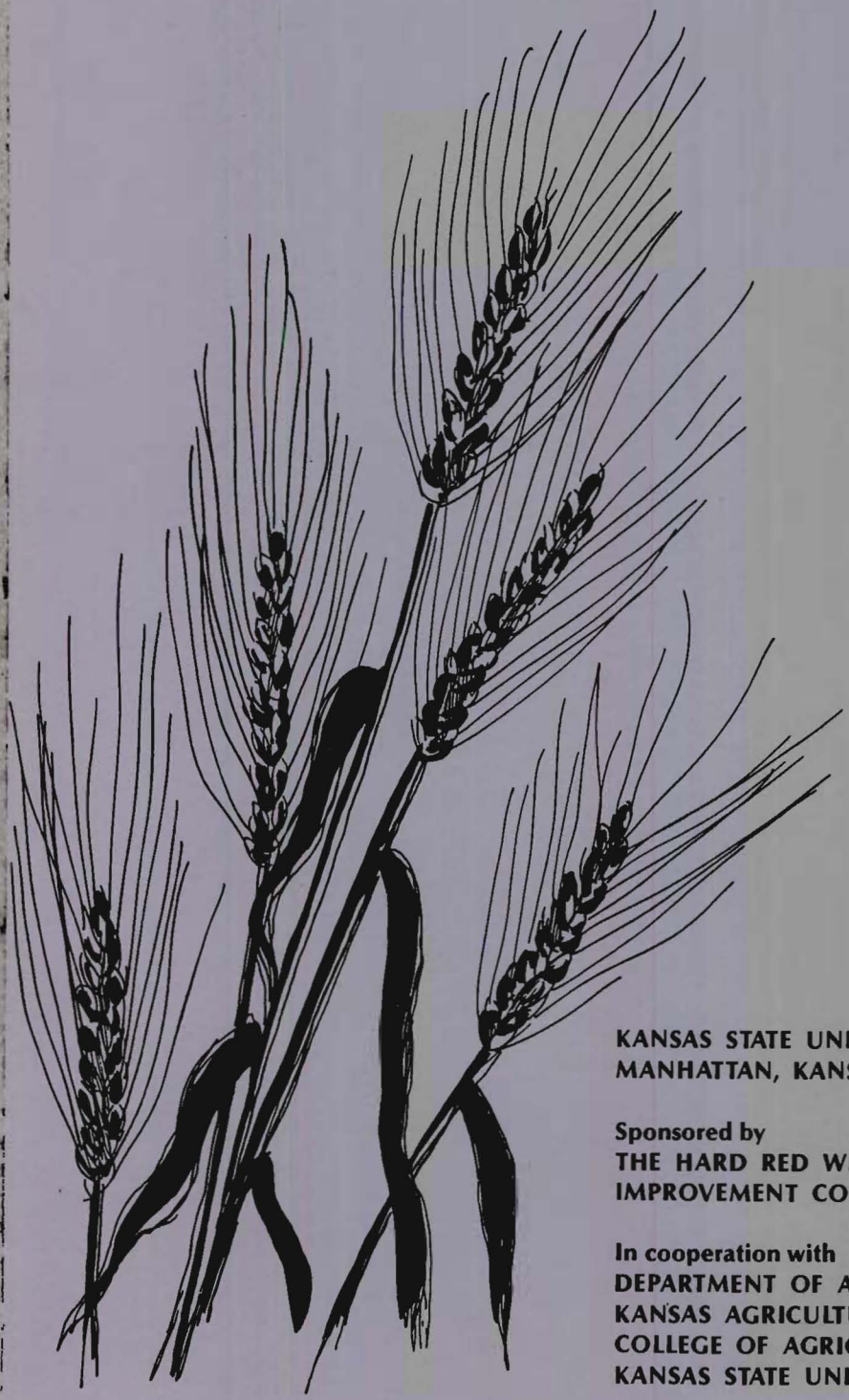
PROCEEDINGS

SEVENTEENTH HARD RED WINTER WHEAT WORKERS CONFERENCE

FEBRUARY 24–28, 1986



KANSAS STATE UNIVERSITY
MANHATTAN, KANSAS

Sponsored by
THE HARD RED WINTER WHEAT
IMPROVEMENT COMMITTEE

In cooperation with
DEPARTMENT OF AGRONOMY
KANSAS AGRICULTURAL EXPERIMENT STATION
COLLEGE OF AGRICULTURE
KANSAS STATE UNIVERSITY

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Service

and

State Agricultural Experiment Stations

in the

Hard Red Winter Wheat Region

PROCEEDINGS

OF THE

SEVENTEENTH HARD RED WINTER
WHEAT WORKERS CONFERENCE

Kansas State University
Manhattan, Kansas
February 24-28, 1986

Report not for publication[1]

Agronomy Department
Kansas Agricultural Experiment Station
Kansas State University
Manhattan, Kansas
July, 1986

[1]This is a conference report and includes information furnished by State Agricultural Experiment Stations, USDA-ARS, and researchers in the private sector. The report is not intended for publication and should not be referred to in literature citations nor quoted in publicity or advertising. Permission to use statements herein should be requested from individuals and agencies involved.

CONFERENCE ORGANIZING COMMITTEE

Program	Local Arrangements
Jim Quick	Rollin Sears
Alice Guthrie	Tom Roberts
Myron Brakke	Lowell Burchett
Dave Worrall	Gary Paulsen
Richard Johnson	Joe Martin
Bob Bequette	
Rollin Sears	

CONFERENCE PROGRAM

February 25

Conference Opening - - - - - - - - - - - - - - - K. B. Porter, Chairman
Hard Red Winter Wheat
Improvement Committee

Welcome - G. E. Ham
Head, Dept.of Agronomy
Kansas State University

Session I
Germplasm Development

Discussion Leader - - - - - - - - - - - - - - - Alice Guthrie
Cargill, Inc.

Session II
Marketing Classification, Quality, Utilization

Discussion Leader - - - - - - - - - - - - - - - Bob Bequette
Rohm & Haas

Session III
Computer Utilization, Data Management

Discussion Leader - - - - - - - - - - - - - - - Jim Quick
ColoradoState University

Session IV
Heat and Drought Tolerance

Discussion Leader - - - - - - - - - - - - - - - Richard Johnson
Oklahoma State University

February 26

Session V
Insect Resistance

Discussion Leader - - - - - - - - - - - - - - - David Worrall
Texas A&M University

Session VI
Disease Resistance

Discussion Leader - - - - - - - - - - - - - - - Myron Brakke
University of Nebraska

Field Trip
Eisenhower Presidential Center

February 27

Regional Business Meeting- - - - - - - - - - - Ken Porter, Chairman
Hard Red Winter Wheat
Improvement Committee

Biotechnology Applications in Wheat
Improvement - - - - - - - - - - - - - - - - - Rollin Sears
Kansas State University

February 28

Tissue Culture "Hands-On" Program- - - - - - - Rollin Sears
George Liang
Kansas State University

DWARFING GENES IN WHEAT

M. D. Gale

In the UK more than 80% of the winter wheat crop comprises varieties carrying a single semi-dwarfing gene Rht2. Trials with sets of isogenic lines carrying Rht1 and Rht2 in adapted European varietal backgrounds show that the semi-dwarfing alleles impart a 10-20% increase in yield due to increased grain number per spike, over and above their effects to increase lodging resistance.

Developmental analysis shows the genes to affect the size of vegetative plant parts but not the numbers or timing of developmental events. Apical growth and development is not affected, other than by reduced competition from the smaller vegetative plant parts. This may be indicative of the action of the gibberellic-insensitive Rht genes only on GA1 and related GA's found in vegetative tissues, rather than the 1-β-hydroxylated GA's found in developing grains.

Cooperataive experiments with breeders at Nickerson RPB Ltd. using the Tom Thumb dwarfing gene in the production of CHA derived F1's indicate that Rht3/rht intervarietal hybrids may represent a means of increasing grain number per ear and effectively channeling hybrid vigor into yield rather than non-productive biomass. Mean yield increases of 17% over the higher yielding parent have been obtained with seven intervarietal F_1's with a common Rht3 female parent.

GENETIC VARIATION AMONG AND WITHIN SAMPLES OF 'KHARKOF'

T. S. Cox and W. D. Worrall

The cultivar 'Kharkof', introduced into the U.S.A. in 1901, is the long-term check entry in the Northern and Southern Regional Performance Nurseries. Seed of Kharkof maintained at the University of Nebraska as well as seed being used at nine other regional nursery locations (Colorado; Idaho; Kansas; Minnesota; Missouri; York, Nebraska; New Mexico; and Dallas and Chillicothe, Texas) was obtained from cooperators for the purpose of evaluating variation.

Field experiments

The ten entries were sown in replicated experiments at Chillicothe, Texas in the fall of 1984 and 1985. In the first year, there was significant variation among entries for grain yield, 500-kernel weight, and other traits, indicating that the entries were not genetically identical.

Gliadin electrophoresis

Up to 27 seeds from each of ten samples, plus a sample of Kharkof (labeled CI 1442) from the USDA germplasm collection were ground individually, and the gliadin protein fraction was extracted. Electrophoresis of extracts in polyacrylamide gels showed at least 28 distinct electrophoretic patterns. The distribution of patterns among and within samples is shown in Table 1, in which patterns are numbered and grouped into six clusters. There is more similarity between patterns in the same cluster than between patterns in different clusters. The USDA and Idaho samples were homogeneous for gliadin patterns, but distinct from each other and from other samples. The Texas samples were also homogeneous and identical to each other, but their single gliadin pattern also occurred in some seeds of the six remaining samples.

Those six samples were highly heterogeneous, containing varying proportions of the different patterns (Table 1). The Colorado and Missouri samples were similar, each having a large proportion of the 'Texas' pattern. The York, Minnesota, and New Mexico samples also showed similarity with one another, as did the Kansas and Nebraska samples.

The variation in gliadin patterns suggests that genetic drift, or natural selection acting at loci linked with gliadin loci, has caused the observed divergence among the heterogeneous Kharkof samples. (Each accession has been maintained at its respective location for an unknown number of years.) Furthermore, the Texas samples appear to have arisen from a single-plant selection out of Kharkof; the Colorado and Missouri samples may consist of the 'Texas' type mixed with a small proportion of other samples.

The Idaho sample, which had a uniform and unique gliadin pattern, significantly outyielded all other entries, and was easily distinguishable visually in the field, is probably a relatively modern cultivar and not Kharkof. Likewise, the USDA sample, which had a uniform and unique gliadin pattern and suffered winter injury at Chillicothe in 1986, is not true Kharkof.

Isozyme isoelectric focusing

Some results of gliadin electrophoresis were confirmed by isoelectric focusing of α-amylase and esterase isozymes from bulk seed of the 11 samples. The two Texas samples lacked one α-amylase band and several esterase bands shared by all other samples, indicating that the plant from which they were derived had isozyme patterns not common to most other plants of the cultivar. The α-amylase pattern of the USDA sample differed from all others for several bands.

Conclusions

1. 'True' Kharkof is a heterogeneous population.

2. Some accessions of Kharkof (Nebraska, Kansas, New Mexico, Minnesota, and York) have diverged from one another genetically, through drift, selection, or seed mixture.

3. Other accessions known as Kharkof (USDA, Idaho) are not Kharkof, while others are a single-plant selection (Dallas or Chillicothe) or contain a high proportion of that selection (Colorado, Missouri).

4. Kharkof should be reconstituted by bulking equal parts of the highly heterogeneous accessions.

Table 1. Number of individual seeds from each Kharkof sample classified in each of six gliadin pattern 'clusters'. There was considerable variation even within clusters of patterns, but less than there was among clusters.

	Gliadin pattern					
Kharkof sample	1	2	3-7	8-11	12-21	22-28
USDA	27					
Idaho		27				
Texas (Chill.)			27			
Texas (Dallas)			27			
Colorado			23	1	1	2
Missouri			21	3	1	1
York, NE			11	4	9	3
Minnesota			11	1	5	7
New Mexico			5	3	12	7
Kansas			2	5	1	18
Nebraska			1	1	9	14

POPULATION IMPROVEMENT IN SPRING WHEAT

K. D. Kofoid

The successful use of recurrent selection procedures requires the formation of an intermating population with an adequate amount of additive genetic variability. The selection procedure and the selection criterion used will depend to a large extent upon seed requirements for testing, the heritability of the traits being improved, and the genotypic correlations among the traits.

A random mating population of spring wheat, NDP1, has been formed by crossing fifteen inbred lines with a recessive, genetic male sterile source followed by three generations of random mating. The parents used in this population represent four spring wheat breeding programs. The parents were selected for high yield and/or high grain protein content and adequate levels of disease resistance. After the last generation of random mating, half-sib, S_1 and full-sib selfed families were generated and tested in two environments.

Means of the three family types did not differ for any of the traits studied (Table 1). Estimating population genetic variances by equating mean squares to their expectations showed dominance genetic variance only for plant height and grain yield (Table 2). Since additive genetic variance is present, recurrent selection procedures should be successful.

To determine the effects of the selection criterion on gains from recurrent selection, five selection criteria were applied to subpopulations of NDP1 using S_1 families. The five criteria used were 1) harvest index, 2) grain yield *per se*, 3) a Smith-Hazel index where only grain yield was given an economic weight, 4) a Smith-Hazel index where economic weights of -0.1, -0.1, 2, and 1 were given to the traits days to head, plant height, grain yield, and grain protein, respectively, and 5) independent culling for grain yield and grain protein. A 20% selection intensity was used for all subpopulations and cycles.

Mean values from the first and second cycles of selection (Table 3) indicate that all methods improved grain yield. Differences in trends for grain protein show that only those methods which include positive selection for grain protein will improve both grain yield and grain protein simultaneously.

Table 1. Mean value of traits for 200 half-sib, 200 S_1 and 180 full-sib selfed families from NDP1 tested for two years in North Dakota.

Family type	Days to head	Plant height	Grain yield	Test weight	Grain protein
		cm	kg ha^{-1}	kg m^{-3}	%
Half-sib	59.3	89.7	2340	726	15.1
S_1	59.7	88.8	2375	720	15.1
Full-sib selfed	59.7	89.7	2365	718	15.1

Table 2. Estimates of genetic variances in NDP1 using half-sib, S_1 and full-sib selfed families.

Genetic variance	Days to head	Plant height	Grain yield	Test weight	Grain protein
Additive	2.49	33.92	183,209	2.02	0.58
Dominance	0.00	22.28	96,334	0.00	0.00
Additive (S_1)	2.21	8.22	34,592	2.62	0.32

Table 3. Mean value of traits from two cycles of recurrent selection using S_1 families from NDP1 and various selection criteria.

Selection criterion	Cycle	Days to head	Plant height	Grain yield	Test weight	Grain protein
			cm	kg ha^{-1}	kg m^{-3}	%
HI	1	55.8	104.5	4085	783	15.0
	2	55.2	103.8	4700	794	14.9
YLD	1	57.2	108.0	3995	779	15.0
	2	56.4	106.0	4775	795	14.9
YI	1	56.9	107.2	4430	786	15.1
	2	56.8	106.5	4860	794	14.7
SI	1	56.5	105.5	4280	783	15.2
	2	56.1	103.8	4725	788	15.3
IC	1	56.0	104.0	4305	786	15.0
	2	55.6	102.0	4740	794	15.1
Base	0	56.4	106.8	3980	786	15.2
LSD		1.1	3.3	305	6	0.2

REGIONAL RANDOM MATING WHEAT POPULATIONS

O. G. Merkle

Two random mating winter wheat populations, designated as the Elite (good X good) and the Broad-Based (genotypes of diverse origin), were initiated in the 1983-84 crop year at Bushland, TX (Dr. K. B. Porter), Fort Collins, CO (Dr. J. S. Quick), Hutchinson, KS (Dr. R. G. Sears), and Lincon, NE (Drs. V. A. Johnson and J. W. Schmidt). To facilitate recombination, CHA was applied each year at Bushland and Fort Collins by Dr. J. P. Foster, Shell Development, and at Hutchinson by K. D. Wilhelmi and J. E. Stroike, Rohm & Haas, Inc.

The F_1 seed was returned to Stillwater each year, where it was composited and returned to each location for the 1984-85 and 1985-86 crop years.

Seed will be distributed after the 1986 harvest, upon request, first to those who contributed germplasm to the populaltions, and then to other requests. Amount of seed distributed will depend upon the amount available and upon decisions made concerning how the populations will be continued.

VARIETY IDENTIFICATION BY CHEMICAL METHODS

L. E. Hansen

Since the concept gained popularity, electrophoretic variety identification by seed storage proteins has been on a saddle point. Original parents were verifiable, however, multiline progeny in breeding programs were not always cleanly discerned. Similarly, feed wheats had been blended or misidentified with baking wheats. Since 1980, this impetus had generated a proliferation of techniques utilizing gliadins, glutenins, and total protein electrophoregrams. Evolution and acceptance of Laemmli gradient gels, two-dimensional gels, and single concentration acid gels had plateaued for large scale commercial and breeder users.

Another parallel method evolving since 1983, which is also rapid, highly controlled, automatable, and very flexible, was Reversed-Phase High-Performance Liquid Chromatography (RP-HPLC). The emergence of the technique followed the improvement of columns and matching improvement of the hardware. With the increasing popularity of HPLC, manufacturers expanded the array of column packings. Many of the packings were remanufactured traditional chromatography matricies for smaller more stringently controlled particle sizes. Size Exclusion was similar to dextran chromatography, anion and cation exchange resins were directly adapted from peptide work. The "new" technique Ion-pair Modulated Hydrophobic Interaction Chromatography (IM-HIC) was ion complexed normal chromatography on reversed-phase columns.

Predominant considerations for the choice of RP-HPLC were: gliadins were soluble in compatible solvents, initially RP-HPLC was the method most advanced mechanically, and the probability of new insights into the proteins due to the "new chemistries" of the separation. Also, with minimal effort, highly reproducible variety fingerprints were obtained. Cataloging these patterns for future comparisons appeared to be automatable.

Practically, the retention times and the apparent position on a relative percent of organic phase scale vary due to instruments, chromatographers, reagents, and columns. The variances may not be large, but the automation of pattern recognition or quantitation required very exacting physical controls.

Once physical control was optimized, then standards were required to demonstrate exact positions. Quantitation of all peaks was the next objective.

The last two years have produced a general set of physical conditions or optimization procedures, an alkylphenone homologous series of standards to establish a hydrophobicity index, and a computerized waveform analysis to determine variety mixtures.

PRESENT STATUS ON WHEAT KERNEL TESTING AS IT RELATES TO MARKET CLASSIFICATION AND PLANT BREEDING

P. J. Mattern

Wheat hardness influences the end-use quality of a wheat flour. For the past 65 years wheat hardness has been indirectly identified in the market place by market classes and a rating system based on traditional kernel shapes. Recent wide crosses made by wheat breeders in their development of new cultivars, without drastic selection to kernel shape, has made classification impossible with several cultivars. This coupled with early generation selection increases the potential for heterogeneity in kernel hardness.

There are many ramifications for the grain industry. The Federal Grain Inspection Service (FGIS) can no longer rely on kernel shape for its classification and is looking for alternative evaluation schemes. Heterogenous cultivars could be classified as "mixed" and would be discounted. Millers have often blended hard and soft wheats to obtain a desired flour product. Best milling results when wheats of diverse hardness are tempered separately and combined for milling on the break rolls.

Merchandisers have intentionally blended hard and soft wheats for an economic advantage. No bulk testing method can detect the percentage of blending with the precision needed. However, a bulk test, such as the NIR, as a first screening tool could identify problem samples. A second test for hardness on an individual kernel basis would provide the percentage of an off type in the blend. Individual kernel analysis by some methods is influenced by kernel size, broken kernels, and growing environment.

One instrument under current field test by the FGIS appears promising. If FGIS adopts such an approach then plant breeding programs will need to better characterize their experimental lines for hardness of individual kernels. The dissecting microscope can provide data on kernel hardness on either a destructive or non-destructive basis. Wheat kernels placed with an appropriate orientation on a plastic, self-adhesive, tape and crushed through corrugated milling rolls at about 0.04 inches are an easily manipulated sample. Crushing between vertically oriented jaws does not provide a sample which can be readily identified by the microscope. A relative dividing line has been established between hard and soft wheats with the microscopic technique.

Several currently grown HRWW cultivars are heterogenous in kernel hardness and have too high a percentage of "soft" kernels. It is possible to improve early generation populations by growing out head rows for several years and checking a few kernels from each entry before compositing for release. The few items discarded would probably not affect the agronomic potential drastically, but would help to reduce the range of hardness within the cultivar.

FGIS AND MARKET CLASSIFICATION UPDATE

Rob Bruns

The controversy surrounding FGIS kernel classification has continued to build in 1986. It is an extremely complex problem that can have a very significant effect upon the entire wheat industry. Each segment of the industry looks at the problem from a different viewpoint. No one person or group of persons truly understands all sides of this issue. The breeding community needs to present a clear picture of the problems we are facing with the current system, suggest alternatives, and hope that rational solutions will be adopted.

On November 7th the National Wheat Improvement Committee organized a symposium to update the members on the current status of the wheat classification issue. Rollie Sears and Rob Bruns were invited to give a wheat breeders perspective on the issue. Rollie Sears conducted a survey of red wheat breeding groups. Of the respondents, 95% felt environmental factors caused fluctuation or loss of typical kernel characteristics. When asked whether potential varieties had not been released due to atypical kernel type, 30% of the scientists indicated they had, but 93% felt future varieties or hybrids should not. Ninety-eight percent of those surveyed felt the present system should be changed, based upon objective tests. Ninety percent indicated they would favor a system based upon hardness and protein. Rob Bruns expanded upon the following general conclusions specifically relating to kernel classing:

- Past and present varieties are not class consistent. A 1983 blind study of a single pure seed source by NAPB staff determined that only 50% of the leading HRW, HRS and SRW varieties from 1963 to 1983 had 50% or more of the nine major class characters.

- FGIS is to be commended on the job they have done to this point.

- Wheat breeders are not confident what constitutes an acceptable kernel type, i.e., how many of the nine characters are needed, which combinations of charactgers are considered critical, which are influenced by environment?

- Breeders are already under tremendous constraints to develop improved genetic combinations. Strict adherence to kernel characteristics is an additional constraint of such magnitude that most breeders consider it unreasonable. This becomes clear when you look at the population sizes required to recover individuals for traits controlled by multiple genes. If the nine kernel characters were independently controlled by a single gene, the perfect F_2 population size would be 262,144. If classification could be controlled by one gene, only four individuals would need to be screened.

The National Wheat Improvement Committee drafted a strong and clear resolution letter indicating the need to develop objective tests for grain grading. At the present time, there are three basic directions this issue can go:

Direction #1 - Status quo - FGIS Board of Appeals and Review will do the best job they can with the varieties out in the market channels and give the breeders an estimate of potential problems in new lines.

- Moderate to extreme confusion in grain channels.

- Difficult for breeders to predict whether the FGIS Board will class their new lines properly.

Direction #2 - Revert to strict adherence of kernel type classing.

- "Total Disaster" - D. Worrall

Direction #3 - Implement new classing systems using newer technologies, i.e., hardness, hardness and protein, image analysis, chemical, PAGE, HPLC, and other.

- Earliest possible implementation would be the 1987 crop, but probably later.

- Once implemented, some varieties will likely cause problems. Three to five year time period could be required for phasing in of new conforming lines.

- Resistance to change in a political arena is high.

TRENDS IN HARD RED WINTER WHEAT BREEDING AND GENETICS

J. L. Gellner

A survey with 28 questions concerning breeding and research programs was sent to the public hard red winter wheat breeders of the United States and Canada. Thirteen responses were received. The majority, nine, foresaw no increase in funding for their projects. Similarly, eleven felt there would be no increase in scientific man years devoted to breeding and genetics in the future at their station. Five were going to increase basic research, three were going to increase varietal development, and six foresaw no changes in the emphasis of their programs. As for plant variety protection, four routinely and nine never apply at present, but three felt in the future they would occasionally apply. Six breeders interact with private breeding companies. Answers to constraints to breeding varied with funding the most common response (4), while the majority (8) felt price limited the winter wheat acreage in their state. Lack of water (4), and winter survival (4) were the most common environmental stresses mentioned. Five individuals use a modified bulk method, while three each use a bulk or pedigree method. The F_5 generation (5) was the most common for plant selection. Six felt in the future they would use "biotechnology" methods, and five responded no. The quality testing laboratory was the most used Federal facility with six individuals routinely using its services.

PROMPT
A MICROCOMPUTER PROMPT PROGRAM FOR DATA COLLECTION

J. S. Quick

Data collection in field and laboratory researach can be time-consuming, laborious and boring which can lead to errors and expense. The use of a computer system and program which will allow rapid, accurate data recording and transmission to a larger computer for analysis and table printing is a great facilitator of research reporting. Also, decisions about harvest order of large field research experiments can only be made upon field inspection at harvest at more remote sites. This prompt program allows this decision to be made at the harvest site by elimiating the need to down-load from a mainframe computer. Its flexibility and capacity are major advantages over other systems.

Uploading plot or treatment numbers from a mainframe system is eliminated and adjustments in harvest order can be made immediately prior to collection. Interfacing with an electronic balance and an RS232 port transfer to a mainframe system eliminates manual data entry. A hand-held computer with 32K bytes of RAM memory is used and the data can be stored on cassette tape or soft disc. Three options exist for field harvest order: 1) consecutive, 2) left to right on serpentined plots, and 3) circular. Field maps can be printed, data from several experiments and traits can be collected simultaneously, and data can be transferred by telephone via a built-in modem or an accoustical coupler.

AN INTEGRATED SYSTEM OF DATA COLLECTION AND UTILIZATION

Paul G. Sebesta and Jeff L. Fraser*

A major component of any plant breeding program is data management. The availability and widespread use of microcomputers enables the plant breeder to quickly and efficiently manage large amounts of data. However, there seems to be little software available that addresses the unique applications required of a plant breeding program. There are three alternatives available to the plant breeder. He can pay a programmer to custom design an application, or he could use MSTAT from Michigan State University and tailor his program to meet the MSTAT requirements, or he could build the application himself. At HybriTech we chose to build our own application using a DEC PRO/350 microcomputer from Digital Equipment Corporation and the RDM Applications Development System from Interactive Technology, Inc.

RDM (Responsive Data Manager) is an application development environment which allows the non-programmer to develop various database applications. These applications can be tailored to meet his unique and specific requirements. The creation of an RDM application is a five step process involving the creation and definition of data files, the definition of forms for data entry, the manipulation of data, the definition of various reports, and finally the definition of menus and sub-menus.

The various applications required for all aspects of yield trial data management were developed using RDM with the exception of the actual statistical analysis. These applications include the printing of planting and harvesting labels, field book printing and the interfacing required for the use of portable data acquisition devices for rating and yield data collection. The eight databases used in our applications are listed in Table 1. Once the databases, reports and processes were developed, a series of menus and sub-menus were created to make the application 'user friendly.' Each of the eight databases is accessed several times throughout the crop season for various applications, however, MASTER is the primary database. The relationship of these databases to one another and the types of output generated by each is diagrammed in Figure 1.

At the beginning of the new crop season the information required to generate labels is entered into the EXPINF database via the Experimental Information sub-menu. The experiment number, trial name, location, tcode (trial code), first plot number, number of entries and number of reps are entered for each experiment. Generally, there are 200-250 experiments per year. This information along with the randomized plot numbers from the RANDON database is used to generate planting and harvesting labels. Other data in EXPINF are entered as the season progresses.

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*Author not in attendance at the conference. He is a business analyst with Monsanto.

During the early winter, pedigree information is entered into the FBOOK database through the FBOOK sub-menu. This database contains tcode, entry number, source, and selection number for each entry in every trial (a trial is composed of multiple experiments). This database contains 5,000-6,000 pedigrees. After all the pedigrees have been entered, checked, and edited, the MASTER database is built.

The EXPINF and RANDON databases are used to build the MASTER database. Typically, there are 13,000-14,000 records in MASTER, one record for each entry in every experiment. MASTER contains information relative to the trial name, experiment number, entry number and plot numbers. This database is where all the rating and yield data are stored. After MASTER is built, the field books are printed using the EXPINF, FBOOK, and MASTER databases.

Data loggers, such as the DataMyte from the DataMyte Corporation, can be used to collect rating data during the growing season. Files of plot numbers for all the locations are created using the Datamyte sub-menu. Plot numbers are loaded into the data logger along with appropriate prompts to aid in data entry. After data collection is completed, the data are transferred to the computer as an ASCII file. This file is first changed to the TMP data file (Table 1) and then merged into MASTER via the Update sub-menu. This procedure is repeated until all rating data have been merged into MASTER.

During harvest, yield data are collected on a system consisting of an electronic balance and a small thermal printer interfaced with a DataMyte. The printer provides for a hard copy of the data should something happen to the DataMyte. This data is also collected as an ASCII file which is changed into the TMP2 data file (Table 1) and then merged into MASTER. The merging of yield data into MASTER is also accomplished via the Update sub-menu. Once in MASTER, the yield data is converted from kg/plot to bu/acre.

Error checking is done during the process of updating MASTER with rating and yield data. This is an attempt to check for valid ranges for rating data and for duplicate plot numbers in the case of yield data. The error messages are collected in the ERRTMP database and are printed periodically during the update process.

Once the raw yield data have been merged into MASTER, yield analysis begins. Through the Analysis sub-menu these data are 'dumped' to one of the two analysis programs. One of these programs is for the analysis of a single experiment while the other is for tcode analysis in which all experiments within a tcode are analyzed. Upon completion of yield analysis, all of the databases are backed up on floppy disks. The databases are then zeroed and the process is repeated for the next crop season.

The applications discussed thus far have been for yield trial data management. Additional applications have been developed for the Adaptation Project. The various databases required for these applications are described in Table 2. These databases, reports and processes handle all aspects of the project including field planting and harvesting labels, field books, field data collection and manipulation, greenhouse screening trial data collection and manipulation, greenhouse labels and books, crossing results, germplasm evaluation and pedigree updates.

This system of yield trial data management has been used for two seasons and has proven to be quite satisfactory. However, during these two years several small changes have been made that enhance the speed of operation of several processes and reports. As illustrated, RDM is a powerful applicaltion development environment which can be used to develop the various database applications required of any dynamic plant breeding program.

Table 1.

DATABASES

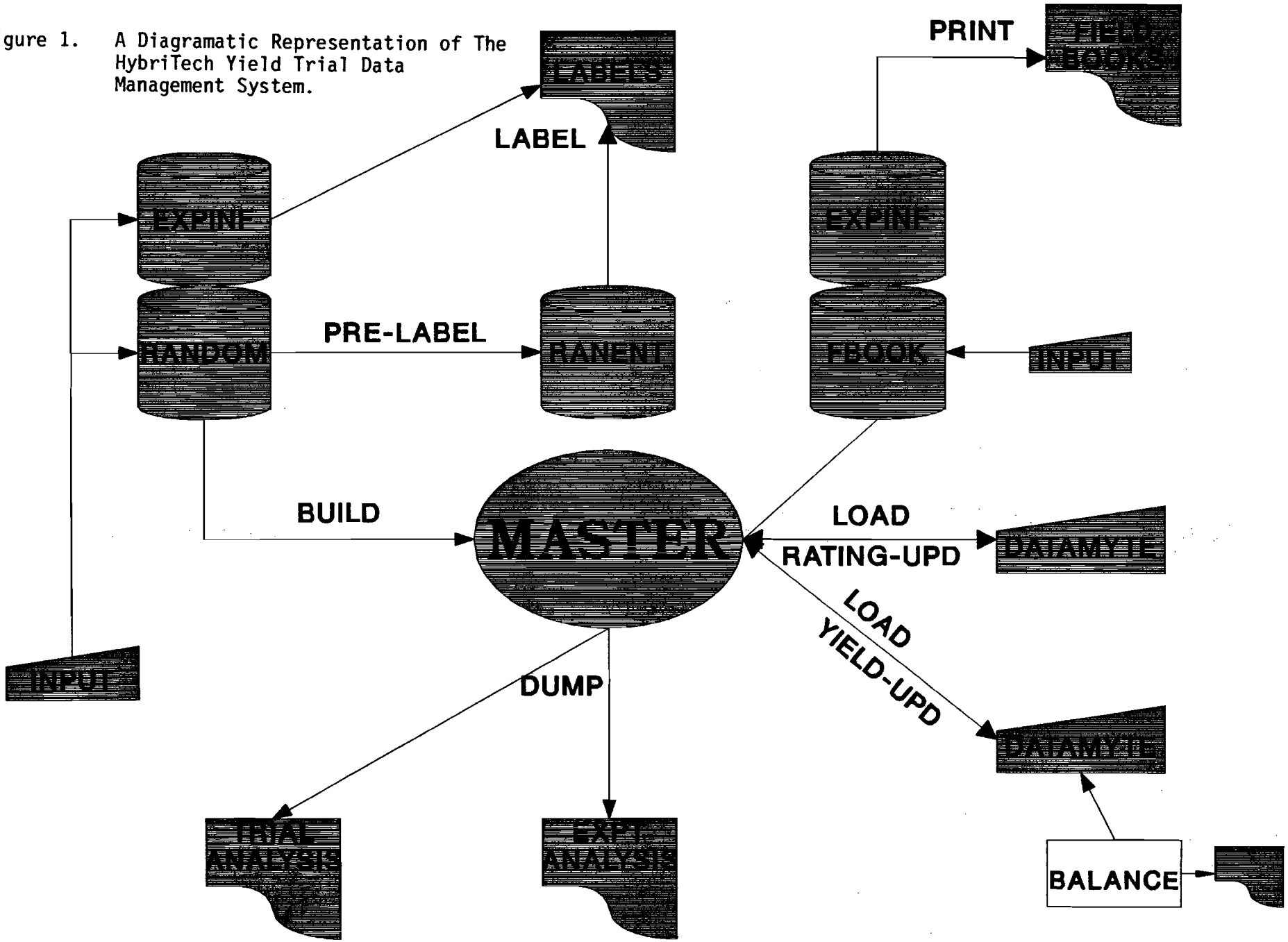
MASTER	Main database containing references to other databases and all raw yield and rating data
EXPINF	Experimental Information
FBOOK	Pedigree Information
RANDOM	Randomized plot numbers
RANENT	Randomized pedigree entry numbers
TMP	Temporary database for merging rating data
TMP2	Temporary database for merging yield data
ERRTMP	Temporary audit database for error messages

ADAPTATION DATABASES

Table 2.

OBSERV	Field Descriptions
GREENHOUSE	Greenhouse Descriptors
CROSS	Crossing Results
TESTING	Greenhouse Rating Information
PEDIGREE	Pedigree Information
EXPINF	Field Experimental Information
GHSEINF	Greenhouse Experimental Information

Figure 1. A Diagramatic Representation of The HybriTech Yield Trial Data Management System.



COMPUTERS AND DECISION MAKING - BEYOND THE BOOKS AND TAGS

Ken Axon

Within agricultural research, computers have become an intrinsic tool for plot design and data analysis. Several systems have been created to generate the necessary material for field and greenhouse applications (i.e., books, labels, maps, and reports). These systems have been very successful, improving the productivity and reliability of trialing techniques, thus bringing powerful aids to the breeding teams. New computer programs are being designed to go beyond the clerical functions and more towards data management for the making of decisions.

Topics to be discussed include:

1) Variety performance and predictability over years throughout various regions and states.

2) Varietal descriptions and PVP patenting.

3) Varietal comparison and compatibility projections.

Presentation plans to discuss the potentials and pitfalls involved in setting up and maintaining these programs.

TRENDS IN CULTIVAR YIELDS AND STABILITY FROM 26 YEARS OF REGIONAL NURSERY TRIALS

C. J. Peterson, V. A. Johnson, and J. W. Schmidt

Mean grain yield of cultivars in the Southern Regional Performance Nursery (SRPN) grown at 11 locations from 1959 to 1984 has increased 67% from an average of 2100 kg/ha in 1959 to 3500 kg/ha in 1984 (Fig. 1). A linear increase of 56 kg/ha per year resulted from cultivar development, improvements in production practices, and increased fertilization. The proportion of yield increase in the SRPN attributed to genetic improvment was determined by expressing the annual nursery mean yield as a percent of the yield of the long-term check variety Kharkof. Mean yield of experimental cultivars has increased linearly from 111% of Kharkof in 1959 to 139% in 1984 (Fig. 2). A 25% improvement in yield, or 31 kg/ha per year, was attributable to genetic improvement and breeding efforts and accounts for 55% of the total yield gain in the nursery.

Mean yield of cultivars in the Northern Regional Performance Nursery (NRPN) grown at 9 sites from 1959 to 1984 has increased 77%, from an average of 1800 kg/ha in 1959 to 3200 kg/ ha in 1984, a linear increase of 56 kg/ha per year (Fig. 3). Genetic contributions to yield increases in the NRPN were less than those in the SRPN. From 1966 to 1984, after stem rust epidemics had subsided, a linear increase in yield of cultivars from 103% to 117% of Kharkof occurred (Fig. 4). This corresponds to a 14% increase in yield, or 22 kg/ha per year attributable to genetic improvement and breeding. Only 40% of the total yield improvement in the NRPN from 1966 to 1984 was attributable to genetic gains.

The genotype by environment interaction mean square associated with cultivar stability over locations in the SRPN has increasd linearly from 1959 to 1984, a total of 134%. A portion of increased genetic gains in yield appears to have come from narrowing adaptation of cultivars, maximizing yield potential in smaller production areas by exploitation of GxE interactions.

The increasing GxE interaction also suggests that the ability of an individual test site to predict the performance of cultivars over the region has decreased. This was demonstrated in trends of correlations between entry ranks from locations and entry ranks in regional averages over years (Table 1). For 8 of the 11 test sites, the ability to predict average regional performance of cultivars has declined. Correlation values have decreased notably for North Platte, NE; Alliance, NE; and Stillwater, OK. Ft. Collins, CO and Colby, KS had the highest average predictive ability among the locations over years.

The GxE mean square in the NRPN also has increased linearly, nearly 300% from 1966 to 1984. Along with an apparent narrowing adaptation of cultivars in the nursery, many recent cultivars have had insufficient winterhardiness for the Northern Plains conditions. The GxE interaction variance was relatively high prior to 1966 due to stem rust epidemics and varying levels of cultivar resistance.

Parameters from regression analyses of cultivar yields on an environmental index, such as nursery means, have been used extensively as a measure of cultivar stability and responsiveness to environmental conditions. Trends in average cultivar response to environmental conditions and constraints in the regional nurseries can be evaluated indirectly in terms of changes in relative responses of the long-term checks. Stability and response of a check would not be expected to change over years. However, since stability parameters are based on average environmental response of cultivars in the nursery, they may change for a check over time as cultivars in the nursery are changed.

Yearly regressions of check yields on SRPN nursery means at all locations show a linear decrease in b values for both Kharkof and Scout 66 (Fig. 5). The b values for Kharkof dropped from 0.90 in 1959, when it was fairly representative of the nursery cultivars, to 0.,60 in 1984. Regressions of check yields on nursery means in the NRPN also show a linear decrease in b values for Kharkof and Warrior (Fig. 6). The b value for Kharkof dropped from 1.03 in 1959 to 0.68 in 1984.

In 1959, nursery cultivars expressed a small yield advantage over Kharkof which increased slightly with improving environmental yield potential. In 1984, nursery cultivars express a large yield advantage over Kharkof in high yielding environments, but the yield advantage diminishes as the environmental yield potential decreases. A major portion of genetic contributions to increased yield levels since 1959 has been from increased cultivar yields as expressed in favorable or less-limiting environments. The decreasing b values of the checks are an indication of the large and significant increases in genetic yield potential and input responsiveness of modern cultivars.

Trends in cultivar performance from the regional nursery trials reported here represent only average responses of cultivars entered in the nurseries and general trends in cultivar development. Individual cultivars will certainly show great differences in environmental response and adaptation.

Figure 1

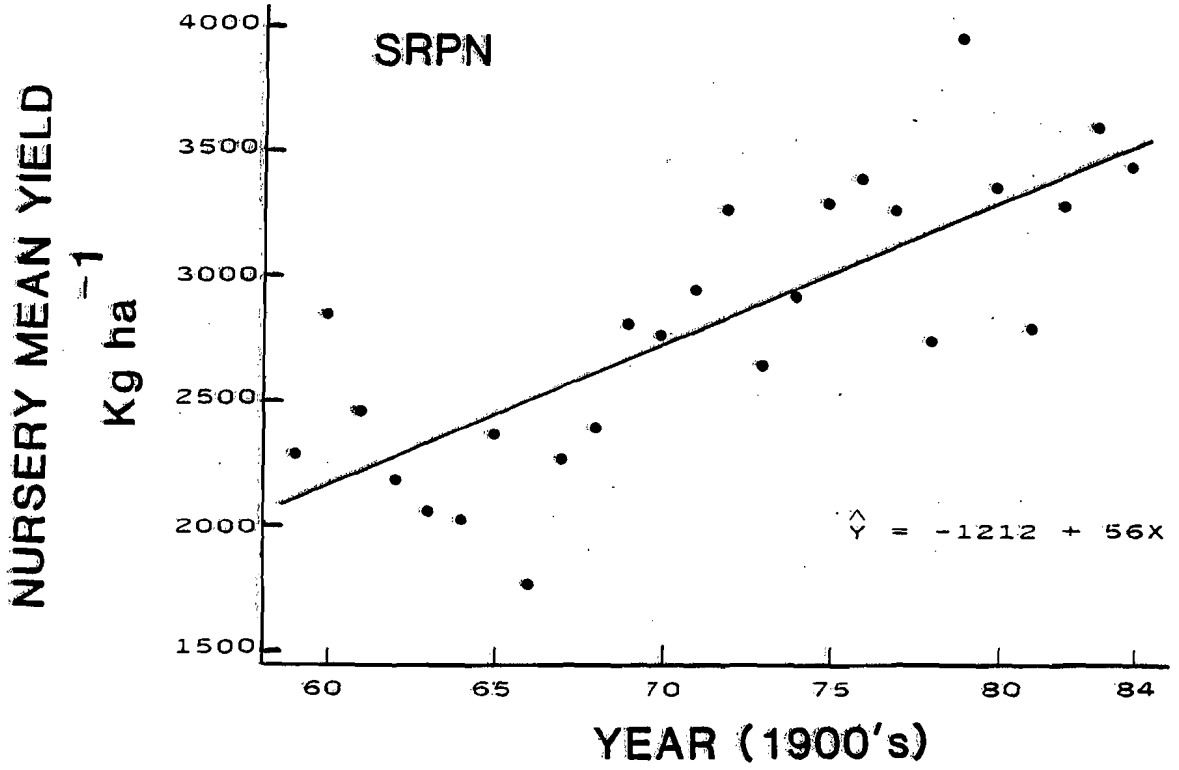


Figure 2

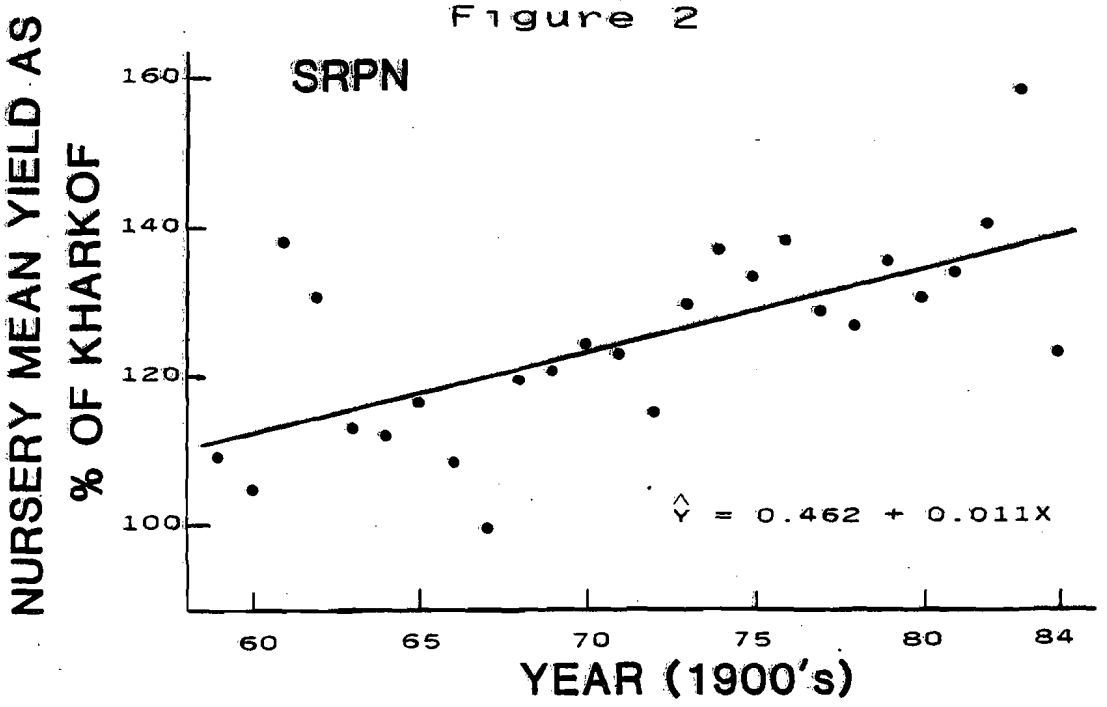


Figure 3

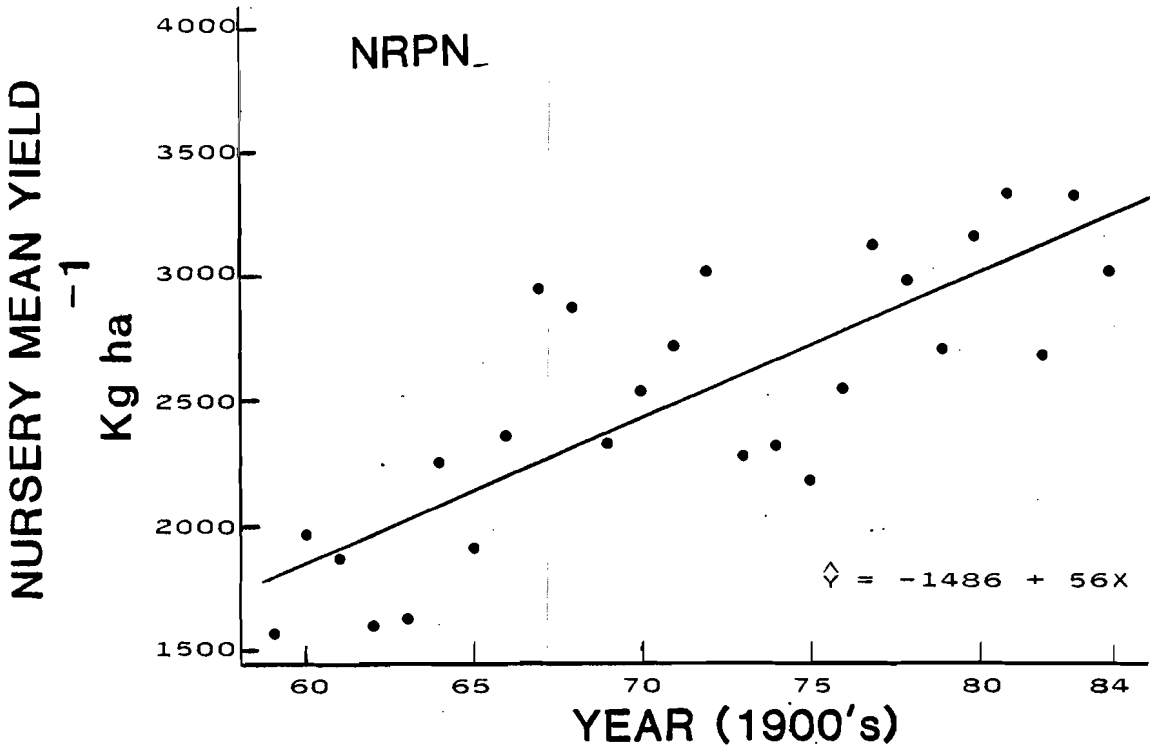


Figure 4

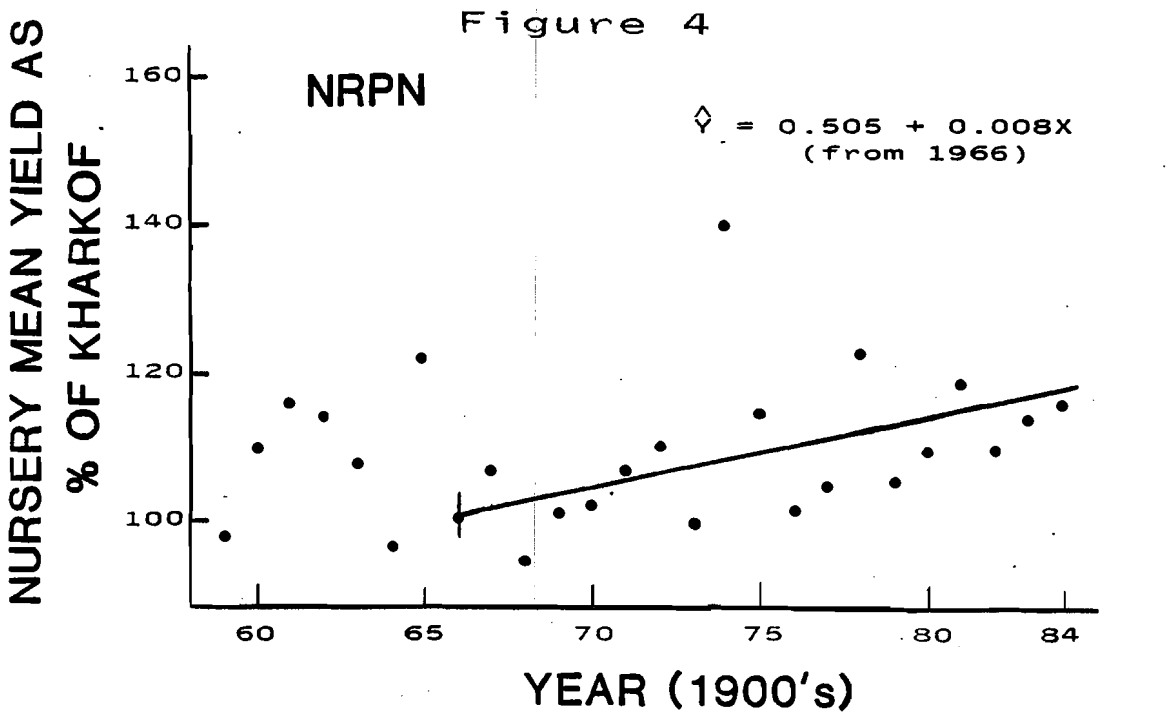


Table 1. Spearman correlations of entry ranks from locations with regional rankings for the SRPN, 1959-1984.

Location	1959*	1984*	Mean	Change
Ft. Collins	0.57	0.63	0.60	+
Colby	0.61	0.55	0.58	-
North Platte	0.75	0.40	0.57	-
Hays	0.63	0.47	0.54	-
Stillwater	0.61	0.41	0.51	-
Lahoma	0.55	0.46	0.51	-
Alliance	0.65	0.37	0.50	-
Garden City	0.53	0.40	0.46	-
Akron	0.39	0.45	0.42	+
Springfield	0.36	0.26	0.31	-
Vernon	0.22	0.36	0.29	+

* Values predicted from linear regression.

Figure 5

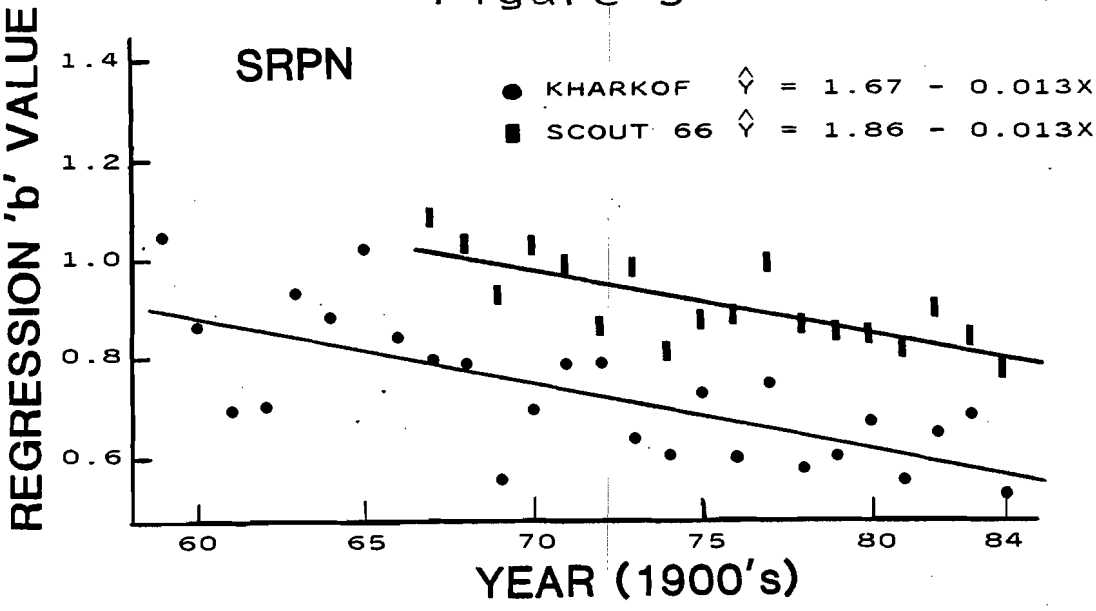
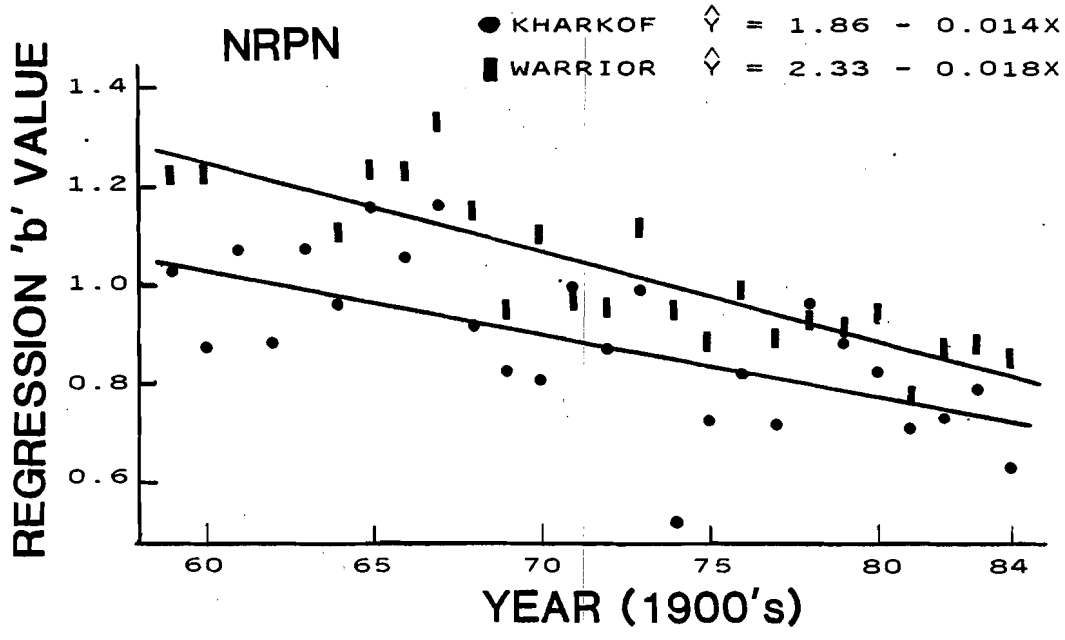


Figure 6



PHYSIOLOGICAL RESPONSES OF WHEAT TO HEAT STRESS DURING GRAIN FILLING

Gary M. Paulsen

Experimental and circumstantial evidence suggests that high temperature stress limits maximum wheat grain yields in much of the Great Plains region. Hot, dry winds are especially injurious, but even normal high temperatures are well above the optimum for grain dry matter accumulation. Objectives of our researach are to determine the mode of heat injury and identify germplasm with superior heat tolerance in order to increase wheat grain yield potential.

Plants are grown at 25°C/15°C day/night until five days after 50% anthesis, when they are subjected to different temperature regimes. At 20°, grain filling duration (GFD) is prolonged, but leaves remain viable through physiological maturity and yields are high. As the temperature increases to 25°, 30°, and 35°C, leaf area duration (LAD), GFD, and grain yields decrease progressively. Photosynthetic activities--$^{14}CO_2$ fixation, ribulose-1,5-bisphosphate carboxylase, and Hill reaction--slow under all regimes as plants mature, but the rate of decline increases greatly with the temperature for growth. Crude protease enzyme activity in leaves, on the other hand, increases markedly and protein content decreases. The increase in specific protease activity (activity per unit protein) from anthesis to maturity, about 4-fold at 25°C and 28-fold at 35°C, may explain the loss of viable leaf area and photosynthetic activities as temperature increases.

Results of differential temperature treatments to roots and shoots suggest the involvement of root processes in heat stress injury. Injury is least and grain yields are highest when roots and shoots are held at 25°C during grain filling. Holding the root temperature at 25°C while warming shoots to 35°C increased injury only slightly, whereas warming roots to 35°C while holding shoots at 25°C increased injury greatly. The latter treatment was nearly as deleterious as warming both roots and shoots to 35°C. Temperature treatments that were not injurious decreased root activity as measured by dye reduction and increased protease enzyme activity in leaves.

Wheat germplasm from the USDA Collection, the Australia National Collection, and China is being examined for heat tolerance. Preliminary results indicate a wide range among genotypes. Cultivars presently grown in the Great Plains already possess substantial tolerance to high temperatures, suggesting that breeders routinely select for the trait. The tolerance of present cultivars also indicates the importance of the trait.

Our conclusions to date are that heat injury to wheat in the region is important, that tolerance is controlled genetically, and that yield potential can probably be raised by increasing heat tolerance. Progress in breeding for the trait will require rapid screening methods to identify genotypes that are more tolerant than current cultivars and further elucidation of the mechanism of heat injury.

USE OF CHLORPHYLLL FLUORESCENCE FOR MONITORING HEAT STRESS IN WHEAT

Scott Harding

Most varieties of wheat, particularly winter wheats, are heat sensitive during the grain filling period. Analysis of fluorescence induction curves has been used in this study to determine the sequence of events leading to photosynthetic failure at 35°C in a relatively heat-tolerant, hard red spring wheat, T. aestivum var. Len. Increased variable fluorescence (F_v) followed by an increase in the amount and rate of P→S quenching preceded loss of the S-M-T transient associated with ATP synthesis.

Inflorescence removal prolonged LAD at 35°C. Inflorescence removal increased P S quenching but delayed loss of the S-M-T transient. At this time, it appears that reduced flag-leaf transpiration in intact plants leads to more severe heat induced alterations of their photosynthetic membranes. It is hoped that further work will 1) distinguish modes of heat failure in tolerant and intolerant wheats, 2) establish a relationship between heat induced membrane failure and the efficiency of heat avoidance mechanisms such as transpirational cooling and leaf angle adjustment.

GENETIC DIVERSITY OF MOLECULAR AND CELLULAR RESPONSES TO HEAT SHOCK IN ACCLIMATED WHEAT

D. R. Porter, H. T. Nguyen, J. J. Burke, and M. Krishnan

Several basic issues must be resolved before biochemical selection criteria can be used in breeding for thermal tolerance in winter wheat for the Great Plains, where high temperatures during anthesis and grain filling limit yields. Texas Tech University has implemented a program in cooperation with USDA-ARS Plant Stress Unit at Lubbock with the immediate goal of generating basic information useful in understanding the phenomenon of acquired thermal tolerance in wheat. Objectives of this research are as follows:

1. To characterize molecular and cellular responses to heat shock in acclimated and non-acclimated wheat.

2. To determine duration and extent of heat shock protein (HSP) and HSP mRNA synthesis.

3. To quantify genetic diversity for thermal tolerance and HSP accumulation in hexaploid wheat and its wild relatives, determine genetic control, identify chromosomal locations and define the molecular structure of HSP genes.

4. To determine cellular sites of HSP synthesis/binding.

5. To establish adaptive value of HSP in relation to thermal tolerance and improved productivity.

6. To develop rapid, effective, plant-conserving screening techniques for germplasm enhancement.

Characterization of cellular responses to heat shock are made by cell viability tests using triphenyltetrazolium chloride (Chen et al., 1982). All spring and winter genotypes tested are acclimated at an elevated, sublethal temperature and then exposed to a typically lethal higher temperature. Those genotypes exhibiting differential sensitivity to this thermal stress undergo biochemical analysis under similar stress conditions.

Biochemical analysis to determine duration and extent of HSP synthesis consists of heat stressing radiolabelled leaf tissue followed by SDS-polyacrylamide gel electrophoresis. HSP mRNA will be studied using RNA hybridization with heat-shock specific cDNA clones.

Ongoing genetic studies of genotypes identified as thermal tolerant and susceptible from aforementioned studies will determine genetic control and chromosomal location of HSP genes.

Separation of cellular organelles and biochemical analyses techniques will be applied to determine specific organelle sites of HSP synthesis and extent of interorganelle transport to binding sites.

Field sudies will run concurrently under differential irrigation treatments providing varying degrees of heat stress to evaluate adaptive value of HSP synthesis in relation to thermal tolerance and resulting improved plant productivity.

Long-term goal of this research is to develop rapid, effective, plant-conserving screening techniques to enhance germplasm and breed thermal tolerant wheat cultivars.

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CELL MEMBRANE STABILITY TO HEAT STRESS IN WHEAT

J. J. Shanahan

Productivity of winter and spring wheat grown under the Great Plains environment of the USA may be greatly reduced by high temperatures that occur during the grain-filling process. Excessive temperatures tend to reduce photosynthetic rates, increase respiration levels, and hasten leaf senescence, resulting in lower kernel weights (Wiegand and Cuellar, 1981). The ability of various plant species to maintain normal photosynthetic rates under extreme temperatures has been related to the ability of the membrane system of both the cell and chloroplast to resist loss of integrity under high temperature stress (Sullivan and Ross, 1979; Bjorkman et al., 1980).

Cell membrane stability of leaf material was determined by a slightly modified version of the procedure developed by Sullivan (1972) for use with sorghum. Using this procedure Blum and Ebercon (1981) found that plant age and leaf position have a very significant effect on the measured values of cell membrane stability in spring wheat. Therefore, similar leaf positions (flag leaf) and similar maturity stages (anthesis) were used each time that the test was performed.

The heat injury data presented in Table 1 indicate a significant environmental effect on cell membrane stability, as shown by the wide range (32-74%) of location means for this trait. The environmental effect appears to be consistent across genotypes (no significant cultivar x environment interaction). Consequently, the cultivar rankings remained similar across environments, indicating that environmental effects do not influence the relative level of expression of this trait. However, this trait was not correlated with yield for a group (n=12) of winter wheat cultivars grown at several locations in eastern Colorado in 1984. This is not surprising considering the the group of cultivars differed for many traits other than cell membrane stability, including maturity, plant height, and overall yield stability.

Another approach was pursued to assess the value of this trait to maintenance of yield under high temperature stress. Spring wheat lines (n=8) developed by the Pioneer Hybrid Int. spring wheat breeding program, derived from two crosses involving adapted and unadapted parents, were evaluated for cell membrane stability (Table 2). The lines were placed into two groups, heat tolerant (n=4) and heat susceptible (n=4), based upon their rating for cell membrane stability. The average heat injury value for the tolerant lines (47%) differed rather significantly from that of the susceptible lines (73%). However, the two groups were similar in plant height, and maturity. Thus, these groups differed mainly for the cell membrane stability trait only. These lines were evaluated by the Pioneer Corp. in their yield nurseries for productivity under four environments in 1981, ranging from northern North Dakota to southern South Dakota (Table 3). These locations represent a significant range in sites which provide temperature stress during grain-filling.

There was no difference in yield between the tolerant and susceptible groups at the most northern location (Drayton, ND). However, the tolerant group outperformed the susceptible group at the remaining three southern locations. Specifically, the tolerant lines yielded,

on the average, 20% more than the susceptible lines at the Frankfort, SD site. Thus, this trait has a substantial effect in maintaining productivity under high temperature stress conditions, while it has no influence on productivity under nonstress conditions.

Acknowledgements: The author would like to thank Dr. I. B. Edwards of the Pioneer Overseas Corp., Johnston, IA, for providing the spring wheat lines.

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Table 1. Heat injury of six winter wheat cultivars across various environments recorded at anthesis, as determined by the cell membrane stability test.

Cultivar	Location - Year				
	Akron (1982)	Akron (1983)	Ft. Collins (1983)	Akron (1984)	$\bar{X}$
	---	---	%	---	---
Tam 105	55	17	42	22	34
Hail	55	16	39	28	35
Brule	79	46	52	48	56
HW 1010	88	38	69	38	58
Vona	77	41	70	49	59
Newton	90	40	71	54	64
L.S.D. (0.05)	18	15	21	15	18
$\bar{X}$	74	32	57	40	51
C.V. (%)	16	31	25	24	24

Table 2. Agronomic traits and heat tolerance differences of various spring wheat lines (F_7 generation).

Genotype	Days to heading	Plant height	Heat injury
		cm	%
<u>Heat Tolerant</u>			
SGW 104-274 1/	59	86	56
" -332	60	84	61
SGW 086-205 2/	59	94	29
" -170	59	81	42
$\bar{X}$	59	86	47**
<u>Heat Susceptible</u>			
SGW 104-268	61	84	83
" - 25	59	97	84
SGW 086-322	60	81	72
" -381	59	76	54
$\bar{X}$	60	85	73

1/ Spring wheat cross (Pioneer) SGW104 = WALDRON/SM2//TOKWE.

2/ Spring wheat cross (Pioneer) SGW086 = ND 487/WALDRON//TWEON/3/68-BAD.

* Genotypic means were significantly different at the 1% level, as determined by the single degree of freedom comparison test.

Table 3. Grain yield of spring wheat lines, differing in heat tolerance, recorded at four locations in 1981.

Genotype	Location			
	Drayton, ND	Glyndon, MN (early)1/	Glyndon, MN (late)	Frankfort, SD2/
	kg/ha			
Tolerant Lines	3656	2621	2668	4281
Susceptible Lines	3454	2157	2359	3555
Difference	202	464**	309**	726**

1/Early and late for the Glyndon locations refer to planting dates.

2/Temperatures at this location ranged from 32-40°C during early grain fill and continued for over a two-week period. The leaf material of the susceptible lines appeared to be totally dehydrated, while leaf material of the tolerant lines remained turgid.

**Significant at 1% level, as determined by the single degree of freedom comparison test.

EFFECTS OF WATER AVAILABILITY ON GAS EXCHANGE AND GRAIN YIELD IN WHEAT GROWN UNDER DIFFERENT NITROGEN REGIMES

Jack A. Morgan

Despite considerable work which has previously been done investigating N-nutritional effects on crop growth and yield, relatively little of the research efforts have been concerned with describing the effects of varying N regimes on the photosynthetic activity of plant canopies in the field. The purpose of the present investigation was to study the effect of N nutrition on wheat canopy photosynthesis and internal leaf water relations, and to determine the sensitivity of plant growth and canopy photosynthesis of plants grown under different N regimes to reductions in leaf water potential. High, medium and low N regimes were established by fertilizing the wheat plots with 150, 100 and 0 kg N ha^{-1}, respectively. Nitrogen nutrition increased tillering, leaf area index and growth of above-ground biomass, but had no effect on leaf water or osmotic potential. Leaf water potential fell from -1.1 MPa at the heading developmental state to less than -2.0 MPa during grain filling. Although proportional changes in leaf osmotic potential over the same period resulted in turgor maintenance, leaf conductance decreased in all of the N treatments with reductions in leaf water potential. The reductions in leaf conductance were, however, relatively greater for the two highest N treatments. Canopy photosynthesis was positively affected by N application, although almost all of the variability was accounted for by the capability of the high and medium N treatments to intercept more of the incident light by virtue of their greater leaf area indices compared to the low N treatment. Reductions in leaf water potential resulted in similar relative reductions in canopy photosynthesis for all N treatments. Greater tillering and kernel number per head from increased nitrogen nutrition resulted in significantly greater yields for the medium and high N plants. The results of the present study indicate that under moderate water stress, crop growth and yield may still be considerably responsive to N, at least partly through its influence on canopy photosynthesis.

DIFFERENCES IN RELATIVE WATER CONTENT IN A WINTER WHEAT POPULATION

R. C. Johnson and Manette Schonfeld

Understanding drought resistance mechanisms is needed before physiologically based selection criteria can be developed for a wheat breeding program. A field experiment was conducted to determine the type and extent of drought resistance under field conditions in wheat genotypes differing in drought resistance.

Plants of the cultivar TAM W-101 (higher drought resistance) and the cv. Sturdy (lower drought resistance), their F_1, F_2 and backcrosses were planted in 6-plant rows in the fall of 1984. Drought was induced in thespring by covering the area with an open ended plastic rainshelter. Plant characteristics measured over time were number of tillers, leaf water potential, solute potential, turgor, and relative water content (RWC). After physiological maturity, yield and yield components were determined.

Mid-day leaf water potential in the flag leaves dropped from -0.6 MPa at booting to -2.3 MPa during grain filling, indicating that drought had developed. Although no significant differences in water potential or its components were found among entries, RWC measurements showed that TAM W-101 maintained a significantly higher RWC over time than Sturdy. The F_1 and F_2 showed intermediate values, and the backcrosses were each closest to their recurrent parent, suggesting that RWC had fairly high heritability. No significant differences in tillering pattern or number were found. Even though drought was most intense during grain filling, the yield component reduced most in both genotypes was number of heads. The maintenance of high RWC under drought appears to have potential as a drought resistance trait.

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USE OF INFRARED THERMOMETRY TO IDENTIFY WATER CONSERVATION IN WHEAT GERMPLASM

J. L. Hatfield

Canopy temperatures when incorporated into the surface energy balance can be utilized to estimate evapotranspiration. The warmer the canopy the lower in the evapotranspiration rate, thus, canopies which are warmer under irrigated conditions will have a reduced rate of water use. In semiarid environments a canopy which has a warmer temperature will have an increased probability of surviving until the next rainfall event.

In wheat canopies with different maturities, the infrared thermometer can see differing amounts of panicles in the viewing area. Panicles can cause the surface temperature to increase by 2°C which can be similar to the difference between lines under study. To overcome this problem, a more nadir (vertical) angle should be used to minimize the effects of panicles.

Studies on cotton strains have revealed that there are consistent differences between days and years and that canopies which were warmer under irrigated conditions produced the largest biomass in dryland studies. This technique has been transferred to wheat studies and it has also been found that there are consistent differences between wheat lines. These studies will continue during the 1986 season with emphasis on the relationship of canopy temperatures to growth and yield of 30 selected wheat lines.

Canopy temperature can provide a rapid means of evaluating water conservation in wheat lines. The technique can be easily transferred among species and will require the linkage between those using infrared thermometers and the wheat geneticist.

HESSIAN FLY RESISTANCE IN WHEATS

J. H. Hatchett

Breeding wheats resistant to Hessian fly has been an important objective of wheat improvement programs. During the last 20 years, damage by the fly has been controlled in many areas almost exclusively by resistant varieties. Historically, the Hessian fly has been a major pest of wheat in the central Great Plains and the Midwest. However, during the past 10 years, the fly has become an economic pest in other wheat growing areas where resistant varieties were not available. Consequently, public and private wheat breeders in 14 states are now developing resistant varieties.

Breeding Hessian fly-resistant wheats has been continuous since the 1950's. As a result, 60 resistant varieties have been developed for commercial production. The use of resistant varieties has been the most effective and economical method for preventing losses. Although only about 25 percent of hard wheat acreage is presently protected by resistant varieties, resistant wheats are now being developed for most areas of the hard red winter wheat region. Thus, the acreage of resistant wheats is expected to increase during the next 10 years.

Long-term stability is a major concern in breeding for Hessian fly resistance. Biotypes of the fly capable of infesting resistant varieties pose the greatest threat to the durability of resistance. Thus, because of potential development of biotypes, identifying new sources of resistance has been an important component of breeding programs. Over the past 30 years, numerous sources of resistance have been identified and used in the development of resistant wheat (Table 1).

The origin and genetics of resistance to Hessian fly in wheats have been reviewed by Gallun (1977), Stebbins et al. (1982, 1983), and Hatchett and Gill (1983). Resistance of these sources is dominant, partially dominant, or recessive, and conditioned by single, duplicate, or multiple genetic factors derived from common and durum wheats and Triticum tauschii. Thirteen major genes (designated H1 through H13) have been identified. Other genetic factors for resistance include those derived from Kawvale and Marquillo. The genetic basis of resistance in Kawvale has not been determined. Painter et al. (1940) reported that Marquillo resistance had an unknown number of genetic factors and tended to be recessive. Studies by Maas et al. (1985), however, indicated that Marquillo resistance appeared to be conditioned by a single partially dominant gene and that resistance expression was highly sensitive to temperature. With the exception of Kawvale resistance, the primary mechanism of resistance conditioned by these genes is antibiosis, i.e., first-instar larvae die after feeding on resistant plants.

The genetic interactions between wheat and the Hessian fly are highly specific. Gene-for-gene relationships exist between resistance in the host and avirulence in the insect (Gallun and Khush, 1980). The ability of biotypes to infest resistant wheats is controlled by recessive genes. Eight biotypes of Hessian flies that differ in their ability to infest wheats having specific resistance genes have been identified from field populations and isolated in the laboratory (Gallun, 1977; Sosa, 1981). These biotypes differ in their ability to infest wheats having the H7H8, H3, H5, and H6 genes (Table 2). The strategy for management of resistance genes in breeding programs has

been the sequential release of varieties with different genes. The H3 and H5 genes have been the most widely used sources in soft winter wheat varieties during the past 15 years. Because of their antibiosis, these genes have exerted strong selection pressure that has favored the development of virulent biotypes. Recent surveys of Hessian fly indicate that these genes are no longer effective in many areas of the soft wheat region.

Only the Marquillo-Kawvale resistance and the H3 gene have been used in hard red winter wheats. The Marquillo resistance has been an effective source of resistance in several hard wheat varieties for more than 30 years without virulent biotype development. For instance, the Marquillo resistance of 'Brule' continues to be highly effective against Hessian fly in Kansas and Nebraska. Although the H3 gene has been used in hard red winter wheats, such as 'Ottawa', 'Shawnee', 'Larned', and 'Arkan', these wheats have not been grown on large acreages. In 1985, only 15 percent of the Kansas wheat acreage was planted to wheats having the H3 gene. Thus, there has been little selection for a biotype virulent to H3 gene. Other resistance genes are highly effective against Hessian fly in the hard wheat region. But virulent biotypes do occur at low frequencies and are expected to increase as varieties with resistance genes, such as H3, increase in acreage. Thus, wheat varieties having different biotype-specific resistance are needed to protect against the buildup of virulent biotypes. Wheat breeders in the hard wheat region are presently utilizing several different sources, including Marquillo resistance, H3, H5, H6, H9, H11, and H13. The development and release of wheats having different resistance genes should enhance the durability of resistance. Also, with the incorporation of new sources of resistance, such as those recently identified in rye, T. tauschii, and durum landraces, it is likely that stable resistance to Hessian fly can be maintained in breeding programs.

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Table 1. Sources of resistance to Hessian fly in wheat.

Source	Gene designation	Genome or chromosome location
Common wheat		
Indiana Swamp	Kawvale	Unknown
Dawson	H1, H2	Unknown
Illinois #1W38	H3	5A
Java	h4	Unknown
Riberio	H5	1A
Seneca	H7, H8	Unknown
Luso	H12	A or B
Durum Wheat		
Iumillo	Marquillo	A or B
PI94587	H6, H11	5A, 1A
Elva	H9, H10	5A
Triticum tauschii		
KU Acc. 2076	H13	6D 1A

Table 2. Biotypes of the Hessian fly.

Biotype	Reaction of resistance genes (wheat varieties)*			
	H7H8 (Seneca)	H3 (Arkan)	H6 (Knox 62)	H5 (Arthur 71)
Great Plains	R	R	R	R
A	S	R	R	R
B	S	S	R	R
C	S	R	S	R
D	S	S	S	R
E	R	S	R	R
J	S	S	R	S
L	S	S	S	S

* R = Resistant; S = Susceptible

GREENBUG DAMAGE: SEEDLING GROWTH AND RESISTANCE

Robert L. Burton

Recently we completed a field study of greenbug damage to resistant and susceptible wheat (Burton et al., 1985). Greenbug infestations were allowed to increase on seedlings until a predetermined level was reached. They were then removed, and plants were kept greenbug free until harvest. Plants damaged in the fall (both resistant and susceptible) showed yield reductions. Moreover, yield reductions were proportionate to the number of greenbugs per plant. Other studies (Kieckhefer and Kantack, 1980; Pike and Schaffner, 1985) have similarly shown that seedling damage significantly reduces yield at harvest. This indicates that greenbug damage is permenent, and control measures, though they may save the crop, do not overcome the effects of the damage on yield.

This idea of permanent damage prompted us to begin studies investigating the definitive causes of greenbug damage. Consequently, a greenhouse technique was developed to study seedling root and shoot growth characteristics using Supercell cone-tainers and a fritted clay growth medium. Roots do not penetrate the clay particles and can be easily washed for study. Root biomass, root volume, and total root lengths could then be measured.

During our tests, greenbugs were allowed to feed until visual damage was evident. lNo measurements were taken during infestation. Sampling was started at the time of greenbug removal and continued weekly for several weeks. Growth patterns for damaged and undamaged seedlings were then determined. Results showed that no differences between damaged and undamaged plants had occurred at the time of greenbug removal. However, during the following weeks, differences in root and shoot biomass between damaged and undamaged plants developed and continued to increase until the test was concluded at five weeks (Burton, 1986). This indicates that greenbug damage is not entirely expressed during infestation, but that the reduction in biomass of both roots and shoots occurs over time, appearing delayed. It is not known if this is a direct cause of the final reduction in yields at harvest or if it is just a strong symptom of physiological dysfunction caused by a toxinlike substance injected by the greenbug during feeding (Al-Mousawi et al., 1983).

We also studied the effect of greenbug numbers on root and shoot damage. When 2 to 18 greenbugs per plant fed for 14 days, we found that root and shoot biomass were reduced in a linear manner.

Histological studies of root apical meristem showed that immediately after infestation, tissue was hardly affected. But five weeks later, root tissue was severely affected by greenbug feeding. Sections taken 100-500 microns from the root tip showed extreme abnormal structure. In contrast to undamaged roots, those damaged had plasmolized cortical cells, larger nuclei (with pronounced darker staining), and a total collapse of cell walls. This disorganization of apical meristem is an apparent reason for the reduction in root biomass. Moreover, since root:shoot ratios remained essentially unchanged during the studies, the reduction of root biomass may be the direct cause of the reduction of shoot biomass.

When nine wheat varieties were tested, all showed a reduction in root and shoot weights. The inherent size of the root systems differed considerably between varieties, but the rate of biomass reduction was similar for all varieties. This indicates that very little difference occurs in the amount of tolerance between varieties.

Three varieties were tested to determine if tolerance to root damage occurs. Amigo, Largo, and TAM W-101 were tested with biotype E greenbugs. Both Amigo and TAM W-101 showed typical root damage. Largo, however, did not show any root biomass reduction, indicating that it is able to resist this type of damage. Tests are now underway to determine if this tolerance remains effective following several backcrosses to TAM W-101.

Other future projects include a study on the effect of greenbug damage on carbohydrate partitioning in roots and shoots of wheat seedlings. We will also continue research on describing and quantifying greenbug-caused root damage to wheat using microphysiological techniques. Other projects include the study of bird-cherry oat aphid damage and sources of resistance for this aphid.

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GREENBUG BIOTYPES ON WHEAT

J. A. Webster

In plant resistance research, insect biotypes are classified by the damage they cause to different crop varieties. The occurrence of greenbug biotypes that overcome resistant wheat lines has been a problem in wheat breeding programs since 1958. Even before 1958, Dahms (1948) reported differences in the reaction of 'Reno' barley infested with greenbugs from Oklahoma and with greenbugs from Mississippi. By definition, these two populations could have been called biotypes. In wheat, a simple method of distinguishing biotype C from E is based on the reaction of the 'Amigo' gene. Biotype E will kill Amigo derivatives, while plants of this entry survive under biotype C infestations. Biotypes C and E cannot be distinguished from each other by their gross physical appearance, whereas biotype B can be distinguished from either C or E by its darker coloring. In addition, CI 4888 oats is resistant to biotype B, but susceptible to biotypes C and E. On the other hand, CI 1579 and 1580 oats are susceptible to B and resistant to C and E. Recently, biotypes B, C, and E have been separated in morphometric studies involving multivariate analysis (Fargo et al. In press). Dr. Dean Kindler and his associates in Nebraska are conducting research on the feasibility of distinguishing biotypes using isoenzyme analyses. The 'Largo' wheat germplasm line is resistant to biotypes C and E and is being used in breeding programs for resistance to these biotypes. However, we have found that Largo and other T. tauschii entries are susceptible to laboratory colonies of biotype B. Biotype B is no longer readily found in the southern Great Plains, but we have found a few individuals in the Stillwater area. Additional surveys are needed. Whether biotype B will again become predominant on the Great Plains as it was in the 1960's is unknown. Amigo derivatives are resistant to B, so breeders are combining the resistance genes from Amigo and Largo to obtain wheat cultivars with resistance to biotypes B, C, and E.

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SUMMARIES OF GREENBUG RESISTANCE RESEARCH
OKLAHOMA, TEXAS, KANSAS

OKLAHOMA

J. M. Tyler, O. G. Merkle, J. A. Webster, E. E. Sebesta

Efforts are underway to combine the resistance of 'Amigo' and 'Largo'. Both genes were in good agronomic backgrounds before initial crosses were made last spring (1985) to combine the two sources. In January 1986, F_1 plants from those crosses were selfed and backcrossed to both parents, and we intend to test the progeny this spring with biotypes B and/or E as necessary. The Amigo derivative used in the program is OK81322 ('Payne'//'TAM W-101'/Amigo). We hope to extract progeny that have leaf rust resistance derived from Payne, in addition to the greenbug resistance derived from Amigo and Largo.

TEXAS

J. E. Slosser and Leanne Bush

Objectives:

1. To determine the influence of wheat gene mixtures on greenbug populations in field and greenhouse studies.

2. To determine if different biotypes are present other than biotypes C and E. Field samples are being collected from around the state. Clones are reared from these culture, colonies built up, and biotypes determined.

Methods

There are 3 different studies.

I. Field Study

The field study has incorporated the use of the split plot design with 4 replications. Treatments are: 1) TAM 105, 2) TAM 107, 3) TXGH 9816, 4) a mixture of TAM 105 and TAM 107, 5) a mixture of TAM 105 and TXGH9816, 6) a mixture of TAM 107 and TXGH9816, and 7) a 33% mixture of TAM 105, TAM 107, and TXGH9816.

The seven variety mixtures constitute the whole plots. Subplots are sprayed with malathion or are untreated. Each subplot is four rows wide and 16 feet long, and each whole plot is surrounded by a fallow, 4 foot alley. Row spacing is one foot. The wheat was planted September 28, 1985 with 22 seeds/ft^2.

Once a month, 3 species of aphids are counted. Greenbug winged and nonwinged forms are recorded. The other 2 species are oat bird-cherry and corn leaf aphids. Two sections, each one foot long, are examined for aphids from the middle two rows of each plot.

A statistical analysis is used to determine if there are any significant differences between treatments on each sampling date.

There are two objectives in this study. One is to determine the seasonal average population density as influenced by the variety mixtures, and the other objective is to measure the yield differences between the check area and the sprayed area.

II. Greenhouse Study

The second study is being conducted in a greenhouse. This is a duplication of the field test, but with smaller plots. Plots are 4 rows wide and 3' long with 7" row spacing replicated 4 times. Planting date was December 16, 1985, and the plots were hand planted with wheat that had been germinated to insure a uniform mixture. As soon as the wheat reached the tillering stage, the middle 2 rows were infested with apterous adult biotype 3 greenbugs at 6" intervals with a total of 8 release sites in the middle 2 rows of each plot. Seventeen greenbugs were released at each of the 8 sites. Sampling will be two 6" sections of the infested rows every 2-3 weeks.

The objective of the greenhouse study is to determine the influence of wheat variety mixtures on biotype E greenbug population development and on yield.

III. Biotype Survey

Multiple locations in Texas will be surveyed for greenbug biotypes. Samples have already been collected from the High Plains, Rolling Plains, Cross Timbers, and Blackland areas during the fall, 1985. There will be two collection seasons, Summer/Fall and Winter/Spring.

Greenbugs will be collected from cultivated and wild hosts to determine biotype. Any new biotypes, other than C and E, will be maintained. Individual colonies will be increased on TAM 105 from a single viviparous female. To determine biotype, TAM 107 (A-C resistant, E susceptible), 'Piper' sudangrass (B resistant, C and E susceptible), OK695157 (A resistant, B-E susceptible), TXGH9816 (C and E resistant and probably B resistant) are planted in an 8" pot with two plants of each variety. The pots are infestd with 20 greenbugs per plant and covered with a plastic cage. Readings, based on a scale of 1-6 (1 = green, no damage and 6 = dead), are taken until the plants die, usually within 7-9 days. The possible biotype determinations are:

1) all varieties alive - Biotype A

2) OK695157 dead; 'Piper' sudangrass, TAM 107 and TXGH9816 alive - Biotype B (possibly the original Biotype B)

3) OK695157 and TXGH9816 dead; 'Piper' sudangrass and TAM 107 alive - Biotype B, or possibly Biotype F

4) OK695157 and 'Piper' sudangrass dead; TAM 107 and TXGH9816 alive - Biotype C

5) OK695157, 'Piper' sudangrass, TAM 107 dead; and TXGH9816 alive - Biotype E

6) All dead or any other combination, new biotype.

K. B. Porter and G. Peterson

Greenbug resistance has been a major objective of the Bushland program for a number of years. The T. tauschii resistance in 'Largo' has been combined with the 'Amigo' resistance in several hundred backcross lines. They include biotype E resistant selections from the crosses TAM 101*4/Amigo*4//Largo and the same crosses, involving TAM 105 and TAM 108. Biotype E resistance was added rather easily to the biotype A, B & C resistant recurrent parents. About 150 lines were selected from 600 single rows on dryland. Many of these equalled or exceeded the recurrent parent in yield, test weight, and seed size and were like the recurrent parent in appearance. Threshability can be a problem but those selected were equal or approached the threshability of the recurrent parent. Mixographs of the majority of these lines grown on dryland, which ranged from 13 to 15% in grain protein, were equal or superior to those of the recurrent parent. Seventy lines were evaluated in replicated irrigated yield trials and a number of these were equal or superior to the recurrent parents in seed size, test weight and yield. Fifteen of these were milled and baked. These lines, which ranged from 10 to about 11.5% protein--somewhat less than the recurrent parent--generally had shorter mixing time and lower loaf volumes than the recurrent parent.

One hundred fifty of these lines are being evaluated in 1986 replicated dryland and irrigated yield trials at several locations. Additional quality evaluations are planned.

N. A. Tuleen

A 42-chromosome plant resistant to biotype E of the greenbug derived from a cross of 'Insave' rye with a Texas experimental wheat formed 20"+2' in the F_1 in crosses with TAM 105. Crosses with the appropriate Chinese Spring wheat telosomic stocks indicated that chromosome 1A of wheat had been replicated by chromosome 1R of rye. The F_1 plants which formed 20"+2' were used as male parents and backcrossed to TAM 105. Several resistant backcross progeny formed 21 pairs indicating that a wheat-rye translocation had occurred. This translocation most likely resulted from breakage and refusion of centromeres resulting in the production of a chromosome consisting of 1 arm of chromosome 1A and the arm of chromosome 1R which carries the gene from resistance to the greenbug.

Roger Ward

Pioneer Hi-Bred initiated lab screening for greenbug biotype E resistance at the Vernon, TX station in 1983 in order to supplement the previous effort made with Amigo (and derivatives) for developing biotype C resistance. Methods similar to those used by OSU and Texas A&M (Bushland) for insect-rearing and host-plant resistance determination are employed. Flats are screened from December to February; resistant backcross selections and F_2-F_3 segregants are vernalized and grown in the spring greenhouse, with harvest in June. Current emphasis in the field is on selection for agronomic type among advanced-generation lines which derive their greenbug resistance from Largo. Newer sources of resistance have been evaluated and are being utilized in the breeding program.

KANSAS

J. A. Wilson

We are maintaining an objective of breeding for resistance to the prevalent field races of greenbugs. Several germplasm sources giving resistance to races B, C, and E are being developed in our breeding program. We have received the assistance from Federal and State workers in screening and supplying races for our own screening work. Since the bug tends to develop new races, single gene resistance breeding will likely give only partial success. Dense leaf pubescence or some other morphological trait may be needed to give a more permanent type of tolerance or resistance.

RESISTANCE TO WHEAT CURL MITES AND WHEAT STREAK MOSAIC VIRUS

T. J. Martin and T. L. Harvey

Wheat curl mite (WCM) resistance derived from Salmon reduced the incidence of wheat streak mosaic (WMS) in naturally infested field plots by 61, 57, and 60% in 1979, 1980, and 1982, respectively. When a single WCM was transferred manually to each plant of WCM resistant and susceptible seedlings in the greenhouse, the incidence of WSM in WCM susceptible lines was 39% as compared to 10% for the WCM resistant lines.

KS80H4200 (PI475772), a WCM resistant F_5 plant selection from the cross Salmon/Sage/3/Larned/Eagle//Sage, was released as germplasm by the Kansas Agricultural Experiment Station in cooperation with USDA-ARS in the fall of 1982. KS80H4200 is susceptible to WSMV when inoculated mechanically. Reduced incidence of WSM only occurs when the virus is transmitted by its natural vector, the WCM.

Resistance to WCM has been identified in Amigo, CI15322, and CI15321. Workers in Canada have identified at least one source of WCM resistance in Aegilops squarrosa.

Recent studies on the effects of the Amigo WCM resistance on transmission of WSM virus have been inconclusive. TAM 107, OK790047, and OK81322 are all derivatives of Amigo and are WCM resistant. However, both in field and greenhouse tests each of these lines have been erratic in terms of reducing WSM virus transmission. It possibly may be due to a reduced level of WCM resistance in the Amigo derivatives as compared to the Salmon resistance.

NEW FUNGICIDES FOR CONTROL OF FOLIAR DISEASES OF WHEAT

John E. Watkins and Ben Doupnik, Jr.

Recent trends in the development of new fungicides for control of diseases of small grains have been in the area of systemic, sterol-inhibiting products with broad spectrum activity against powdery mildews, rusts, and leaf spots. This trend essentially began with the testing of triadimefon (Bayleton) and propiconazol (Tilt). The goal of new fungicide development has been to formulate products that are effective against a wide range of plant pathogens when applied once at low rates.

Several of these new sterol-inhibiting fungicides are annually evaluated for foliar disease control in field trials conducted by the University of Nebraska. In addition to Bayleton and Tilt, the experimental fungicides XE 779, HWG 1608, and RH-3866 show excellent potential for control of leaf rust, tan spot, and speckled leaf blotch. Table 1, which is the three-year average of all treatments, shows that each product reduced leaf rust severity. To a lesser extent, combined leaf spot (tan spot and speckled leaf blotch) severity was reduced, with increased yields and 1000-kernel weights. In some of the test years, yield increases were as high as 15 bushels/acre, whereas in others the yield response was less dramatic.

Our data show that the new fungicides being tested for rusts, powdery mildew and leaf spots are effective and will eventually offer the wheat grower a wider choice of products for wheat disease control. In the central Great Plains, foliar fungicides have potential application in dryland wheat production in eastern Nebraska, in intensive wheat management systems, and in conservation tillage systems.

Table 1. A 3-year average of all treatments[1/] of each fungicide for disease control and yield response.

Treatment	Disease severity: Leaf rust	Disease severity: Combined leaf spot[2/]	Yield: bu/A	Yield: Adv. (bu/A)[3/]	1000-k: Adv. (%)
Mancozeb[4/]	15.9	30.4	52.3	+4.6	+6.6
Bayleton	28.0	38.1	50.6	+2.9	+7.9
Tilt	26.5	24.7	52.9	+5.2	+7.8
XE 779	8.9	26.1	52.1	+4.4	+8.5
HWG 1608	4.1	27.7	55.0	+7.3	+9.9
RH-3866	10.4	29.2	54.5	+6.8	+9.5
Nontreated control	46.1	32.1	47.7		

1/ Represents an average of all treatments to include 1 or 2 applications, various rates of application, and different times of application for each treatment.

2/ Combined leaf spot includes tan spot and speckled leaf blotch.

3/ Advantage as compared to the nontreated check treatment.

4/ Mancozeb products include Dithane M-45 or Manzate 200.

DISEASES ASSOCIATED WITH MINIMUM AND LOW TILLAGE WHEAT PRODUCTION

W. W. Bockus

Certain wheat diseases have been shown to be favored by reduced tillage production systems, particularly when wheat is continuously cropped. With some diseases or some environments this aggravation may express itself even when wheat is rotated with some other crop such that wheat is only planted every other year. Generally speaking, however, when wheat is planted every three or more years, these diseases are of minor importance.

Diseases favored by reduced tillage include: tan spot, a leaf spot disease; strawbreaker foot rot, a disease of the basal stem (foot) area; Cephalosporium stripe, a root-infecting disease that goes systemic to produce leaf stripe;Rhizoctonia root rot, a root rot disease; and Take-all, also a root and crown rot disease. The major ecological factor involved with increase in severity of these diseases with reduced tillage is the carryover of the causal pathogens in the undecayed wheat refuse. Any activity which reduces the microbial decomposition of the refuse (reduced tillage) will result in more inoculum surviving to the following wheat crop. Alternatively, when the refuse decays, the pathogens die out.

Current controls for these diseases include cultural, chemical, and host resistance measures. Future controls may include biological and/or additional chemical controls. Development of highly resistant hard red winter wheat cultivars is very likely for tan spot; probable, though more difficult, for Cephalosporium stripe; difficult, though possible, for strawbreaker and take-all and, of unknown feasibility for Rhizoctonia root rot.

ECOLOGY OF WHEAT ROOT PATHOGENS AND OTHER SOIL MICROORGANISMS

R. James Cook

Root diseases and not the lack of water or soil fertility limit the production capability of semi-dwarf winter wheats in most wheat-growing areas of the Pacific Northwest receiving 45-50 cm (18-20 inches) or more of precipitation or precipitation plus irrigation annually. Wheat in these areas yields 70-90 bu/A, 2-3 times the U.S. average, but still only 60-75% and rarely 90-100% of the attainable with healthy roots. On the other hand, yields of 100-130 bu/A with the same water and fertilizer have been obtained repeatedly in some 50 experimental plots over the past 10 years using soil fumigation or heat to eliminate wheat root pathogens. The crop response to these soil treatments resembles the response of plants to improved soil fertility, and has been misinterpreted as such in the past, but is due to the more efficient uptake of nutrients by the healthier roots. Two of the most important root diseases in the areas described are Pythium root rot caused by up to 10 Pythium species and take-all caused by Gaeumannomyces graminis var. tritici. Rhizoctonia root rot (= bare patch disease) is also present but less important. All three diseases are favored by reduced tillage. Besides the higher yields and more efficient use of fertilizer, plants with healthy roots are also more competitive with weeds, return more organic matter to the soil, and probably do a better job of anchoring soil against erosion.

Having demonstrated the potential of healthy wheat, our objective is to use biological methods to achieve the same effect. Crop rotations and tillage provide biological root disease control, but the trend is toward shorter or no rotation and less or no tillage. The presence of a complex community of nonpathogenic microorganisms on roots and leaves provides an important barrier to the establishment of pathogens on the plant. Strains of fluorescent Pseudomonas spp., obtained from roots of relatively healthy plants growing in soil naturally infested with Pythium spp., Gaeumannomyces graminis, or both pathogens, and selected for in vitro inhibition of one or both of these pathogens, resulted in 10-25% greater yield of wheat when tested as seed treatments in field trials conducted since 1979. A U.S. patent has been granted for the process of selection and use of the rare but naturally occurring root-inhabiting strains effective against G. graminis from among the milieu of ineffective indigenous strains of rhizobacteria, and a patent is pending for selection and use of rhizobacteria effective against Pythium. Ability to colonize roots and to inhibit the target pathogen(s) both are important traits of the beneficial bacteria. No plant-growth response to the bacteria can be demonstrated in pathogen-free soil. Research is now focused on the genetics and ecology of the beneficial rhizobacteria, on finding or developing superior strains of rhizobacteria, and on finding or developing wheat germplasm more supportive of the bacteria.

SOIL-BORNE WHEAT MOSAIC VIRUS

Myron K. Brakke

Soil-borne wheat mosaic virus is unique in its rapid mutation rate, its translation strategy, and its virulence when manually inoculated to resistant wheat cultivars. The smaller of the two RNA components frequently loses part of its 3500 bases to give a shorter but still functional RNA between 2500 and 3500 bases. The mutants predominate over wild type virus in plants infected for several months and produce more severe symptoms than wild type. Wild type viral RNA II codes for three proteins of 20 Kd, 28 Kd, and 90 Kd. All three proteins react with antiserum to virions which have a 20 Kd capsid protein. The 28 Kd and 90 Kd proteins are apparently read-through translation products. All three proteins are found in infected plants. The 90 Kd protein is not produced by mutants.

Cultivars of wheat that are resistant in the field are hosts for the vector, Polymyxa graminis, and also are susceptible to the virus by manual inoculation. Roots of resistant cultivars are more severely stunted by virus infection than are roots of susceptible varieties. The mechanism of field resistance is unknown.

MOLECULAR STRATEGIES FOR VIRUS DISEASE CONTROL IN WHEAT

Steven A. Lommel

Recent research on such model systems as tobacco and tobacco mosaic virus (TMV) have illustrated that virus diseases can be controlled by the insertion and expression of viral genes in the host. Two strategies are currently being pursued. The first strategy involves transforming potential viral hosts with the mild strain of a virus capsid protein gene. Presumably the capsid protein from the mild strain is expressed in transformants and thus generates a cross protection phenomenon when challenged by a severe strain. A second strategy involves transforming plants with portions of a viral genome in an orientation that generates complementary (-sense) transcripts upon expression. The negative sense transcripts hybridize to incoming challenge viral RNA generating a duplex thus preventing viral RNA expression. This strategy may also be a mechanism involved in the cross protection phenomenon.

Our laboratory is working on the characterization of a virus coded cell-to-cell movement function with the red clover necrotic mosaic virus (RCNMV) tobacco model system. RCNMV is a split genomed ssRNA spherical plant virus. We have evidence which indicates the large genomic RNA codes for replication and capsid protein. The small genomic RNA is monocistromic and codes for a 34 kd polypeptide which is presumed to be involved in cell-to-cell movement. We have a full length cDNA clone of RCNMV RNA-2. We are currently transforming tobacco plants with the RNA-2 cell-to-cell movement gene. Transformants will be inoculated with RCNMV RNA-1 and monitored for its systemic movement. This experiment will establish that the cell-to-cell movement protein is functional. Our ultimate goal is to transform tobacco with mutants of the RNA-2 cell-to-cell movement gene and determine if the transformants are protected from systemic infection by wild type virus. This constitutes a third molecular strategy for virus disease control.

Most of the important viruses of wheat are amenable to these virus control strategies. Our laboratory is characterizing and cloning wheat soilborne mosaic and wheat streak mosaic viruses for eventual transformation into wheat when wheat transformation becomes a reality.

WHEAT ANTHER CULTURE TECHNOLOGY

S. G. Metz, T. A. Armstrong, H. C. Sharma,
P. N. Mascia, and P. S. Baenziger

Wheat anther culture is one of the first tools of biotechnology to be applied to commercial breeding programs. Modifications of the protocol described by Schaeffer, et al. (1979, Crop Sci. 19:697-702) were used. The steps of callus induction, green center formation, spontaneous doubling, and colchicine doubling are genotype dependent. Variation in callus induction ranges from 0-40%, with an average response of 10%. Green center formation ranges from 0-60%, avg. 20%. Table 1 represents the diversity found in hard red winter wheat germplasm for anther culture response. If the number of anthers required to produce one doubled haploid is 50 or less, it is feasible to use the genotype in a breeding program. Spontaneous doubling ranges from 25-65%, avg. 50%. The frequency of aneuploids is 10% or less. Table 2 shows the progeny of two genotypes which were characterized for their chromosome constitution after anther culture. Colchicine treated plants produce at least one fertile head 90% of the time. This ranges from 50-100%. The time required to produce DH 1 seed is 18-21 months in winter wheat. Vernalization is required for uniform flowering in tissue culture derived plants. We have found that 2 years may be eliminated from a breeding program using this technology.

Table 1. Response of hard red winter wheat lines to anther culture.

Line	Percent anthers forming callus	Percent callus forming green centers	Number of anthers needed to produce one DH plant
Centurk	7.7	25.7	51
B546	9.9	3.6	250
B456	6.0	18.3	91
NB88	15.3	22.9	29
B523	5.0	8.4	250
B450	11.9	35.9	23
NB68	8.1	5.0	250
B355	4.2	1.0	2500
B437	1.7	12.8	454
NB187	3.3	0.0	?
B492	9.1	28.2	33
NB211	11.9	8.8	100
NB213	1.5	5.4	1250
Mean	7.4	13.5	100

Table 2. Chromosome constitution of anther culture derived plants.

Category	# Clones		Percent	
	NB88	Centurk	NB88	Centurk
Haploid	68	64	47.6	48.4
Diploid	59	55	41.3	41.6
Aneuploid Haploid	4	0	2.8	0.0
Aneuploid Diploid	12	13	8.3	10.0
Total	143	132		

APPLICATIONS OF TISSUE CULTURE IN MUTATION BREEDING FOR WHEAT

A. C. Guenzi and R. G. Sears

The utilization of regenerable wheat tissue cultures, either diploid or haploid, represent an important new technique to mutation breeding. Tissue cultures provide several immediate advantages over other tissues, organs or organisms when treated with mutagens. Population sizes, which can be exposed and subsequently screened for mutants, are much larger. Because each mutant initially identified as a cell or cell cluster is subsequently regenerated into a plant, it is likely all such mutation events will be involved in meiosis. Selection for site specific resistance at designated metabolic pathways is more easily obtained at the cellular level. The tissue culture procedure itself is now recognized as a system which itself causes genomic instability and subsequent mutation. These advantages can be utilized to systematically select for specific mutation events for an array of current production constraints in the Great Plains.

Selection for resistance at the cellular level for specific toxin resistance has been demonstrated repeatedly in cereals (1). Toxin mediated damage for wheat diseases, such as tan spot, septoria, and insects like greenbug, may lend themselves nicely to selection in tissue cultures. Certainly, herbicide resistance, especially to effective grass herbicides, will become an important objective of tissue culture programs. In addition, selection at the cellular level for mutants with altered nutritional properties, growth regulator responses (GA, ABA, and cytokinin) are possible and being attempted. This brief report describes the use of tissue culture to select lysine overproducers in hard red winter wheat. The techniques utilized can be applied to any of the above discussed selection schemes.

In wheat seed protein, lysine is the first limiting amino acid and is present in less than one-half the amount required for proper human nutrition. The described research was initiated to select at the cellular level and regenerate plants with mutant forms of either aspartate kinase and/or dihydropicolinate synthase, the two enzymes which regulate lysine biosynthesis.

Cell cultures from the wheat selection ND7532 were initiated and maintained on a modified M.S. medium (2). One-month-old calli were transferred to media containing 0.25 mM S-2-aminoethylcystiene (AEC). AEC is a lysine analog which inhibits the activity of aspartate kinase and dihydropicolinate synthase. AEC is also incorporated into cellular proteins, presumably causing deleterious changes in protein structure or function. The selection scheme applies intense selection pressure for not only deregulation of lysine biosynthesis, but also for overproduction of lysine to dilute the cellular concentration of AEC. Sectors from calli growing on media containing 0.25 mM AEC were transferred to media containing 0.50 mM AEC (Figure 1). Selected cell lines, which remained alive in the presence of .5 mM AEC, were regenerated, grown in the greenhouse, and their progeny analyzed for lysine levels in the grain using HPLC.

Ninety selections were regenerated from AEC tolerant calli of which 41 had significantly higher lysine concentrations in R_1 seed. All have been characterized for lysine levels in R_2 and R_3 generations. The data presented below in Table 1 represents three individual hilysine selections, AEC-1, AEC-2 and AEC-3, and R_2 selections from each

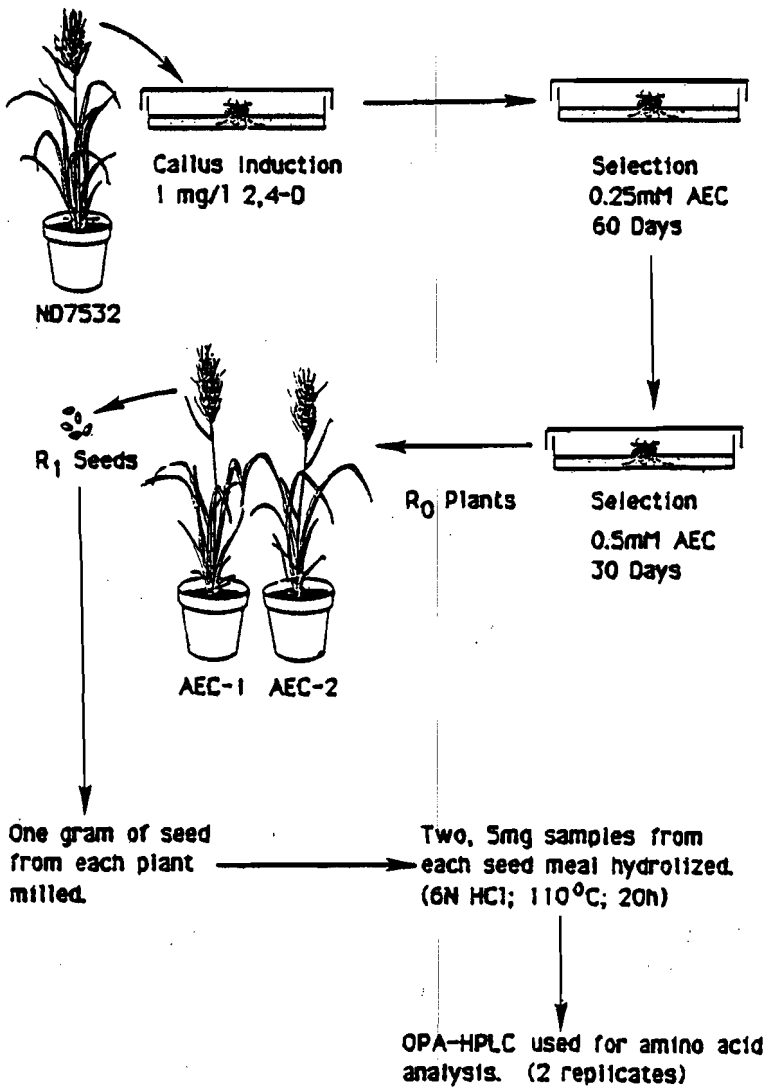

Figure 1. Schematic diagram for in vitro selection of wheat callus tolerant to AEC.

Table 1. Lysine levels of R_1 and R_2 seeds for three regenerated plants selected for tolerance to .50 mM AEC in vitro.

R1 Seed	Lysine %*	R2 Seed	Lysine%
AEC-1	2.98	AEC1-A	2.67
		AEC1-B	2.66
		AEC1-C	2.50
		AEC1-D	2.46
		AEC1-E	2.38
		AEC1-F	2.37
ND7532	2.07	ND7532	1.92
AEC-2	2.75	AEC2-A	2.61
		AEC2-B	2.60
		AEC2-C	2.47
		AEC2-D	2.45
ND7532	2.07	ND7532	1.92
AEC-3	2.74	AEC3-A	2.43
		AEC3-B	2.40
		AEC3-C	2.38
		AEC3-D	2.37
		AEC3-E	2.27
		AEC3-F	2.25
ND7532	2.07	ND7532	1.92
L.S.D (0.05)	0.15		0.20

* Lysine % = (ng lysine/ ng of total recovered amino acids) x 100

original plant selection. In every case, lysine levels were significantly higher in the R_2 seed when compared with the control ND7532. Lysine levels (% increase) over ND7532 in both R_1 and R_2 selections are comparable with a tendency to decrease for some R_2 selections. At this time, we are not sure whether the increased lysine levels represent stable mutations or transient genetic changes. Further investigations on the inheritance and field performance of these selections is being conducted.

Literature Citations

1. Gengenbach, B. G., C. E. Green, and C. M. Donovan. 1977. Inheritance of selected pathogen resistance in maize plants regenerated from cell cultures. PNAS 74:5113.

2. Sears, R. G. and E. L. Deckard. 1972. Tissue culture variability in wheat; callus induction and plant regeneration. Crop Sci. 82:546-550.

REGIONAL BUSINESS MEETING

Hard Red Winter Wheat Improvement Committee
February 27, 1986
Manhattan, Kansas

MINUTES

The meeting was called to order by Chairman Porter at 8:00 a.m. Committee members in attendance were:

R. Bruns, NAPB, CO
D. Johnston, Cargill, CO
J. A. Morgan, ARS, CO
J. S. Quick, CO
J. F. Shanahan, CO
L. E. Browder, ARS, CO
S. Cox, ARS, KS
J. H. Hatchett, KS
C. Hayward, Pioneer, KS
T. J. Martin, KS
G. M. Paulsen, KS
R. G. Sears, KS
K. D. Wilhelmi, Rohm & Haas, KS
A. L. Diehl, Rohm & Haas, NE
V. A. Johnson, ARS, NE
*S. L. Kuhr, ARS, NE
P. J. Mattern, NE
*C. J. Peterson, ARS, NE
R. E. Finkner, NM
D. J. Cox, ND
O. G. Merkle, ARS, OK
E. E. Sebesta, ARS, OK
J. L. Gellner, SD
D. S. Marshall, TX
H. Nguyen, TX
K. B. Porter, TX
N. A. Tuleen, TX
W. D. Worrall, TX

*New members

Committee members not present:

J. W. Echols, CO
J. P. Hill, CO
R. E. Atkins, IA
J. R. Erikson, Hybritech, KS
B. S. Gill, KS
W. J. Hoover, KS
D. Seifers, KS
A. L. Scharen, MT
E. L. Sharp, MT
V. R. Stewart, MT
G. A. Taylor, MT
M. K. Brakke, ARS, NE
M. R. Morris, NE
J. E. Watkins, NE
L. I. Croy, OK
F. J. Gough, ARS, OK
E. L. Smith, OK
B. B. Tucker, OK
E. C. Gilmore, TX
J. Michels, TX
R. W. Toler, TX
B. J. Kolp, WY

Members voted to approve minutes of last meeting held at Las Cruces, NM on February 8-10, 1983 and dispense with reading of the minutes. The minutes are printed in the Proceedings of the Sixteenth Hard Red Winter Wheat Workers Conference, February 8-10, Las Cruces, NM.

V. A. Johnson, Secretary of the Hard Red Winter Wheat Improvement Committee, indicated his intention to retire from ARS in June, 1986. C. J. Peterson will assume responsibilities for coordination of the Regional Nursery program. A motion was passed appointing C. J. Peterson as new Secretary of the Committee and as a representative of the Committee on the National Wheat Improvement Committee.

R. G. Sears was elected Chairman of the Hard Red Winter Wheat Improvement Committee. W. D. Worrall and J. S. Quick were elected Representatives to the National Wheat Improvement Committee. They, together with the Chairman and Secretary, will represent the Hard Red Winter Wheat Region on the National Committee.

Regional Nurseries

SRPN -- Maximum number of entries (45) and check varieties Kharkof, Scout 66, and TAM 105 to remain the same.

NRPN -- Motions to replace the check variety Warrior with Roughrider and retain Colt as a check were passed. Kharkof will remain as the third check variety. Motion to reduce the maximum number of nursery entries to 30 was defeated. Maximum number of entries will remain 45.

UWHN -- (Southern and Northern Sections) -- Check varieties will remain and maximum number of entries for each section will remain at 300. Warrior, Scout 66, and Vona are currently used as checks in the Southern Section and Warrior, Centurk 78, and Norstar in the Northern Section.

Soilborne Mosaic Nursery -- Check varieties Pawnee, Bison, and Concho will remain and maximum entries remain at 200.

Cooperating states and companies are not limited to a specified maximum number of entries in the SRPN or NRPN; rather they are instructed to prioritize candidate entries to provide guidance to the regional coordinator in the event that the total number of candidate varieties exceeds the 45 entry limit.

Seed Requirements for Regional Nurseries: (seed must be untreated)

Currently: 15 lb/new entry in SRPN
11 lb/new entry in NRPN
100 g/entry for Northern or Southern Sections of UWHN
80 g/entry for Soilborne Mosaic Nursery

A conference paper by T. S. Cox and W. D. Worrall showed considerable variation and genetic drift in samples of Kharkof used by cooperators as a check in SRPN and NRPN test sites. A motion was passed to reconstitute Kharkof from sources having similar characteristics, increase the reconstituted Kharkof at Lincoln, NE, and distribute seed of Kharkof and other check varieties along with seed of new entries each year from Lincoln.

Regional Reports: Current format is to be retained.

Submission of Data:

The Regional Coordinator will pursue possibilities and develop formats for optional electronic transmission of Regional Nursery data from cooperators to Lincoln, NE. Submission of hard copy data will continue for the next couple years during development and testing of communication and transmission protocols.

Site of Next Wheat Breeders Field Day:

An invitation from K. B. Porter to hold the 1986 Wheat Breeders Field Day at Bushland, TX, sometime after June 1 was accepted.

Site of Next Regional Conference:

A motion was passed instructing Chairman Sears to contact persons in states that logically could host the 1989 Regional Conference and contact Chairmen of other regions to determine interests in holding an Interregional Conference in 1989. An invitation to hold the next meeting at Dallas, TX was tentatively accepted pending outcome of discussions. Recommendations by Tom Roberts to hold a joint meeting with the Wheat Quality Council, and Virgil Smail to hold a joint meeting with the Wheat Foundation and National Association of Wheat Growers will be considered.

Regional Population Improvement Program

O. G. Merkle reported that seed of the Elite and Broad Base Regional Random Mating Populations will be released to public and private breeders in August, 1986, following the third cycle of random mating this summer. After considerable discussion concerning future management of the populations, a motion was passed instructing Chairman Sears to reconstitute the Population Improvement Committee. The committee is to recommend options for future management of the populations and options for a regional approach to selection and reconstitution of the populations through a second cycle of random mating with objectives to increase favorable gene frequencies. The Committee is to discuss with private companies the possibilities for further cooperation with gametocide applications and will report on recommendations at the 1986 Breeders Field Day.

C. J. Peterson
Secretary

Resolutions

The following five resolutions were unanimously adopted:

No. 1. WHEREAS, the FGIS is currently having difficulty in the identification of some HRS and HRS varieties due to their out of class kernel characteristics; and

WHEREAS, HRW and HRS wheat have essentially the same end use properties; and

WHEREAS, mixtures of HRW and HRS wheat are no less in value than HRW wheat alone; and

WHEREAS, the grading of HRW and HRS wheat mixtures by FGIS as mixed wheat, currently results in unjustifiable and unacceptable economic losses to wheat producers;

BE IT THEREFORE RESOLVED that the HRWWIC strongly urges that the use of mixed wheat grades be discontinued for mixtures of HRW and HRS wheat.

BE IT FURTHER RESOLVED that the HRWWIC recommends that any mixture of HRW and HRS wheat which would be graded mixed wheat under present standards, be graded HRW. The HRWWIC recommends this as an interim solution of significant value to the entire industry.

No. 2. WHEREAS, the HRWWIC recognizes the need for long-term solutions of grading problems; and

WHEREAS, the HRWWIC believes there is a need for improved grading methodology that can be standardized and implemented; and

WHEREAS, there is a strong willingness on the part of the HRWWIC to adopt a long-term solution to grading problems;

BE IT THEREFORE RESOLVED that the HRWWIC recommends a simple classification system based on objective tests for kernel color, hardness, and protein content as applicable. Color separates white from red wheat, hardness will separate from soft wheat, and protein content will allow for quality improvement and recognize certain quality markets.

BE IT FURTHER RESOLVED that the HRWWIC favors the development of a hard red wheat class to replace the current hard red winter and hard red spring class.

BE IT FURTHER RESOLVED that the HRWWIC recommends, as a temporary solution, that existing wheat hardness tests be used in conjunction with current grading practices as a means to facilitate the differentiation of classes of wheat.

No. 3. WHEREAS, the Wheat Quality Council has reported a concern on behalf of the domestic flour millers and bakers that loaf grain and texture characteristics of the past several crops have been marginal,

BE IT THEREFORE RESOLVED that the HRWWIC recognizes the need for continued improvements in all quality aspects, especially loaf grain and texture.

No. 4. WHEREAS, the HRWWIC recognizes the long and distinguished contributions by Dr. Virgil Johnson to wheat and wheat improvement on regional, national, and international levels; and

WHEREAS, Dr. Virgil Johnson has aided wheat researchers, and the wheat industry by his able guidance and leadership; and

WHEREAS,Dr. Virgil Johnson's contributions and coordinating of USDA regional series has led to a greater understanding of wheat improvement;

BE IT THEREFORE RESOLVED that the HRWWIC unanimously recognizes and commends the efforts of Dr. Virgil Johnson and all aspects of his contributions to wheat improvement.

No. 5. WHEREAS, the 17th Hard Red Winter Wheat Workers Conference has been an informative and enjoyable meeting and has been conducted in an efficient manner;

BE IT THEREFORE RESOLVED that the Hard Red Winter Wheat Workers express their appreciation to Dr. Walter Woods, Dean of the College of Agriculture, Kansas State University, and to Dr. George Ham, Head, Department of Agronomy, Kansas State University, for serving as hosts in this conference; to Dr. Rollin Sears for directing the local arrangements committee; and to Dr. Jim Quick and the program committee for developing an interesting and informative program for this conference.

BE IT FURTHER RESOLVED, that the Hard Red Winter Wheat Workers commend Dr. Kenneth Porter and express their appreciation to him for his able leadership during the past three years.