldwell

The advantages and permanent value of general resistance for reliable genetic protection of crop plants from disease is being recognized by an increasing number of plant breeders. This recognition in our time is relatively recent and still has a long way to go. It was known to our plant-breeder grandfathers as expressed by the celebrated Australian wheat breeder, Farrer, in 1898, and resides in the progeny of the wheats they left to us.

Breeding work and most research on slow rusting of the small cereal grains was unfortunately sidetracked during the rapid development of cereal breeding in North America, after the discovery of the sensational and apparently dependable hypersensitivity ("single-gene") specific resistance. However serious shortcomings in the reliability of specific resistance have long been evident.

Since the revival of interest in slow rusting there has been apprehension regarding its use in practical wheat breeding programs. This has been due to questions regarding ability to effectively test and select for this character in hybrid progenies. These presumed limitations have contrasted sharply with the familiar techniques of seedling and mature-plant testing currently used with the single-gene, hypersensitivity resistances.

Question also arises relative to the level of economic protection. Experimental data on this question relative to leaf rust of wheat is almost nil. Circumstantial and convincing nationwide observations have been made of the effectiveness of general resistance in nurseries and fields. As yet nature has not cooperated in our several attempts to make detailed studies of relative yields of fast and slow-rusting varieties in the field under rust and rust free conditions.

The evaluation of slow rusting or general resistance is not a "yes or no" problem. Varieties, or hybrid segregates, differ on a continuous scale from very slow rusting, which confers highly adequate plant protection to fast rusting where obviously very serious damage is done. At all levels of slow rusting the wheat plant is "compatible" with the leaf rust fungus (i.e. no hypersensitivity). Once the exclusion mechanism is "breached," normal pustules are then produced. The rust estimate on the Cobb scale, or counts of rust pustules per unit area, measures the level of slow-rusting resistance of a line relative to that of check varieties of similar maturity and known history of rust susceptibility.

Breeding for specific resistance alone for over 50 years in North America has failed to produce a widely grown wheat variety that has maintained its resistance to leaf rust. This happens despite long years of encouraging greenhouse and field testing before release, even in widespread uniform nurseries. Fortunately, some varieties that prove to be susceptible to new virulent rust populations are then found to possess some useful degree of slow-rusting that previously had been "masked" or obscured by the specific resistance genes.

Many cases can be cited of more or less slow-rusting varieties that have maintained such protection over a long period of years. There are methods of quantitative measurement of the effectiveness of slow rusting under controlled inoculation of adult plants in the greenhouse. This can also be done effectively, but less accurately, in the field. From considerable experience I believe that present standard breeding methods need not be changed significantly to breed for slow rusting. However the timing of rust observations and rust inoculation must receive special attention.

The delcine in ability to exclude leaf rust by the stomata of flag leaves, (also lower leaves, sheaths and peduncles) with the onset of senescence, must be recognized in order to schedule and interpret the observations of slow rusting. Rust observations should be made before the later stages of kernel filling and when flag leaves are still normally green. Slow rusting must be judged in selection nurseries by comparison with check varieties of approximately equal earliness and known tendencies to take leaf rust.

When leaf rust observations are made too late in heavily inoculated nurseries, plant or lines with fully adequate slow-rusting under field conditions may show discouraging amounts of leaf rust. Conversely when natural epidemics occur late in breeding nurseries the exposure to leaf rust may occur after senility begins and the sharp distinctions between levels, of slow rusting may not be expressed. Nevertheless in ordinary inoculated nurseries there is usually adequate time to distinguish clearly between the slower and faster rusting lines of similar maturities and to select those at the good levels.

Effective selection can be made with early, natural leaf rust epidemics, but not when several hypersensitivity genes are introduced in the crosses to be tested. However we need to use superior new parental varieties, that have several hypersensitivity genes, in crosses with superior slow-rusting parents. Then we must inoculate the selection nurseries with leaf rust cultures that collectively have the ability to attack the segregates that received one or more of the hypersensitivity genes. Without such cultures a majority of the preferred type segregates cannot readily be picked out for slow-rusting, since only the hypersensitivity resistance will usually be seen. Obviously then very large segregating populations are required.

Certain slow-rusting varieties have been observed at latitudes from Winnepeg, Canada to Cd. Obregon, Mexico. I have seen no important interactions between varieties relative to expression of the slow-rusting character across these latitudes.

Crosses of each of 3 slow-rusting varieties with one extremely fast rusting variety have been observed in the F_2 to F_4 generations. With severe leaf rust infection, superior, slow-rusting segregates have occurred in these populations in frequences high enough to permit effective and economical selection for both slow rusting and plant type.

AGROTRITICUM RESPONSES TO WHEAT STREAK MOSAIC VIRUS

C. L. Niblett, M. K. Brakke, E. E. Sebesta

Wheat streak mosaic virus (WSMV) continues to cause serious losses in wheat production on the Great Plains. In 1973 and 1974 losses in Kansas alone were estimated at 15 and 30 million bushels, respectively. Cultural methods of control are no longer economical because it is desirable to seed early and maintain volunteer wheat for cattle pasture. Also adjacent planting of wheat and irrigated corn is resulting in increasing WSMV damage to both crops. Therefore, rapid incorporation of WSMV resistance into agronomic wheat cultivors is essential.

Cytogenetic research on WSMV resistance is in progress at Oklahoma and South Dakota State Universities and resistant germplasm has been released. All germplasm derives its WSMV resistance from _Agropyron_, with CI 15092 derived from _A. intermedium_ and CI 15321 and 15322 derived from _A. elongatum_. This germplasm has been tested at Kansas State and Nebraska and inoculated with several isolates of WSMV. CI 15092 has been inoculated in the greenhouse with at least 23 isolates of WSMV from the Great Plains and other parts of the U.S. Several days after inoculation, large chlorotic lesions developed on inoculated leaves. The lesions eventually coalesced and the inoculated leaves died. WSMV was readily transmitted from these lesions. Symptoms were never observed on leaves produced after inoculation and WSMV could not be isolated from these leaves. In greenhouse and growth chamber experiments, local lesions also developed on inoculated leaves of CI 15321 and 15322. However, systemic symptoms were later observed on all leaves developed subsequent to inoculation and WSMV was readily transmitted from all leaves. When CI 15321 and 15322 were inoculated in the field, few (probably $\not<$ 1%) systemically infected plants were observed and inoculated plot yields were comparable to uninoculated controls. Yields of companion plots of adapted wheat cultivars were reduced an average of 43% by WSMV inoculation. CI 15092 has not been inoculated in the field.

Our results suggest that the Agropyron-derived lines possess a hypersensitive type of resistance which limits WSMV to inoculated leaves. With CI 15092 this resistance is manifested in the greenhouse and probably in the field. With CI 15321 and 15322 this resistance is manifested in the field but not under existing greenhouse conditions. Experiments are in progress to determine conditions under which this resistance will be expressed in the greenhouse in order to utilize large scale seedling tests in breeding programs.

In both sources, the Agropyron resistance to WSMV can be broken by excessive heat. Exposure of inoculated plants to temperatures of 95-100° F for 36-48 hours causes all plants to become systemically infected and develop typical WSMV symptoms. This suggests that the Agropyron resistance is conditioned by a temperature-sensitive gene. However, this should not significantly reduce the effectiveness of this resistance unless wheat is planted extremely early or unusually hot fall weather occurs.

Most inoculations of WSMV to the Agropyron-derived lines have been done manually or by air-blast. This evokes the question as to whether these lines are resistant to WSMV when inoculated by the mite. Field experiments with CI 15321 and 15322 suggest that this resistance persists after mite inoculation. A moderate natural infection of WSMV occurred in the Hays, Kansas, WSMV nursery in 1974 and the same amount or fewer infected plants were observed in the control plots of CI 15321 and 15322 as in the inoculated plots ($<1\%$). Control plots of adapted cultivars contained many more naturally infected plants. In experiments at Nebraska, CI 15092 developed systemic WSMV symptoms after mite inoculation. However, manually inoculated CI 15092 also developed systemic symptoms and greenhouse temperatures exceeded 100° F on several days during this experiment. Additional experiments are in progress to determine if the systemic symptoms resulted from inoculation by the mite or excessively high temperatures.

NON-MERCURIAL FUNGICIDES FOR CONTROL OF WHEAT DISEASES AND A BETTER ENVIRONMENT

Earl D. Hansing

After several years of research volatile mercurial fungicides were registered about 1935, for use as seed treatments for replacements of inorganic copper and formaldehyde fungicides. Organic ethyl and methyl mercurial fungicides were more effective, in part, because they provided a broad spectrum of control, i.e., they were effective for control of all or at least most fungi and because they were volatile. Therefore, it was not necessary for the fungicide to completely cover the surface of each seed, nor to come in contact (except through vapor action) with each fungus spore.

From 1935 to 1970 mercurial fungicides used as seed treatments, not only played an important role for control of bunt (*Tilletia foetida*), but they were highly effective for control of seed decay and seedling blights (*Fusarium*, *Helminthosporium*, *Pythium* et al,); thus, a better stand of healthier plants and higher yields of grain and/or forage.

Extensive research has been conducted with organic nonmercurial fungicides, in part, to develop seed treatments which would be equal to or superior to mercurial fungicides and for eventual replacements for mercurial fungicides. We now not only have organic nonmercurial fungicides which are equal to or better than mercurial fungicides, but systemic fungicides which control diseases which were not controlled with mercurial fungicides.

Captan, maneb, terrazole, thiram and several non-named fungicdes are highly effective for control of seed decay and seedling blights of wheat. Research also has been conducted with combinations of these fungicides to obtain a broader spectrum of control of seed and soil fungi.

Captan, maneb, terrazole and thiram in combinations with HCB or PCNB are highly effective for control of bunt (stinking smut) of wheat.

Not only does carboxin control these diseases but it also controls loose smut (*Ustilago tritici*) of wheat, a disease which in susceptible varieties was controlled only by treating the seed with hot water. Volatile mercurial fungicides gave no control of this disease.

In addition, carboxin, in combinations with captan and thiram, is highly effective for control of seed decay and seedling blights, and in other combinations with HCB and PCNB equally effective for control of bunt.

Furthermore, research has been conducted with flowable formulations of several of the above fungicides used singly or in combinations. Flowable formulations are better adapted to go through our modern liquid seed treating machinery than wettable powders.

CEPHALOSPORIUM STRIPE OF WINTER WHEAT

D. E. Mathre

The stripe disease of winter wheat is caused by a fungus which enters the plant in the spring through root wounds caused by the heaving of soil. It has been found in Washington, Idaho, Montana, New York, Michigan, Indiana, Illinois, and recently in Kansas and Alberta, Canada. Work in Montana has shown that delayed seeding in the fall when soil temperatures at the 4 inch depth are below 55° F will reduce the incidence of this disease. Also, rotation with spring sown cereals will also reduce the disease incidence if the time period out of winter wheat is at least three years. Work in Montana and by Dr. Pope in Idaho indicates that there may be sources of resistance to Cephalosporium stripe and a major effort in this direction is being exerted in Montana.

DISEASE INCIDENCE IN SORGHUM IN A WHEAT-SORGHUM-FALLOW ROTATION WITH MINIMUM TILLAGE

Louis Palmer

Research conducted for a number of years by Gail Wicks, Extension Specialist, Agronomy at the North Platte Experiment Station, North Platte, Nebraska has demonstrated a reduction in stalk rot when sorghum is planted directly into wheat stubble (no-tillage). When the minimum tillage is compared with clear cultivation (normal tillage) sorghum yields have increased 15-20% and stalk rot in sorghum has decreased from 45% to 15%. Wheat yields have been increased about 10% in the no-till treatment compared with clear cultivation. The effect of this stubble mulch on wheat diseases is unknown at this time.

Insect Session

WHEAT INSECTS IN TEXAS

N. E. Daniels

The greenbug, *Schizaphis graminum* (Rondani), is a name reserved for the most important of several kinds of aphids which infest small grains in Texas and several other states. This green plant louse, adults of which are about 1/16 inch in length, has caused periodical crop failures. The greenbug is generally most abundant in winter and spring (in 1973 it was abundant in the fall) before most other pests appear. It is small and nearly the same color as the wheat leaf and may go undetected in the field until yellow or brown spots appear. Since 1966 these aphids have infested sorghum. Experiments for chemical control of greenbugs have been conducted in the Panhandle since 1950. Several insecticides, mainly phosphorus compounds, have been tested and found effective.

The brown wheat mite, *Petrobia latens* (Muller), is also a pest of small grains. Damage by this mite occurs only during dry weather and in some respects resembles that of drought. Infested leaves show a silvery cast and later turn brown. When this stage is reached, hundreds of mites can be seen on the leaves and on the ground at the base of the plants. The adult mite has a rounded, metallic dark brown or blackish body about the size of a period in ordinary newsprint. The legs are pale yellow, with the forelegs characteristically longer than the other three pairs. It is believed that chemical control of the brown wheat mite is not practical.

Wireworms, *Conoderus* spp. sporadic pests of germinating wheat and sorghum in the northern Panhandle, can be controlled by clean culture and correct tillage. Clean culture associated with summer fallowing will reduce the amount of injury; whereas a cropping system of continuous wheat or sorghum favors their development. Grubs, *Phyllophaga* spp. and false wireworms, *Eleodes* spp. are also controlled in this manner. Effective chemical seed treatments have been developed for the control of all three pests.

Since 1960, flea beetles, *Chaetocnema* spp. have become more serious, causing damage in some area of the Panhandle almost every fall. These small shiny black beetles are about the size of a pin head and jump readily when disturbed. Their hind legs are distinctly enlarged and thickened, resembling those of a grasshopper. During the fall they will invade a wheat field and gradually move across, feeding on and killing the plants as they go. Generally, if the infestation is found early enough, spray treatment with malathion or sevin, along the border of a field, is sufficient to prevent extensive damage.

KANSAS WHEAT INSECTS

H. W. Somsen

Insects are usually not a major factor in wheat production in Kansas but localized outbreaks of many insects often occur.

The southcentral and southwest districts usually feel a need for some chemical control of green bugs in the spring. Some research is needed to determine the proper chemicals to use, the dosage needed and when to apply them. Benefit is being received from present usage but there is considerable unnecessary spraying. Some spraying is done on greenbug populations too light to cause damage and some is applied late in the season when the greenbugs would naturally diminish.

The spread of greenbugs from the wheat field to the grain sorghum field is still not understood. It will take a great deal of field work to solve this problem.

Damage from Hessian fly has shifted from Northeast to north central Kansas to the southcentral, southwest, central and westcentral districts. This is probably due to the slight change in weather conditions more favorable to the insects. This shift from Northeast to Southwest and back, has occurred several times during the past 100 years. A little bit more attention to cultural control practices and use of currently recommended resistant varieties, especially where early pasture is desirable, will bring this problem under control.

An area wide survey of the Hessian fly has been completed. The following brief table gives the distribution of the biotypes of the fly. Biotype of Hessian fly in Nebraska, Kansas, Missouri and adjacent areas of Colorado and Oklahoma.

State	Crop Reporting District	Hessian fly Biotype and percent
Nebraska	1	GP-100
	5	GP-100
	7	GP-98, A-1, B-1
	8	GP-97, A-3
	9	GP-75, A-19, B-4
Colorado	6	GP-100
Kansas	1	GP-96, A-4
	2	GP-96, A-3, B-1
	3	GP-89, A-9, B-8
	4	GP-95, A-5
	5	GP-90, A-8, B-2
	6	GP-80, A-16, B-4
	7	GP-97, A-2, B-1
	8	GP-96, A-4
	9	GP-88, A-9, B-3

State	Crop Reporting District	Hessian fly Biotype and percent		
Oklahoma	2	GP-100		
	3	GP-83,	A-17	
Missouri	1	GP-40,	A-40,	B-20
	3	GP-5,	A-36,	B-59
	4	GP-20,	A-53,	B-26
	5	GP-15,	A-62,	B-23
	7	GP-44,	A-26,	B-29

There are wheats with suitable genes for resistance to give protection in all of these areas.

Wheat streak mosaic caused considerable damage in western Kansas this past year. There is still considerable difference of opinion on the movement of streak mosaic and mites from wheat to corn and then from corn back to wheat in the fall. There have been reports of streak mosaic spreading from corn, in sprinkler irrigated fields, to the adjacent wheat fields in the fall. A study is planned in this area.

WHEAT-RYE CROSS FOR GREENBUG RESISTANCE

E. A. Wood, Jr.

In 1966 Emil Sebesta, Plant Geneticist at Oklahoma State University successfully crossed Insave F. A. rye, a greenbug resistant variety from Argentina, with Chinese Spring wheat. The resultant, Triticale, he named 'Gaucho'; which has a high degree of tolerance and shows antibiosis to the greenbug.

Backcrosses of Gaucho to commercial wheats has resulted in a gradual elimination of rye characters but retention of the resistant dominant gene. Gaucho has been released as greenbug resistant germplasm and is available in small quantities.

It is anticipated that release of an acceptable greenbug resistant wheat may become reality in a few years. Such a release would certainly be a boon to mankind.

PLANT ARCHITECTURE

General Question: A major evolution has occurred in the morphology of the wheat plant in many of the major wheat production areas of the world. The HRWW Region has moved cautiously toward these new forms. Are these changes likely to accelerate and what are the limitations and opportunities in modifying the morphology of the plant?

Topics Discussed:

We will be considering changes in architecture of the wheat plant to maximize performance in the Hard Red Winter Wheat Region. The Russian variety Bezostaya 1 and similar types have swept the wheat-growing areas in Eastern Europe and are spreading to other areas. Many of you are using Bezostaya types in your breeding programs and are aware that they differ substantially from our Great Plains varieties in various plant and seed characteristics. Can we use the Bezostaya-type morphology in the Great Plains? Should we use it? Will we use it? What are some of the production potentials offered by this type? What problems are likely to be encountered with this type? We should, perhaps, consider the following characteristics with regard to plant architecture:

1. Resiliency of the Straw. Do we need to be concerned with this when considering Bezostaya straw type?
2. Tillering Potential. What will be the consequences of drastically reducing tillering potential?
3. Seeds/Spike. How much can we increase yield potential by genetic improvement in this character?
4. Kernel Weight. We have germplasm to increase kernel weight substantially. What is likely to happen if we do?
5. Leaf Area Duration. Can we extend the duration of photosynthetic activity of the leaves for a longer seed-filling period? Do we need to?

PLANT ARCHITECTURE FOR MAXIMIZING GRAIN YIELD IN THE HARD RED WINTER WHEAT REGION

E. L. Smith

Winter wheat production in the Great Plains was established 100 years ago by the introduction of Turkey Red from Russia. Over the years, genetic improvement has been made in the basic Turkey prototype for a number of traits including grain quality, yield potential, pest resistance, and standing ability.

A significant improvement occurred thirty years ago with the development of the Triumph variety. Compared to Turkey, Triumph has shorter straw for better standing ability and earlier maturity for escaping some of the production hazards frequently encountered in the southern plains. Today, early maturing varieties of the Triumph type are grown on a significant acreage in the region. Varieties of this type include Triumph 64, Improved Triumph, and more recently Danne, Nicoma, and Trison.

Another significant level of variety improvement was reached fifteen years ago with the development and release of Scout. Scout represented an improvement over Turkey in standing ability, yield potential, stability of production, and rust resistance. Today, Scout is the leading variety in the Hard Red Winter Wheat Region. Subsequently, a cluster of Scout-type varieties have been released including Scout 66, Scoutland, Eagle, and Baca. Here again as with Triumph types, substantial improvements in production potential have been made in a Turkey type plant.

More recently, a substantial change in plant type occurred with the development of Sturdy. This variety, adapted to the southern plains, was the first semidwarf hard red winter wheat to be released. It is essentially a Turkey type except for the straw. Sturdy, Caprock, and Tam W-101 have demonstrated that semidwarfs have a place in both dryland and irrigated culture in the region.

These three groups of varieties (Triumph, Scout, and Sturdy) represent improvements in production potential due to changes wrought in the basic Turkey prototype. Continued improvement in grain yield potential can and will be made by further refinement in the basic Turkey type plant. However, significantly higher levels of production may be reached by abandoning the Turkey prototype and taking up a strikingly different plant architecture. The question is, do we have the courage to make this change?

This architectural type is typified by the Russian variety Bezostaya 1. Wheat production patterns in eastern Europe have been markedly changed by Bezostaya 1, and varieties of this type are affecting breeding programs in the winter wheat growing areas around the world. In contrast to our Turkey-type Great Plains wheat varieties, Bezostaya 1 has large kernels, high number of spikelets per spike, low tillering potential, and thick culms.

Bezostaya 1 has been evaluated at nearly every breeding station in the region. Many of us have dismissed it as a type that had no place in the Great Plains. We argued that it would crumble under drought and temperature stress and that high winds would break the straw and that its lack of tillering potential would be a disaster.

However, the Bezostaya type was not to be dismissed so easily. Segregates from crosses between Bezostaya 1 and other Great Plains winter varieties have performed rather well in yield tests at a number of stations in the region, although their appearance in the field left much to be desired. Bezostaya 1 and related types are finding their way into breeding programs in the region. Whether or not the Bezostaya type architecture will be substituted for the typical Great Plains type remains to be seen.

In any event, the time has come for us to take a long, hard look at the Bezostaya architecture as a prototype for maximizing grain yield potential in the HRW wheat region. No doubt, everyone agrees that it would be desirable to increase the number of seeds/spike and kernel weight but the problem rests on how much tillering potential we are willing to give up in order to improve these two traits. The problem with tillering appears to be critical for Great Plains breeders.

High tillering potential has been emphasized throughout the history of winter wheat breeding in the Great Plains. In many instances selection for tiller number has been made at the expense of other yield components. We have argued that high tillering potential is necessary to adjust spike populations where stands were reduced as a result of poor emergence, disease and insect damage, winterkilling, and other factors. Spike populations per unit area can be adjusted to some extent by increasing seeding rate. Perhaps we should select for increased number of seeds/spike and high kernel weight and let tillering potential fall where it will.

Another question arises. How far can we go and how far should we go in increasing seeds/spike and kernel weight? Will we be in trouble with seed shrivelling if we increase these traits substantially? Perhaps the seed-filling period will have to be extended in some fashion in order to get proper seed fill of large kerneled types in the Great Plains area.

A proposed model of plant architecture of maximizing grain yield is presented on the next page. This model is, at best, preliminary and is subject to modification. The most critical change proposed in the model is a reduction in tillering substantially below that of our present types. A wheat variety with the characteristics as proposed in the model should give maximum yield under favorable growing conditions. However, since growing conditions are now always favorable in the Great Plains, some adjustments in this model may have to be made.

PLANT ARCHITECTURE

Proposed Model for Maximizing Grain Yield Potential in Hard Red Winter Wheat

CHARACTER		OPTIMUM CONDITION
ROOTS	-	Large, extensive root system that is efficient in uptake of water and nutrients from the soil. Resistance to root and foot rots.
LEAVES	-	Medium-sized leaves. Resistance to foliar diseases and insects. Long duration of leaf function for extended photosynthetic activity.
STEMS	-	Medium-short strong straw for resistance to lodging under high management conditions. Resilient stems for recovery from strong winds and driving rain.
TILLERING	-	Medium-low tillering potential for more efficient seed fill. Number of spikes per unit area can be adjusted by seeding rate. (Optimum tillering potential; perhaps 50% of Scout.)
SPIKES	-	Large number of spikelets and florets. Potential for 5 florets per spikelet. Uniform development of secondary florets. Large glumes for added photosynthetic activity and reduction in shattering. (Optimum number of seeds/spike; perhaps 150% of Scout.)
KERNELS	-	Large kernels (photosynthetic sink). Efficient translocation of assimilates to grain. Potential for long seed-filling period. Tolerance to drought, high temperatures and winds to insure proper seed fill. (Optimum kernel weight; perhaps 125% of Scout.)

YIELD COMPONENTS OF CENTURK AND SCOUT 66

A. Diehl

Ten spikes per plot were sampled at various SRPN sites in 1971 and 1972 to study spike and kernel yield components in an effort to identify the morphologic basis for the performance of Scout 66 and Centurk. In prior regional tests Centurk had been approximately 10% more productive than Scout 66. Kernels per spike and kernel weight were measured from spike samples from each plot; spikes per square meter was estimated by dividing the yield per plot by the product of kernels per spike and kernel weight.

Centurk and Scout 66 were nearly identical in yield in 1971. Yield component means, however, differed. Centurk exhibited more spikes per square meter and more kernels per spike. Kernels of Scout 66 were heavier than Centurk kernels. In 1972 Centurk was 8% more productive on the average than Scout 66. The superiority of Centurk over Scout 66 could be attributed to more spikes per unit area and kernels per spike which more than compensated for its lower kernel weight.

Of 37 location-years Centurk produced significantly more spikes per square meter at two location-year combinations. Centurk consistently produced greater kernel numbers per spike than Scout 66; 41% of the time Centurk significantly differed from Scout 66 for kernel number. Greater kernel number of Centurk could be attributed to more spikelets per spike and kernels per spikelet. At all location-year combinations Centurk was equal to or greater than Scout 66 for spikelets per spike. In addition Centurk produced more central kernels per spike than Scout 66 at all locations. Kernel weight differences were significant 76% of the time. Scout 66 consistently produced heavier kernels. Only four location-year combinations had significant differences for yield -- two in favor of Scout 66, two in favor of Centurk.

Correlation coefficients between yield and its components were significant and positive. No significant negative correlations between yield components were found for either variety within years. Phenotypic correlation coefficients between yield and its three major components were partitioned by path coefficient analysis into direct and indirect effects. Results indicate large positive direct effects.

Remarks by K. and B. Goertzen:

We like to feel we operate a practical wheat breeding program. From this standpoint coleoptile length has presented few if any problems in semi-dwarf breeding. At a planting depth of four inches we've experienced no problem with emergence of the semi-dwarfs or full dwarfs in advanced generations. Our planting depth automatically elimates short coleoptile wheats in the developmental stage. We know we have had some linkage problems in breeding for semi-dwarf stature but these have not been impossible to overcome.

We are stressing semi-dwarf stature in our program, high tiller number instead of the single culm wheat, three or more seeds per spikelet tendency, good straw strength, shatter resistance, and high protein level, Most of our selections made during the past three years will average 1-3% points higher protein than the presently grown commercial varieties. We feel pounds of protein produced per acre gives a better means of evaluating high protein wheat than percentage protein. Irrigated hard red winter wheat we feel should produce more than 500 lbs. protein per acre to be considered a high protein wheat. One thousand pounds of protein per acre now seems a reasonable goal for high protein hard red winter wheat under irrigation and good soil fertility.

The variety, Sturdy is an excellent source of semi-dwarf germplasm for both quality and straw strength. But for those who are prejudiced against semi-dwarfs and fail to recognize Bezostaja I as a semi-dwarf its fine yield record has probably been one of the greatest stimuli for the use of semi-dwarfs in hard red winter wheat breeding programs. It is relatively easy to recover segregates with good bread quality and good straw strength in semi-dwarfs from Bezostaja even when the crosses are made with the commonly used normal height wheats. This circumvents many of the problems with linkage for quality factors encountered when many of the CIMMYT and Vogel wheats are crossed with normal height hard red wheats and the semi-dwarf segregates are selected.

A part of the good production of Bezostaja I may be that its lack of tillering helps it tolerate high seeding rates under conditions that induce stress. In our own experience at this station stands of wheat obtained from 20 lbs. per acre seeding rate withstand moisture stress much better than those from 60 lbs. per acre seeding rate and with good tillering capacity will compensate for seeding rate to produce high yields if moisture is adequate.

MANAGEMENT

General Question: What changes in cultural practices, seeding rates and dates, fertilizer practices and other management systems will be required to maximize the production of anticipated new type of cultivars with regards to grain yield, quality, and forage characteristics?

Remarks by K. B. Porter:

Improved wheat cultivars have contributed to increases in acre yield but improvements in production methods and cultural practices have possibly been the most important factor in the substantial increase in wheat yields during the past 25 years.

Possibly more efficient use of moisture has been of major importance but increased use of fertilizer has undoubtedly contributed greatly to increased yields. Residue management, fewer tillage operations, improvements in seeding equipment and improved weed control have all aided in conserving soil moisture or increasing its use efficiency. Improvements in tillage equipment which permits more timely operations and the use of herbicides have made the above advances possible.

Many separate factors have contributed to higher yields and efficient production but none have contributed separately. Greatly increased acre yields have resulted from putting together, in the proper sequence, all of these factors and improved cultivars in the best combination. Optimum combinations of production factors is our hope for increasing yields in future years.

Wheat breeders have been cognizant of genotype - environment interactions which would include genotype - management interaction. However only limited progress has been made in breeding wheat for specific environments or management systems. Possibly the development of short wheats for fertility and soil moisture levels or other high production levels is the most notable example. Although wide adaptation will continue to be an important consideration in breeding new wheats-- wheats tailor-made for specific environments or situations and the use of specific cultural practices for particular genotypes offer possibilities for improving production.

Wheat breeders will be required to give more attention to production and management methods.

Some have proposed the uniculm as the desired plant type. However, can such a plant be used in areas where grazing is an important part of wheat production? Will they have sufficient flexibility to the stresses and varability in environments that occur during the crop year?

Considering the importance of energy requirements in crop production can wheats be developed, without a decrease in yield potential, that make more efficient use of nitrogen and other nutrients?

There is some indication short wheats can be developed that deplete the soil moisture to as great a depth and to the same degree as taller types. Is this true? Can we go too far in developing short wheat at the expense of needed plant residue?

Will the availability of chemical fungicides, growth regulators and herbicides make it possible to give more attention to yield potential per se?

Can planting rates and row spacing be advantageously specified for given types of cultivars?

Will vernalization requirements and responses to temperature and day length alter optimum planting dates of a given cultivar?

These are only a few examples of questions we will need to answer when breeding wheats for the future. The correct answers will lead to greater acre yields and efficiency in production.

Remarks by G. Hinze:

In 1966-67, relatively large strips were planted to Scout, Warrior, and Wichita. Two drills were used, an 8-inch "surface" drill with disk openers, and a 14-inch "shoe" drill giving very deep furrows. In addition, two seeding rates (15- and 30-pounds/acre) were used. All plots were harvested by combine.

Evaporation-transpiration was measured early in the spring by means of a solar-still. Early data indicated greater ET from the 30-pound seeding rates, but technical difficulties prevented completion of the experiment. However, across varieties and drills, the 15-pound rate produced 1.5 bushels more of grain per acre than the 30-pound rate (34.2 vs. 32.7). In only one plot did the 30-pound yield exceed the 15-pound rate.

The deep-furrow drill is used in our area to reduce soil erosion and protect the wheat seedling. It also permits reaching into soil moisture at planting when moisture may be too deep to reach with a disk drill. However, in this experiment surface planted, 8-inch rowed wheat produced 2.7 more than 14-inch, deep furrow wheat (34.8 vs. 32.1).

In this experiment, Warrior produced 39 bushels, Scout 32, and Wichita 30.

NUTRITIONAL QUALITY

General Question: Wheat provides man with the greatest single source of protein and calories. What is the potential to further improve protein nutrition and increase important trace mineral content for both food and feed uses?

Status of ARS-Nebraska Research on Wheat Protein Improvement

V. A. Johnson

This research is supported in part by funds from the Agency for International Development, U. S. Department of State. The work involves genetic manipulation of both quantity and amino acid composition of wheat protein and supervision of an international winter wheat performance nursery network at 57 test sites in 35 countries.

From analyses of 12,600 common wheats in the World Collection it is evident that lysine per unit protein is negatively correlated with protein. The relationship is curvilinear and most pronounced at protein levels below 15%. Despite this tendency for higher protein in wheat to be associated with depressed lysine per unit protein, high protein wheat provides more lysine per unit of grain weight than low protein wheat. We have shown from mouse bioassays that high protein varieties produce higher weight gains and more favorable feed efficiency ratios than lower protein varieties.

Our main genetic source of high protein has been the Atlas 66 variety which carries protein genes from the Brazilian variety 'Frondoso'. Additional potentially useful sources of genes for high protein include Nap Hal, the Nebraska male fertility restorer, and Hand from South Dakota. Nap Hal and CI13449 exhibited elevated lysine per unit protein.

Environment exerts influence on protein level of wheat. However, high protein lines from Atlas 66 crosses generally maintain their protein superiority over ordinary varieties at low levels as well as high levels of average protein. High yields frequently are associated with low protein content of the grain but not always. Correlations of yield with protein based on international nursery data indicate that yield level provides little predictive value for protein content of the grain produced.

NE701132, an F_2 selection from Atlas 66/Cmn//Lancer shows promise as a commercial variety and is undergoing initial seed increase in Nebraska. It combines excellent productivity, field resistance to leaf and stem rust, and good milling and baking quality with genetic potential for 1 to 2 percentage points higher grain protein content.

We have evidence that the protein level of Atlas 66 can be further increased. Transgressive segregates for very high as well as low protein were identified among F_2 bulk progeny rows from Atlas 66 crossed with Nap Hal. The continued high protein of selections from these progeny rows provides further evidence that the parent varieties carry different genes for protein that function additively when combined.

Crosses of Nap Hal/CI13449 have produced progeny rows higher in lysine than the parent varieties. In some of the progeny rows the elevated lysine was combined with the Nap Hal level of protein. It appears that we have sufficient genetic variability for lysine to more than compensate for the depression of lysine per unit protein that normally accompanies increases in protein level.

The high protein effect in Atlas 66 resides entirely in its starchy endosperm and is transmitted to the white flour in the milling process. In Nap Hal, the high protein results from protein elevation in both the starchy endosperm and bran fractions. We believe that the elevated lysine of Nap Hal results from the very high lysine-rich protein in its aleurone layer. In CI13449 the high lysine appears to result from higher lysine in the endosperm.

GENETIC ANALYSES

General Question: A great deal of quantitative genetic information has been generated during the past two decades. What have these studies contributed to wheat improvement and what kinds of genetic analysis are needed for further improvement in economic characters of wheat cultivars?

No presentations were submitted for inclusion in the Proceedings.

Minutes

Hard Red Winter Wheat Regional Business Meeting

College Station, Texas
April 8, 1974

Meeting called to order by Chairman K. B. Porter at 7:30 p.m.

Roll call taken.

Members present:

K. B. Porter, Texas
E. C. Gilmore, Texas
N. A. Tuleen, Texas
L. W. Rooney, Texas
L. H. Edwards, Oklahoma
E. L. Smith, Oklahoma
H. C. Young, Jr., Oklahoma
B. B. Tucker, Oklahoma
J. Erickson, North Dakota
E. D. Hansing, Kansas
E. R. Heyne, Kansas
R. W. Livers, Kansas
J. R. Welsh, Colorado
J. W. Schmidt, Nebraska
P. J. Mattern, Nebraska
V. A. Johnson, Nebraska
G. A. Taylor, Montana
L. P. Reitz, Maryland

Members absent:

R. E. Atkins, Iowa
W. J. Hoover, Kansas
L. W. Schruben, Kansas
M. R. Morris, Nebraska
B. J. Kolp, Wyoming
E. L. Sharp, Montana
R. E. Finkner, New Mexico
D. G. Wells, South Dakota
N. E. Daniels, Texas
R. W. Toler, Texas
G. E. Hart, Texas
V. R. Stewart, Montana

Minutes of the February 9, 1971 meeting at Stillwater, Oklahoma, were read and approved.

B. C. Curtis, Cargill, Inc., was the only member of the Industry Advisory Committee in attendance. Absent members were J. A. Wilson, DeKalb Agricultural Research Association, and R. E. Baumheckal, International Harvester Company.

Regional Nurseries

Southern Regional Performance Nursery -- no changes.

Northern Regional Performance Nursery -- no changes. Extra seed will be provided to Mark Grant at Lethbridge, Alberta, to permit growing the NRPN at both Lethbridge and Swift Current, Alberta.

Soil-borne Mosaic Nursery -- no changes.

Uniform Winterhardiness Nursery -- use following as check varieties:
Northern Materials Section:
- Froid (very winterhardy check)
- Winoka (winterhardy check)
- Warrior (moderately winterhardy check)

Southern Materials Section:

Warrior (winterhardy check)
Scout (moderately winterhardy check)
Tascosa (wintertender check)

Regional Reports

It was suggested that a table of conversions of data from English to Metric Units of measurement be included in each report.

The question of permissible use of data in regional reports by cooperators was discussed. Regional averages of performance data in which performance information from individual sites are not shown can be used by cooperators without prior permission from contributing state Experiment Stations -- provided that data on all varieties in the nursery are included. Selective use of regional summary data, ie/ for only some of the varieties in the nursery, should be cleared through V. A. Johnson's office. Use of performance data from individual test sites requires the prior permission from the State Experiment Stations involved.

Wheat Streak Mosaic

The regional situation was discussed with reference to variable host reactions, possible strain differences in the virus, the need for a system of regional monitoring of the virus, and available breeding stocks with resistance to the virus. A committee comprised of C. L. Niblett (Chairman), M. K. Brakke, E. E. Sebesta, R. W. Toler, and H. C. Young, Jr. was appointed by Chairman K. B. Porter to prepare guidelines for planning and executing a program in the region to identify variations in the wheat streak mosaic virus, variations in reactions of genetic stocks to the virus, and variations due to inoculation techniques.

National Wheat Committee

The past role and possible future role of the National Wheat Committee in providing national wheat coordination under ARS reorganization was discussed. Chairman Porter appointed a committee consisting of J. W. Schmidt (chairman) and E. G. Heyne to prepare a resolution for presentation to the Conference in which the concerns of wheat researchers in the hard red winter wheat region over apparent lack of adequate continuing national overview of wheat problems would be expressed (see attached).

Hard Red Winter Wheat Breeders Field Day

A joint invitation from the wheat project of the Colorado Agricultural Experiment Station, Cargill Incorporated, and North American Plant Breeders to meet at Fort Collins was received. July 9, 1974 was tentatively set as the date for the field meeting. This annual meeting of breeders is the outgrowth of a meeting in January, 1973 in Kansas City at which strong sentiment for such an annual meeting of breeders was expressed. The breeders met at the USDA Southwestern Great Plains Research Center at Bushland, Texas in 1973.

Resolutions Committee

L. H. Edwards (chairman) and P. J. Mattern were appointed by Chairman Porter to prepare appropriate resolutions for action by the conference (see attached).

Election of Committee Chairman

Chairman Porter declined consideration as Chairman of the Hard Red Winter Wheat Regional Improvement Committee for another term. E. L. Smith and J. R. Welsh were presented as nominees by a nominating committee comprised of J. W. Schmidt and N. A. Tuleen. E. L. Smith was elected.

The Secretary was directed to include in the minutes an expression of appreciation to the outgoing chairman K. B. Porter for his efforts as chairman of the regional committee since 1966.

Meeting adjourned at 9:30 p.m.

V. A. Johnson
Secretary

RESOLUTION 1

of the

Fourteen Hard Red Winter Wheat Workers' Conference,
College Station, Texas
April 8-10, 1974

Whereas, the United States Department of Agriculture has provided a highly satisfactory framework of national and regional leadership for cooperative research by state and federal food and feed grain investigators; and

Whereas, this cooperative research coordinated through investigation leaders has provided the basic and applied research enabling this country to meet its own food and feed grain needs and to attain international leadership in this vital human endeavor; and

Whereas, this framework appears to have been weakened significantly, leadership disrupted, and research fragmented by the recent reorganization of the Agricultural Research Service of the United States Department of Agriculture; therefore, be it

Resolved that the Fourteenth Hard Red Winter Wheat Workers' Conference meeting at College Station, Texas, April 8-10, 1974, go on record as urging the administrators of the Agricultural Research Service, United States Department of Agriculture to consider carefully the impact of the reorganization on the continuing need for coordinated cooperative research to enable this country to meet its own needs and to fulfil its international role in food and feed grain production; be it further

Resolved that the Agricultural Research Service recognize this leadership void as viewed by the researchers in the field and, therefore, provide reciprocal tangible input into National Program Staff planning and regional and area research through a program of national technical advisors or such other leadership and to draw on the resources of groups such as the National Wheat Improvement Committee so that an integrated national cooperative research program for food and feed grain crops be continued; be it further

Resolved that the Fourteenth Hard Red Winter Wheat Workers' Conference make its position known to appropriate administrators of the Agricultural Research Service, United States Department of Agriculture and to the Directors of State Agricultural Experiment Stations in the Hard Red Winter Wheat Region by sending them copies of this resolution.

Respectfully submitted

E. G. Heyne
J. W. Schmidt

RESOLUTION 2

of the

Fourteenth Hard Red Winter Wheat Workers Conference

Whereas, the Hard Red Winter Wheat Improvement Committee is constituted to foster cooperative research resulting in improved hard red winter wheat varieties; and

Whereas, the Fourteenth Hard Red Winter Wheat Workers Conference strongly supports the objectives and functions of state crop certification agencies which are invaluable in the increase and distribution of wheat variety seed stocks; and

Whereas, the release of hard red winter wheat varieties under Title V, Section 501, of Public Law 91-577, which states that varieties be sold by name as a class of certified seed only, would restrict full distribution and utilization of wheat varieties by wheat producers; and

Whereas, collection of royalties upon sale of varieties protected by a Certificate of Variety issued under Public Law 91-577 would tend to restrict the exchange of ideas, information, and seed stocks among wheat research workers; and

Whereas, full utilization of varieties and exchange of information and seed stocks by research workers is in the best interest of the public;

Be it Resolved, that the Fourteenth Hard Red Winter Wheat Workers Conference respectfully recommend that Agricultural Experiment Station Directors favorably consider the release of publically developed hard red winter wheat varieties without the restriction of Title V, Section 501, of Public Law 91-577 and without the provision for collection of royalties.

RESOLUTION 3

of the

Fourteenth Hard Red Winter Wheat Workers Conference

Be it resolved that the Hard Red Winter Wheat Workers express their appreciation to Dr. H. O. Kunkel, the Texas Agricultural Experiment Station, and the College of Agriculture, Texas A & M University, for the use of their facilities and for serving as Host for this conference; to Dr. O. G. Merkle and the Local Arrangements Committee for their hospitality during and preparation for this conference; to Dr. E. L. Smith and the Program Committee for their excellent program planning.

Be it further resolved that the Hard Red Winter Wheat Workers express their appreciation to each of the Discussion Leaders and to each of the participants who made this type of "Unstructured" Conference a success.

Be it further resolved that the Hard Red Winter Wheat Workers express their gratitude to Mr. Tom Roberts, the Kansas Wheat Improvement Association and to the Commercial Research Groups of DeKalb, North American Plant Breeders, Cargill, Northrup King, Seed Research Associates, Pioneer, and Taylor-Evans for sponsoring the social hour.

Be it further resolved that the Hard Red Winter Wheat Workers express their most sincere appreciation to Dr. L. P. Reitz for his stimulating ideas during this Conference, for his years of advice and guidance to wheat workers, and for his continued support of wheat research throughout the United States and the world.

Submitted by

Lewis Edwards
Paul Mattern

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