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PROCEEDINGS....

TENTH HARD RED WINTER WHEAT WORKERS CONFERENCE

COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO
FEBRUARY 8-10, 1965

ADMINISTRATIVE, FOR STAFF USE
** -- **

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Crops Research Division
and
Agricultural Experiment Stations, Cooperating
in the
Hard Red Winter Wheat Region

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TENTH HARD RED WINTER WHEAT WORKERS CONFERENCE

Colorado State University Student Center
Colorado State University
Ft. Collins, Colorado
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Report not for publication[1/]

Agronomy Department
Agricultural Experiment Station
Lincoln, Nebraska
June 21, 1965

1/ This is a conference report of cooperative investigations containing data, the interpretation of which may be modified with additional experimentation. Therefore, publication, display, or distribution of data or any statements herein should not be made without prior written approval of the Crops Research Division, ARS, USDA, and the cooperating agency or agencies concerned.

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FOREWORD

The Tenth Hard Red Winter Wheat Workers Conference was held at the Colorado State University Student Center, Fort Collins, Colorado, February 8-10, 1965. The conference, sponsored by the Hard Red Winter Wheat Improvement Committee, was attended by 68 state and federal workers from 15 states.

Abstracts or full texts of presentations are contained in this report. The many ideas and comments expressed during discussion periods are not included so the report of the conference is not a complete one.

The Hard Red Winter Wheat Improvement Committee met in a $\frac{1}{2}$ day session on the morning of February 8 prior to the conference opening. A. M. Schlehuber was re-elected chairman of the committee. The National Wheat Improvement Committee, composed of representatives of the four wheat regions and the USDA Wheat Investigations Leader, also met during the conference.

Appreciation is expressed to E. G. Heyne, B. C. Curtis, K. F. Finney, and H. C. Young, Jr. for organization of this successful and stimulating workers conference. A word of thanks also is expressed to A. M. Schlehuber, Chairman of the Hard Red Winter Wheat Regional Committee for his continued enthusiastic leadership and many contributions to the regional program.

V. A. Johnson
Regional Wheat Improvement Leader

TENTH

HARD RED WINTER WHEAT WORKERS CONFERENCE

Ft. Collins, Colorado

February 8-10, 1965

Program

Afternoon, February 8
Chairman - A. M. Schlehuber
General Session

Morning, February 9
Chairman - P. J. Mattern
Quality of Hard Red Winter Wheats

Afternoon, February 9
Chairman - E. D. Hansing
Disease Problems in the Hard Red Winter Wheat Region

Morning, February 10
Chairman - K. B. Porter
Hybrid Wheat Research

* Report submitted for inclusion in the Conference Proceedings but not presented at the conference.

Afternoon, February 10
Chairman - V. A. Johnson
General Topics

POPULATION IN RELATION TO FOOD SUPPLY[1/]

Warren H. Leonard

INTRODUCTION

Farmers, agronomists, and all other agriculturists will soon be confronted with the greatest challenge that civilized man will ever have to face. The problem will be to provide food for a world population that continues to grow at an accelerated rate. Civilized man now depends almost entirely on agriculture for his food supply. Hunger is the No. 1 world problem in the years ahead. Unless population is controlled, starvation will take over as a partial solution of the problem (Brown, 1963).

In the next 35 years (2,000 A.D.), the Free World may breed itself into Communism, or the Communist World may breed itself out of Communism. Agriculture is the key. The side that eats longer will have the more practical social system. That side may set the social pattern for the rest of the world. The entire Communist world is now in a deficit food position.

FAMINE CONDITIONS

Food shortages during or after World War II caused famines or threats of famine that shocked many Americans.

East Bengal Famine

About 2 million people of India starved to death in East Bengal in 1943. When the Japanese Army threatened to invade East Bengal during World War II, the merchants sold most of the rice or other cereals out of the Province to avoid confiscation. When responsible British officials learned of the food shortage, it was too late to import food before famine occurred. One observer was George McKelvie who was in East Bengal at the time building airfields as well as other war projects. He states: "While the famine raged, I employed (and fed) more than 100,000 laborers (and their dependents) on war works in Bengal alone." Before World War II, he also wrote the Central Provinces Scarcity Manual for the Government of India on famine relief.

Threat of Famine in Occupied Japan

A typhoon hit southern Japan on September 19, 1945, just after the American Occupation began. It destroyed 25 percent of the rice crop. An early estimate indicated that 5-10 million Japanese people might

1/ Instigated by "Why Hunger is to be the World's No. 1 Problem," U. S. News and World Report, January 6, 1964, pages 28-31 (inclusive).

starve to death unless 2,600,000 metric tons of food (rice equivalents) were imported before June 30, 1946. Famine was averted by the Occupation through food imports, although some people without ration cards did die of starvation.

China Famine

An estimated 5 to 7 million Chinese people starved to death during the spring of 1946. Starvation occurred in Honan, Hunan, Kwangsi, Kwantung, and Hopeh provinces. A U. S. Food Mission was sent to China to observe famine conditions. One pertinent paragraph of the report 2/ on Kwangsi Province follows:

> "Famine kills slowly. The famine is not to be discovered in emaciated people dying in the streets. Most districts do not report in their vital statistics 'so many persons died from hunger.' Living on unnatural foods lets the life ebb out slowly, reveals itself in lack of energy, and in other diseases. A village population disappears; the village is uninhabited. They have died! Yet they are not reported as having died of hunger. There are no specific figures, but there have been reports of deaths and of suicides and of the abandonment of children, from all over the Province. After a month and a half to two months of improper eating the people die of disease. The next few weeks will bring that critical time limit to most of the two million now in need, and we are entering the time of the year when the pestilences come, with cholera already reported from many places in the South".

TRENDS IN WORLD POPULATION

World population started its run-away course about 1650 A.D., when modern science destroyed the equilibrium between births and deaths.

Malthusian Doctrine

The problem of sufficient food for a population that continues to increase in a world of limited land area was raised by Thomas R. Malthus in 1798. He argued that man could increase his subsistence only in arithmetic progression, whereas, his numbers tended to increase in geometric progression, i.e., by the compound-interest law. Acre yields might be doubled once or even twice, but there is a limit beyond which increases are impossible. Malthus asserted that the history of mankind demonstrated that population always tends toward the limit set by subsistence. The population is contained within that limit by the operation of checks such as war, famine, pestilence, and premature mortality (Malthus, 1798). The Malthusian doctrine is now operative in some over-populated countries in East Asia.

2/ Copy of U.S. Food Mission to China report dated May 19, 1946, furnished by Dr. David H. Bau, Center for Chinese Studies, U. of Michigan, 319 Braun Court, Ann Arbor, Michigan.

Population Growth

There is considerable guesswork in early world population estimates. Man was a relatively rare creature 500 million years ago. The human population at the beginning of the Christian era has been estimated as about 250 million people (Cook, 1962). The aggregate world population reached 500 million about 1650 A.D., or double the population at the start of the Christian Era. It doubled again to 1,000 million in 200 years, or by 1850. The United Nations estimate of the world population 100 years later in 1950 was 2,406 million people (Bennett, 1954). The population in late 1964 reached 3,300 million people.

Modern population trends stem from the 17th century, the period when the foundations of modern science were established, i.e., the Rennaissance. Until 1650 A.D., the rate of world population increase was very slow. Man often faced a precarious existence, because the number of births only slightly exceeded the number of deaths. In no half century prior to 1650 A.D. did the population increase by more than 10 percent. After that date, there was an upsurge at an accelerated rate because man has drastically altered the balance between births and deaths. The world population more than quadrupled during the 300 years from 1650 to 1950 A.D. It increased by 20 percent during the 1950's or by 500 million people, the estimated world population in 1650 A.D. Population of the United States has also contributed to this growth, with a particularly rapid rate of increase in recent years. The population of this country reached 190 million people during 1963 (Cook, 1962, 1963). With the accelerated rates of growth now apparent, it is easy to understand the alarm of many contemporary Malthusians (Bennett, 1954).

The net excess of births over deaths determines the speed at which world population grows. Birth rates in the world as a whole have pressed toward 40 to 50 per thousand population (4-5 percent) per year. High birth rates have prevailed until recently. There is credible evidence of a decline in birth rate only since 1800 A.D. in a few industrialized countries--all Europe, Soviet Russia, United States, Canada, temperate South America, Japan, and Australia, (Cook, 1962). High birth rates are now typical in under-developed countries of the world (Bennett, 1954). The world growth rate from 1950 to 1961 averaged 1.8 percent per year. The average world birth rate is now 36 per 1,000 population per year, whereas the death rate is only 18 (Cook, 1963).

High annual death rates appear to explain the slow population growth prior to 1650 A.D. Mortality was high among infants, children, and youths. These deaths were caused by disease, infanticide, famine, and wars. In early times, 6 to 8 children per woman were necessary to maintain human numbers. Advances in knowledge of medicine as well as in sanitation have contributed to markedly lower death rates since 1650 A.D., particularly during the past 100 years. Today in the industrial countries of the West, only a fraction over 2 children per woman (2.27) are required to maintain a stable population (Cook, 1962).

Future Population Problem

Population problems in the world, as well as in the United States, between now and 2,000 A.D. are ominous. The median estimate of the United Nations predicts a world population of 6,280 million people for the year 2,000 A.D., or about 3,000 million more than in 1964 (Cook, 1959a, 1962). This estimate is based on current high birth rates with a concurrent decline in death rates. The population of the United States will probably reach 350 million people by 2,000 A.D., or 35 years from now (Cook, 1959a).

Continued population growth at this rate would soon blanket the surface of the earth. The ancient reproductive pattern was based on a life expectancy of 25 to 28 years. This expectancy has been greatly modified by modern medicine together with scientific public health control (Cook, 1962). For example, since the introduction of such practices, Japan has approximately doubled the span of life expectancy to about 60 years. The combination of a low death rate, with a constantly high birth rate, cannot long co-exist. The birth rate either must be reduced to approximate the death rate, or the population will be reduced to the available food supply by the ancient population adjusters. These adjusters are now in operation in many parts of the world, as in India, where half the children die before they reach the age of 13.

It is paradoxical that the application of modern medicine, together with sanitation, has lowered death rates in under-developed areas but has failed to lower birth rates. The Point Four Program for increased food production in over-populated areas has been offset to a considerable extent by the concurrent spread of modern medicine in such areas. Consequently, the food population balance has been upset in these densely-populated areas. This is true in many countries in Asia, Africa, and South America. The birth rate in such countries may create social conditions conducive to the spread of Communism, unless drastic measures are taken to curb the population increase.

WORLD FOOD NEEDS

Part of the world population is under-nourished, quantitatively as well as qualitatively. The FAO scale of calorie requirements provides a basis on which hunger or malnutrition can be appraised. The "reference" man is assumed to require an average of 3200 calories per day, while the reference woman would need 2300 calories, or an adult average of 2750 calories per day. An FAO study revealed that one-third to one-half of the world population, that is, between 1,000 and 1,500 million people, still suffer from hunger or malnutrition or both. Undernutrition refers to hunger, whereas malnutrition refers to the quality of the diet. Probably 300 to 500 million people in the Far East suffer from hunger. Group I, or under-developed countries, were found to average 2150 calories per head per day. Group II, or developed countries, averaged 3050 calories per head per day (Anonymous, 1962).

Cereal grains are a suitable common denominator for food production, consumption, and trade. On a calorie basis, cereals account for 53 percent of human food by direct consumption. Probably another 20 percent of human food comes indirectly from cereals in the form of meat, dairy products, and eggs. For instance, North America produces about 2500 pounds of cereal grain per person per year, whereas Asia produces only about 450 pounds. The difference is between an economy that can afford to convert most of its grain output into livestock products in comparison with one where direct human consumption requires nearly all the grain produced (Brown, 1963).

An estimate was made on the amount of food supplies needed for the world population in order to close the hunger gap as well as to reduce substantially the number of malnourished people. In the Far East the total supply of cereals would have to be more than doubled by 2,000 A.D., whereas the supply of animal products would have to be increased to six times their present quantity for adequate nutrition. For the world as a whole, food supplies will need to be doubled by 1980 A.D., but tripled by the turn of the century (Anonymous, 1962).

WORLD FOOD SUPPLIES

The available world food supply in 1956 was estimated at 800 million tons (Cook, 1959b). World food supplies can be increased by higher production on present agricultural land, or the reclamation of new land for food production. Aside from conventional agricultural means, food supplies also may be increased by the synthesis of foods as well as by the culture of certain lower plant forms such as yeast or chlorella.

Increased Acre Yields on Present Land

Since 1950, about 80 percent of the increase in world food production has come from higher yields on present agricultural land. This result was achieved by improved agricultural technology plus capital. One of the preconditions for increased acre yields is literacy of the rural population. Yield increases may be obtained by improved varieties, fertilizers, irrigation, drainage, pesticides, more effective farm implements, multiple cropping, and improved cultural practices.

World Utilization of Agricultural Land

Roughly, about 11 percent of the total world land area of 33,422 million acres is now cultivated. Recent FAO estimates indicate that 3,458 million acres of this land are now arable, fallow, or in orchards. About two-thirds of this total--somewhat less than 2,223 million acres--are actually devoted to major crops. The balance of the cultivated acreage is in temporary pastures, fallow, or minor crops. Another 6,422 million acres, or 19 percent of the total, is used for grazing. The remainder of the land, or about 70 percent of the total, now produces little or no food (Cook, 1962).

The cultivated area of the world has increased significantly since the end of World War II. There was an increase of 198 million acres in land under major crops between 1948-52 and 1958. However, in some countries the area of cultivated land is on the decrease. It is being taken for a variety of uses other than for the production of food, e.g., cities, airports, roads, military grounds, industrial plants, and for numerous other needs. The United States now loses agricultural land to other uses at the rate of 4,000 acres per day. It is paradoxical that for such purposes, first-class agricultural land is generally selected. Other farm lands throughout the world continue to be abandoned due to improper irrigation, water erosion, and soil blowing. The total amount of land taken out of food production each year due to poor husbandry practices is appreciable. Loss of good agricultural land usually has been more than offset by new land brought under cultivation, but it is generally less productive than the land that was lost.

Possibilities to bring new land into cultivation for the production of additional food was explored by Salter (1947). About 50 percent of the total world land area consists of snow, ice, tundra, mountains, and deserts with no agricultural value. The other 50 percent of the land area is occupied by world soil groups that are used in agriculture (Chernozem, Chestnut, Gray Forest, Podzol, and Red soils). These soils may offer possibilities for agricultural expansion. Many of them are unsuitable for cultivation because they are too sandy, too stony, too salty, too hilly, or too wet. Based on modern agricultural technology, Kellogg (1964) now estimates the potential arable land in the world as about 6,589 million acres. This includes the 3,458 million acres of arable land currently in use. It involves large areas of present grazing lands as well as tropical forest lands on red soils in South America, Africa, and elsewhere. Improved ground transport would be necessary for effective utilization of these lands for cultivation, i.e., harbors, navigable streams, railroads, and truck routes. Reclamation would call for heavy capital outlays. Most of these soils would need heavy fertilization to maintain continued crop productivity. In many cases, this land would also have to be drained, irrigated, leveled, or terraced.

World Food Production

Late in 1945, the Food and Agriculture Organization (FAO) of the United Nations was formed to make "freedom from want" a world-wide reality. As a result of the first FAO World Food Survey in 1946, it was reported that there had been a noticeable deterioration in food production since the pre-World War II period of 1934-38. A crash program was initiated to increase food production in countries where food supplies were inadequate.

Despite the FAO program, a second world food survey published in 1952 indicated that food production only overtook the increase in population five years after World War II was over. Although food production was increased materially during this period, the average food supply per person over large areas of the world was still lower than before the war (1934-38). It was estimated that a well-balanced increase of one to two percent per annum in world production of basic food in excess of population growth is the minimum necessary to achieve some improvement in nutritional standards. World food production in 1954 was about 20 percent greater than in 1934-38. The increase in food production has slightly outweighed the growth in population since before World War II. The tenuous success of this all-out effort to increase world food production largely is due to the intensive work of FAO, Point Four, Columbo Plan, and other organizations (Leonard, 1957).

It was reported in 1963 that only 2 regions of the world will have sizeable food surpluses in the future: North America (Canada-United States) and Australia-New Zealand. Since World War II, Latin America has been changed from an export to an import continent on cereal grains. North America now exports 39 million tons of grain per year, or 86 percent of the world total grain exports. Canadian wheat stopped famine in Red China in 1959, 1960, and 1961. The United States is now the only major cereal grain export country that holds contingency stocks of any significance. It is the only country to which the world can now turn in the event of a serious food crisis. More hunger is ahead.

With all potential land resources utilized, population growth after 1980 would be possible only by a reduction in the per capita consumption of milk and meat, with more and more of the diet obtained from cereals, starchy roots, sugar, and vegetable oils. Even with such a vegetable diet, conventional agriculture may reach its limit in the production of food within 75 years at the present rate of population growth.

Civilized nations depend on agriculture for food production. The challenge to agriculture to supply future world food needs should be obvious.

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A WHEAT PILGRIMS' PROGRESS

L. P. Reitz

A pilgrim is a traveler; he may journey far, often in strange lands, to reach some goal, or to visit a shrine, revered because of associations, as a devotee. You and I, here today, are wheat pilgrims and, each in his own way, and at various times, responds and progresses on his pilgrimage.

I wish to consider 4 aspects of my chosen topic:

(1) The Colorado "shrine".

(2) The pilgrims who have finished the journey.

(3) Some philosophical obstacles (an allegory).

(4) Some biological obstacles.

Professor A. E. Blount carried on the first wheat tests at the Ft. Collins station. This was in 1879. Through pedigree selection and by hybridization he applied his principle of "selecting the best to cross on the best to get a better offspring". He selected "Regenerated Defiance" and this was grown in Colorado; "Gypsum", another of his selections, was grown in Idaho. Not many of his hybrids were used in this country, but Wm. Farrer obtained many of his seed stocks and developed selections for use in Australia including "Blount's Fife", "Blount's Lambrigg", "Blount's Improved Fife" and "Blount's Hornblende". These entered pedigrees of the well-known varieties "Bobs", "Thew", "Hussar", "Florence", and some 30 lesser known varieties.

F. Knorr, W. H. Olin and A. H. Danielson kept the records on many varieties of wheat tested prior to 1909. Then until 1920, Alvin Kezer, D. W. Frear and B. Boyack did the work. This brings us to the modern period under D. W. Robertson and the current staff.

Chemist W. P. Headden and associates exploded the notions that Colorado wheat was poor for bread-making, that hard wheat deteriorated into soft wheat when grown under Colorado conditions, and that yellow-berry was due to over-ripeness, exposure, or fungi. Following these studies he helped establish a sound fertilizer program.

The proper irrigation practices for wheat were developed by Robertson, et al.

Dry land rotation and tillage practices were developed early by F. A. Coffman, J. F. Brandon and associates at Akron and other points in the State. These experiments, the adoption of Turkey wheat and more modern varieties as they came along, and related research, established Colorado as a great wheat state.

Wheat storage experiments initiated at Ft. Collins in 1921 are classic. The results of the last samplings are now being milled for baking trials.

High altitude cake baking problems were solved here by Miss M. W. Peterson (1930) and our own M. A. Barmore (1935).

These men, pilgrims themselves, make the pilgrimage to Colorado significant for us. We can catch from them the glow of discovery and pursuit of knowledge that constitutes the primary rewards to a scientist.

The list of former pilgrims in wheat research glitters with names of greatness: W. J. Spillman, M. A. Carleton, E. F. Gaines, J. H. Parker, B. B. Bayles, C. O. Swanson, J. G. Dickson, J. J. Christensen, M. A. McCall, T. A. Kiesselbach, and many more. We revere their memory and are proud to continue in their tradition.

Pilgrims in science travel a road fraught with danger and uncertainty. Not mortal danger, but danger that comes from dissipating or scattering our energy in profitless endeavor. We wish it were possible to assure that the path would lead to productiveness. Only onerous study, self evaluation, purging out biases, careful planning, etc., and some luck, can do this. Socrates is credited with the statement that "he is not only idle who does nothing; but he is idle who might be better employed". We are also obliged to do something unique and not merely duplicate discoveries already made.

Last August 28, Science carried an article by H. A. Wilmer, professor of psychiatry, Stanford. His "Odyssey of a Psycho Therapist" (i.e. the travels or wanderings of a scientist) punches some points home in a satyrical way, and I call it to your attention for study and reflection.

Three years ago I talked to this group at Lincoln. I pointed out some areas in which we have made progress and some that were neglected. What is the situation today? Let's look at three of them.

Yield levels--National acre yields continue to be high. The average increase is about 10 or 11 bushels per harvested acre since the turn of the century. Breeding of better varieties accounts for about 1/3 of this. I don't know the limit. Many new varieties have broken all previous high yield records and hybrid wheat surely could push them still higher. I am glad to see that a few people are still trying to establish an ideal plant type that would maximize the factors for yield. Mostly, the studies that I have seen, however, are "post mortem" studies about the varieties that did well; they lack predictiveness.

Losses--Our record continues to be unsatisfactory and rather embarrassing. Acreage abandonment from diverse causes is excessive. Drought damage and winter loss are easily the worst although diseases and insects have taken their toll during the last 3 years. Three years ago I told winter wheat workers they were 20 years behind on breeding stem rust resistant varieties. You have released some fine wheats to help with this job, but you are still far behind. The International Rust Nursery reflects the progress in the rust work. Only 16% of the winter wheat entries (1963 IRN) had resistance to leaf and stem rust compared to 29% of the spring wheat entries.

You geneticists, entomologists, physiologists, soils men and pathologists (may as well have everybody mad at me). Don't think I am talking only to breeders. You are in this too. Have you found any new mechanisms of disease or insect control? Have you come up with any new genes lately? Where are those new forms you promised from induced mutations? How come hessian fly caused as much damage a year ago in large regions as had ever before been recorded? What have you done to ensure against loss of stand and injury from drought? Have you learned how to save an inch of rain for the crop or how to increase protein level profitably?

I know you are working on these problems. They are tough. Some, in the ultimate degree, are unsolvable. While here, I hope to hear about progress and better procedure on all of these problems.

Quality--Our quality levels are really quite good in spite of the fact that quality is so poorly understood. In all honesty, the chemistry of quality is a very "soft" area. Liza made it across the river on blocks of ice; by comparison, she had good footing for we are still trying to cross on "ice cubes". Is it true that the proteins are basically the same in all our wheats and that the differences we try to follow are induced by factors completely outside the protein? If this is not so, then it is high time we had protein chemistry in sufficient depth to untangle the mystery.

Actually, I'm not discouraged by the progress you and others like you are making. I'm impatient, mainly.

Other research areas to emphasize:

1. Soil adaptation factors--recent work at Beltsville shows that roots of some genotypes alter soil pH. Is this a general phenomenon, and do roots alter other properties in the rhizophere?

2. Interference phenomena--recent work in Kentucky shows that increased resistance to mildew in red clover was accompanied with virus infection. Kansas results some years ago showed that infection by leaf rust in wheat was reduced by prior inoculation with crown rust. Virus blocking phenomena have been known a long time. Mostly these aren't very useful, but could they be made to be?

3. Are pesticides a 2-edged sword as the Montana and Nebraska work indicates? At Beltsville, DDT has been shown to kill some genotypes of barley and injure wheat. Maybe this principle can be utilized to produce hybrid seed more efficiently. Certainly, chemical residues do, in some cases, become a part of the environment to which varieties are responsive.

4. Mutations--we need a higher content of certain amino acids in wheat flour. Can we find a mutant gene for high lysine in standard stocks or from mutations in wheat? They did in corn (see Science 145:279). I would rather invest future funds in this kind of mutation work rather than duplicate the genes nature has already given us in abundance. How would you screen a population for such a trait? In another corn test, they used angoumois moth to skew populations for amylose content.

5. Population genetics--it is rather vague to me what most people are talking about when they use this term. There appear to be a great many parallel thoughts covered by it. I assume we mean a study of the genetics of the mass in contrast to a study of the genetics of the individual. Only a few workers have earnestly tried to do anything with wheat. Male sterile stocks will aid in population management.

6. Heterosis--we are beginning to get some information on gene action in heterosis in wheat. Do you have experiments planned to determine how the genes are related to this phenomenon? Are we dealing with simple dominance or is overdominance involved?

7. Field worthiness--not only are more efficient metabolic activity, vigor, health, and quality sought, but an intangible factor of field worthiness is desired in our varieties. This may include good appearance, standability, shatter and hail resistance as well as resistance to subtle maladies not yet diagnosed.

I think we have a lot of work to do, the pilgrimage is not ended, nor the crusade finished!

THE SOUTHERN, CENTRAL, AND NORTHERN UNIFORM QUALITY SERIES TESTS

Karl F. Finney

Mr. Chairman and coworkers. I am particularly interested in talking with you briefly about the Southern, Central, and Northern Uniform Quality Series individuals because of their usefulness in obtaining extremely important quality data not obtainable on composite samples.

For overall and average milling and baking quality evaluation of a variety relative to others of known quality, the Southern and Northern Regional Performance Nursery composites are highly suitable.

If the Southern and Northern Regional Performance Nursery composites were our only sources of material, however, a number of questions would go unanswered. Thus, the Central, Southern, and Northern Uniform Quality Series individual samples are ideal materials for answering the following important and related questions:

1. What is the effect of location environment on physical and baking properties of new wheat varieties compared to those in commercial production?

   In these studies we and others have found that certain varieties, especially those with medium-long to long mix times, often are better than those with short mix times.

2. What are the most important environmental factors, and when, to what extent, and why do they effect quality characteristics? High temperatures and low relative humidities are important factors that usually impair one or more baking properties. But to evaluate the effect of high temperatures and low humidities, we must know both heading and ripening dates.

3. Why do man-made environmental factors such as irrigation impair quality characteristics of wheat varieties grown at one location and not at another, or impair varieties grown at a given location one year and not another?

Irrigated samples have headed at the same time one year and in another year several days later than dryland samples. When heading at a later date, the developing and ripening period of irrigated wheats was as much as 12 days longer than that for wheats grown on dryland.

Data obtained at Manhattan, Kansas have suggested that after wheat has attained physiological maturity (about 2 weeks before combine ripe), it is feasible that if temperatures are not high enough to effect at least slow maturing or drying out, certain biological components of the system, such as proteases, are not apt to remain static, but instead may reverse their normal function and affect protein degradation. Certain irrigated samples appear to have undergone degradation by some such process as evidenced by mixing times, and in certain instances loaf volumes, that were materially less than those of dryland samples harvested the same year at the same location.

Irrigated wheat grown at Bushland, Texas in 1962 had an average fruiting period of 12 days longer and had mixing times that were much shorter than dryland samples. Irrigated wheats harvested at Clovis, New Mexico in 1962 also had a long fruiting period (48 days) and had mixing times that were much shorter than those for dryland samples. In contrast, irrigated wheats harvested at Goodwell in 1958 and Bushland in 1959 had fruiting periods that were not much longer than those for dryland samples, and had mixing times that were equal to or longer than those of dryland wheats.

During the past 6 years, 20 dryland vs. irrigated comparisons have been made. In 10 instances, dryland samples were superior to irrigated samples. In the other 10 tests, irrigated samples were equal to or superior to dryland samples.

We have only a meager amount of data on the importance of length of fruiting period because in only a few instances do we know the fruiting periods of both dryland and irrigated samples. Data available, however, appear to justify following the clue to a satisfactory conclusion. We need your help in supplying "headed" and "ripe" dates for irrigated as well as dryland samples.

PILOT-SCALE TESTING OF MILLING AND BAKING QUALITIES OF WHEAT

John A. Johnson

The development of new improved wheat varieties is vested with state and national governmental agencies--a prudent arrangement because interests of all segments of society are best served by this approach. The success of the total program of research and development of new and better Hard Red Winter varieties is attested to by the industry flourishing in the Great Plains during the past 60 years. The success has been due, in large measure, to the development of superior strains of wheat which have withstood the ravages of drouth, insects, diseases and have had superior yield potential. It is due also to the development of new wheat varieties that find a ready acceptance and demand in the market place. This paper discusses some of the evolution in methods of quality testing with particular reference to pilot-scale procedures.

Wheat enjoys a unique place in man's diet. Wheat is grown over the widest geographical area of all cereals. It is a concentrated, energy food contributing to the human diet significant amounts of protein, minerals and vitamins. It can be safely stored, transported and converted to products of wide acceptance. Notwithstanding those properties, the unique position of wheat must be attributed mainly to its properties for production of the basic food, bread. Since, by nature, wheat varieties of different genetic ancestry vary greatly with respect to properties for this purpose, testing for quality is important to insure acceptance in the market place.

<u>Milling and Baking Quality a Summation of Many Factors.</u> There are many factors that influence the quality of wheat from the utilization viewpoint. Over the years, many methods have been evolved to measure these factors. Test weight, weight of a 1000 kernels, pearling index, sizing test, flour yield, protein content, ash content, acidulated viscosity, sedimentation value, maltose or gassing power, vitamin content, rheological dough properties, and bread quality determined on small quantities of wheat or flour have all contributed to the development of superior wheat quality. The various tests are intended to measure some characteristic that has significance to the consumer whether it be the miller, the baker or the housewife. For the most part, the tests must be used on small amounts of material. Such small-scale tests have been successful and will necessarily continue to be the main basis judging wheat varieties for the production of high quality baked goods. It cannot be otherwise. Seldom, if ever, have the baking properties of new wheat varieties assessed on a small-scale experimental basis been challenged when the variety was finally released for commercial production.

During the past 15 years, a system of pilot-scale tests has been developed for testing milling and baking qualities. After these years of experience, it is logical that the pilot scale quality testing program should be viewed in retrospect. If the small-scale testing program has been so successful, how can the pilot-scale tests with associated higher costs be justified? Has any information been developed that is not available from the small-scale tests? Let us examine the contributions and limitations of the pilot-scale program.

The procedure followed, in recent years, has been to bring new wheat varieties along in the breeding program using small-scale tests for quality selection. Two years before a variety is ready for release to commercial growers, plots of the varieties, together with the standard varieties for comparison, are grown at several locations within each state. The location samples are tested for quality and then varietal composites are made. The variety composites are milled on the KSU pilot mill using 20 to 25 bushel lots. During the milling operation, numerous data on milling quality are collected. The resulting flour is shipped to mill and bakery laboratories for evaluation of baking characteristics in terms of wheat qualities the customer desires. The data are summarized to provide a rank comparison of quality for breadmaking purposes. Such data with recommendations are transmitted to wheat research workers. Usually the same varieties are studied for at least two years under this program before being approved or rejected. The pilot-scale information must be regarded as supplemental to that developed from small-scale tests.

<u>Milling Quality Assessed on Pilot-scale Flour Mill.</u> The pilot-scale testing program has provided certain data and information which have not been available or possible to obtain from the small-scale tests. Experience has shown that flour yield values from small-scale tests are extremely variable and usually not a reliable index of milling quality. In contrast, pilot-scale tests in which flour extractions are compared with cumulative ash content of 23 mill streams provide a fairly accurate estimate of extractable flour in any wheat. Based on the amount of calculated patent, first and second clear flours and total feed, a relative milling monetary value is assigned to each wheat sample. The milling results are usually compared only within a set of variety composites that have been grown under identical conditions. Within a given series of samples, the least significant mean difference of $\pm$ 2.5 cents per cwt. has been calculated. Experience has shown that Triumph wheat, for example, usually has a higher value than most other varieties while Wichita has a significantly lower milling value. The milling value of wheat samples tested during the past five years has been variable ranging from 3.95 to 4.20 per cwt. Not all this variability is associated with inherited characteristics but is dependent also on environmental conditions of growth which vary with location and from year to year.

Pilot-plant scale milling quality studies have several limitations. The number of samples that can be studied is limited by time and expenses involved. The average cost of milling each sample is approximately $175. For that reason and for reason of a uniform representative sample, compositing has been practiced. Since only a single sample of each variety is milled each year in comparison with other varieties, measurement of reliability of results is limited. With an ideal experimental design, at least duplicate samples of each variety should be milled each year to obtain an accurate estimate of standard error. On some occasions, the potential flour yield may not be reached. Sometimes proper wheat temper for optimum milling results is not attained.

Baking Quality Assessed by Collaborative Effort. The evaluation of the baking quality of the varieties by collaborative testing has several advantages. Such studies provide data on baking quality characteristics evaluated in terms of what the millers and bakers believe desirable. For many years, the varietal baking characteristics have been evaluated on an experimental small-scale. Such data are not to be challenged as they are usually assessed accurately and with many more observations than is possible using the pilot-scale testing procedure. The quality characteristics as measured by both the small-scale and pilot-scale tests have shown that they support each other. The differences in conclusions, if any, between small-scale and pilot-scale tests have been in terms of quality characteristics the trade desires. The pilot-scale tests are designed to provide a rank comparison of the varieties within a state based on the judgment of as many as 40 independent observations of the same sample.

The collaborative study of varietal quality has the added advantage of having industry shape in the responsibility of release of a new variety. They, too, are better prepared to accept the new variety when it meets commercial channels.

The collaborators are asked to bake white pan bread of all the variety samples since Hard Red Winter wheat is intended for bread production. The bread is scored using an established scoring system based on weighted points for loaf volume, break and shred, grain texture, absorption, mixing tolerance and dough handling properties. A total score of 100 denotes the perfect loaf of bread.

The collaborators are requested to rank the varieties in order of their preference. This rank comparison permits the miller and baker to evaluate the varieties in terms of their demands. If there is a predominance of a short mixing time variety being grown commercially, it may seem desirable to introduce a variety having longer mixing requirements. That desire or need should be reflected in the rank comparisons. Although opinion may differ from one area of the country to another as to needed varietal characteristics, the rank comparison represents an average opinion. This appears to be justified because wheat varieties recognize no boundaries, and when they are grown commercially, the market is not limited to a small area from which a given mill or bakery may draw its supply.

The quality rank comparison of varieties for white pan bread is highly correlated with the average total quality score. This suggests that the collaborators are evaluating the baking quality of the varieties in terms of inherited quality characteristics. Also, quality rank comparisons for blending purposes vary only slightly from the quality rank comparisons for white pan bread production. This suggests recognition of the importance of inherited quality characteristics.

Pilot-scale Studies Have Several Limitations. The collaborative study of baking quality of wheat varieties has some of the same limitations as pilot-scale milling studies. In any one year, only one sample of the variety is examined. The effects of environment have been eliminated by compositing. Thus, the findings should represent only inherited quality differences. In some years, the studies have been plagued with nonuniform protein content of samples within a state. In some years the protein content has been either too high or too low for white pan bread production. The reaction of collaborators to quality is frequently affected by the protein content of the samples. Much attention must be given to having representative samples of satisfactory protein content.

With an eye on the future, it seems prudent to continue pilot-scale testing. Better means to evaluate and measure errors and differences in milling quality should be developed. The flour produced by pilot-scale milling should be studied from the viewpoint of application to continuous mixing methods of bread production. Several laboratories are equipped to make such studies. Further consideration must be given to defraying the costs of pilot-scale testing. Certainly, any commodity having the economic importance of wheat, should be given rightful consideration in budget planning. It seems apparent that not only the wheat producer but also the miller and the baker should share in this associated effort.

THE EFFECT OF WHEAT VARIETY ON THE AIR CLASSIFICATION EFFICIENCY OF HARD RED WINTER WHEATS

P. J. Mattern

The basic milling procedures for wheat remained essentially unchanged for many years until the introduction of air classification about seven years ago. The new process permits the separation of a normally milled flour into various fractions with different protein and starch levels. This permits the miller to have more choice in the protein level of the wheat he uses. In addition, a number of different "quality" type flours are possible from a single "parent" flour. There is also a potential for certain fractions to be used in non-food uses.

The hard Nebraska wheats selected over the years worked well in the conventional milling system. However, softer textured wheats process more efficiently with air classification. It was important to have an evaluation of Nebraska grown wheats with the new milling system. This included an evaluation of the effects of wheat variety and growing environment on processing efficiency along with quality of the flour fractions. If presently grown commercial wheats cannot be utilized for this new milling process, then information is needed in order to make future selections from new breeding materials which will meet processors' demands.

Perhaps "dual" purpose wheats exist. These would be useful for both conventional and air classification processing. This type of material would permit the smoothest transition to a new milling method for all persons concerned with the buying and processing of wheat. Even though the future role of air classification is not completely known, a breeding program must have "quality" information available which would permit quick movement in the direction of any particular quality type. I will discuss efficiency in the air classification process, but remember, this is only part of the story since "quality" of individual fractions is also important.

Three years of study on air classification have been completed on Nebraska grown materials. This report will summarize the more important aspects of two years of study.

Figure 1 is a diagram showing the scheme of air classification used. The normal 100% straight grade Buhler milled flours were air classified with MIAG Walther Model 150 at a setting of 30 on the secondary air supply. This makes a separation at about 40 microns (u). The coarser fraction (greater than 40u) will be called 30C; the finer fraction (less than 40u) will be called 30F. The 30F fraction was pin milled at 14,000 rpm with an Alpine Kolloplex Laboratory Mill Model 160Z pin mill. The pin-milled fraction 30F (PM) was air classified at a setting of 8 on the secondary air supply. The coarse fraction (12-40u) was called 8C and the fine fraction 8F. Flour 8C is the pastry flour. Bread blends are made by combining proper amounts of 30C and 8F to produce the desired protein content.

Flour yields for the pastry flour (8C) and high protein fines (8F) are useful indices to gain an insight into the efficiency rating for a particular variety.

Samples grown in 1960 from either two or three counties were blended into individual Eastern, Central and Western Nebraska composite samples.

	1960 Samples % Flour Protein	
Location	Range	Mean
Eastern	9.85 - 12.30	10.73
Central	9.90 - 12.15	10.94
Western	8.10 - 10.70	8.83
Overall	8.10 - 12.30	10.20

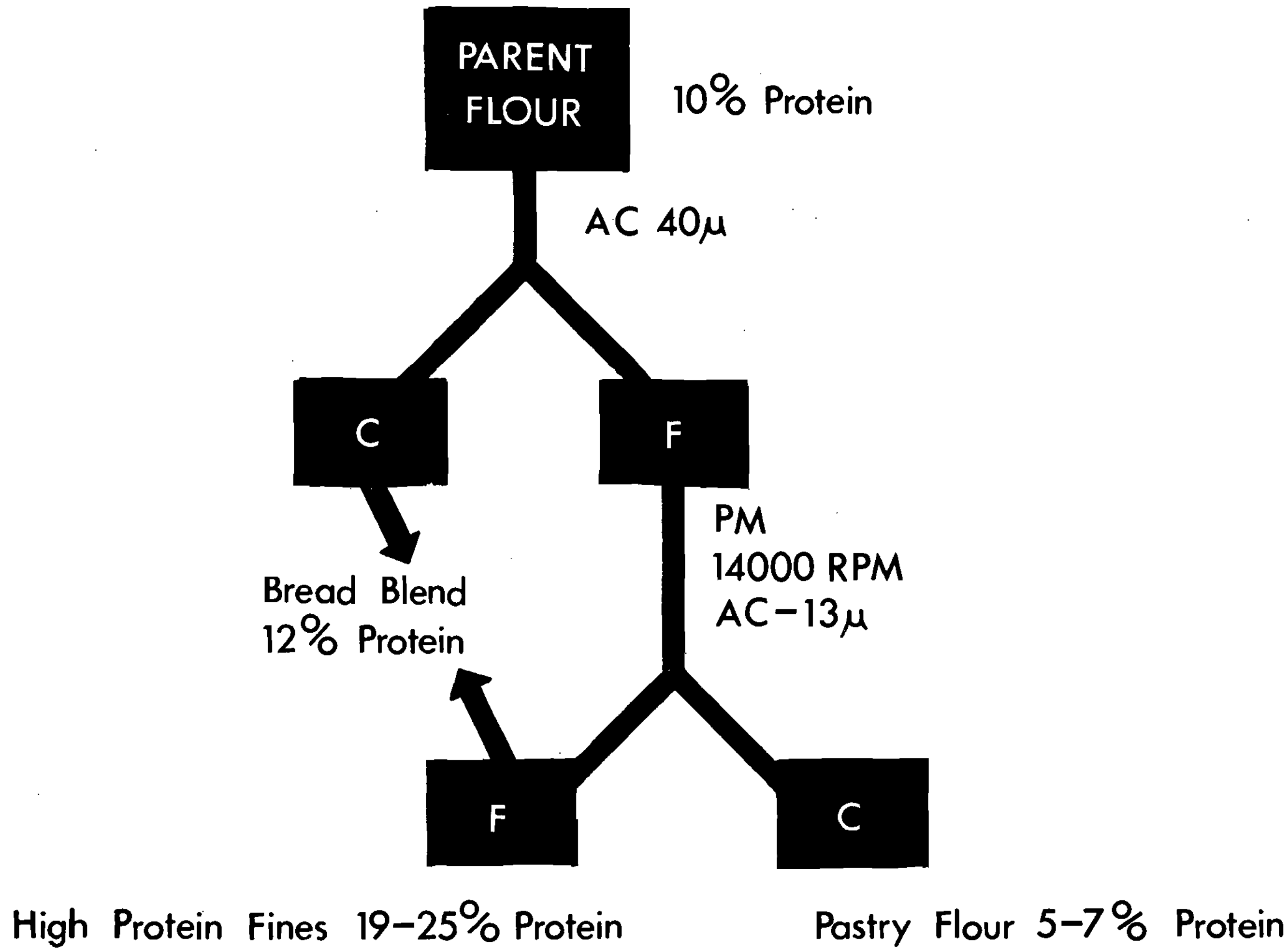
Air classification data for the yields of high protein fines (8F) and pastry flours (8C) for these samples is listed in Figure 2.

Figure 2. 1960 Harvested Wheat.

Wheat Variety	Flour Fraction	% Yield* of Flour Fractions Eastern	Central	Western
Nebred	8F	8.8	8.0	9.2
	8C	24.7	25.5	21.4
Turkey	8F	13.2	10.2	7.0
	8C	35.1	28.0	31.7
Warrior	8F	9.5	8.0	8.2
	8C	27.3	20.2	21.0
Ottawa	8F	9.1	7.1	6.0
	8C	21.3	24.4	20.2
Omaha	8F	8.6	7.1	6.5
	8C	26.0	21.4	27.2
Exp. A	8F	12.1	12.9	11.0
	8C	25.7	31.4	25.0
Scout	8F	9.1	9.0	9.7
	8C	25.1	30.0	31.8
Lancer	8F	7.3	7.6	8.4
	8C	22.7	24.2	28.2
Gage	8F	5.5	7.9	12.6
	8C	20.0	28.9	28.0

*Based on parent flour.

Air Classification Procedure for a HRWW Flour



The following ranges of flour fraction yields were found for the three most and least efficient varieties grown in 1960.

	% High Protein Fine (8F)	% Pastry (8C)
Turkey	7.0 - 13.2	28.0 - 35.1
Scout	9.0 - 9.7	25.0 - 31.8
Exp. A	11.0 - 12.9	25.0 - 31.4
Ottawa	4.5 - 9.1	14.9 - 24.4
Lancer	7.3 - 8.4	22.7 - 24.2
Omaha	4.8 - 8.6	21.4 - 26.6

These data support the conclusion that variety is an important consideration in the efficiency of processing using air classification techniques.

Figure 3 is a compilation of data from wheat samples grown in 1961 at Lincoln, Nebraska and at six additional locations which represent good coverage across the state. The Lincoln samples were grown with a high stem rust infection and are compared separately.

Figure 3. 1961 Harvested Wheat.

Wheat Variety	Flour Fraction	% Yields* of Flour Fractions: Lincoln	6 others	Overall Average
Nebred	8F	3.0	9.2	8.1
	8C	26.5	23.3	22.9
Warrior	8F	3.9	11.1	10.1
	8C	27.6	23.6	24.2
Ottawa	8F	4.5	7.9	7.4
	8C	14.9	21.8	20.9
Omaha	8F	4.8	8.7	8.1
	8C	23.2	22.5	22.6
Scout	8F	2.9	9.2	8.3
	8C	20.6	22.1	21.8
Lancer	8F	3.0	8.5	7.7
	8C	17.3	22.5	21.7
Gage	8F	2.9	7.3	6.7
	8C	18.1	18.7	18.6
Range of All Varieties	8F	3.0 - 4.8	5.6 - 16.6	--
	8C	14.9 - 27.6	15.2 - 34.2	--

* Based on parent flour.

Rust may not be the only factor with the Lincoln samples because the rust resistant varieties were also not producing normal yields of pastry and high protein flours.

An analysis of variance indicated variety was important in both 1960 and 1961 to account for variation encountered in yields of pastry flour and high protein fines. In 1960 location had little effect, while in 1961 location accounted for a large amount of variation.

As was pointed out earlier the yield of flour fractions is only one part of the story. Just as important is the end use of a particular product. For example, of all varieties tested in 1961 Lincoln samples only Triumph, Wichita and Bison made acceptable cookies. Almost all pastry flours made acceptable cakes with the lean formula method. However, Ottawa, Gage, Lancer and Comanche had the poorest cake scores. All varieties were satisfactory for bread production at 12% protein and performed as one would expect the parent flour to perform at a comparable protein level.

Air classification adds additional cost for the processor. It requires additional control and knowledge. As with conventional milling variety will still dictate certain end uses for quality. Environment will still modify processing efficiencies and, in certain instances, quality factors.

It is possible for a wheat breeding program to make selections of varieties which are essentially dual purpose wheats. Such wheats would mill satisfactorily during the conventional milling and also process rather efficiently with air classification.

MONOSOMIC WHEAT QUALITY STUDIES

C. A. Watson and J. R. Welsh

Some of the data obtained on Kharkof MC-22 wheat lines and Kharkof MC-22 x Itana wheat lines are presented in Tables 1 and 2. The averages presented in Table 1 are for three replications. The material used to obtain the data in Table 1 has the following history. The progeny of the identified monosomics were grown in the field in 1962. The progeny from this material was grown in 1964 and used to obtain the data reported in Table 1. Therefore, these samples would represent the second selfed generation following identification as monosomics. Theoretical calculations would predict that this material is 42% monosomic and 48% disomic if one assumes a 75% monosomic and 25% disomic population from a selfed monosomic. The most striking example of monosomic effect on quality is shown by chromosome 1-D. Chromosome 5-D shows some indications of affecting quality. Generally the monosomics are slightly higher in protein content than their corresponding disomic.

The material used to obtain the data in Table 2 has the following background. These samples represent the F_3 populations from a monosomic or disomic F_1's of a Kharkof MC-22 x Itana cross. The monosomic F_1's were identified in the greenhouse in 1961. Again theoretical calculations would predict this material to be 42% monosomic and 48% disomic. The F_2's were grown in 1962 and the F_3's grown at several locations in 1964. The samples used to obtain the data shown in Table 2 are composites of 100 g. from Havre, 125 g. from Moccasin, 150 g. from Sidney and 800 g. from Bozeman.

The data in Table 2 do not show the striking results of the effect of chromosome 1-D on quality as with the Kharkof MC-22 monosomic material. This would indicate that Itana has a compensating effect on the mixing properties of monosomic 1-D material. Monosomic F_2 studies of this cross showed the 1-D chromosome effect but to a less degree than the parental Kharkof material, because of the strengthening effect of other Itana chromosomes.

Table 1. Mean values and statistical data for quality characteristics of several monosomic and disomic lines of Kharkof MC-22. Averages are of three replications.

Line	Quad Mill %	Protein %	Farinograph Data Abs. %	Peak (min)	Stab. (min)	Val.	Sed. c.c.
Grand Mean	47.9	17.8	62.4	14.4	18.2	87.0	66.9
F-Ratio	0.95 ns	3.4**	1.9*	7.0**	57.8**	21.5**	25.8**
L.S.D. (.05)	4.01	0.674	1.33	3.73	1.87	6.32	4.08
1-A (M)	49.9	17.9	61.8	15.5	20.2	90.7	70.5
2-A (M)	48.7	17.9	62.5	12.8	16.7	84.0	69.8
2-A (D)	47.0	18.2	62.2	16.2	21.0	91.0	70.2
3-A (M)	46.6	18.6	63.7	17.7	23.7	94.7	69.7
3-A (D)	47.6	17.6	62.5	16.0	19.7	92.0	69.5
5-A (M)	45.5	18.3	62.7	17.5	20.3	92.3	70.2
5-A (D)	47.9	17.5	62.4	16.5	20.3	91.7	70.3
6-A (M)	48.5	17.3	62.3	14.7	17.8	89.3	66.7
7-A (M)	46.8	17.8	62.6	12.2	17.5	89.0	65.2
1-B (M)	48.1	18.4	62.7	9.5	11.3	76.0	65.5
2-B (M)	45.7	18.2	62.5	15.2	18.0	89.0	70.0
2-B (D)	48.9	17.3	62.5	16.3	16.8	91.0	70.3
5-B (M)	46.2	17.9	63.3	17.5	15.5	92.7	70.7
6-B (M)	48.6	17.9	61.9	14.0	19.3	88.3	65.2
7-B (M)	48.3	17.5	61.7	17.3	25.8	94.3	68.7
1-D (M)	46.8	18.1	61.6	4.7	4.2	54.0	40.8
1-D (M)	47.5	18.2	61.7	4.5	4.2	53.3	45.5
1-D (D)	48.5	17.5	62.3	15.3	21.2	91.0	70.3
3-D (M)	48.9	17.4	61.7	14.7	16.8	88.7	69.5
3-D (D)	48.3	17.3	61.7	12.8	17.5	84.3	67.3
4-D (M)	51.3	17.4	62.6	17.3	21.2	93.7	69.0
4-D (D)	49.1	17.2	62.2	15.3	22.7	91.0	68.3
5-D (M)	49.0	18.5	64.7	12.8	22.2	85.7	57.7
5-D (D)	48.5	17.4	62.2	16.7	19.0	92.3	69.8
6-D (M)	46.5	18.3	62.2	18.2	23.3	94.7	70.8
6-D (D)	45.5	18.2	62.8	12.8	18.3	85.0	67.0
K MC-22	48.1	17.1	62.0	14.3	18.2	88.3	67.5

Table 2. Quality data of Kharkof MC-22 x Itana Monosomic wheat lines. Material is the F_3 populations from Monosomic or Disomic identified plants.

Variety	% on 6½/64	Kernel wt. mg.	Test wt.	Flour yield %	Flour Ash %	Farinograph Data: Abs. %	Farinograph Data: Peak (min)	Farinograph Data: Stab. (min)	Farinograph Data: Val.	Flour Prot. %	Sed. Val. c.c.
K-MC-22-1 x It-17	18.0	28.3	61.2	70.8	0.42	60.2	6.5	10.0	67	13.1	68.0
1-A x It (M)	14.9	27.3	60.5	64.5	0.41	57.0	7.0	10.0	69	12.7	70.0
2-A x It (M)	18.7	25.7	60.4	66.5	0.40	60.0	7.5	15.0	73	13.3	71.0
2-A x It (D)	15.8	25.5	60.6	68.8	0.38	59.0	6.0	12.0	67	12.7	69.0
3-A x It (M)	21.4	26.5	60.3	68.0	0.37	58.3	6.5	13.0	69	12.8	71.5
3-A x It (D)	18.9	26.6	61.3	69.5	0.37	60.5	7.0	10.0	70	13.0	69.0
4-A x It (M)	16.8	25.4	61.2	65.9	0.37	59.0	5.5	12.5	67	12.6	68.0
4-A x It (D)	21.1	26.9	60.9	69.7	0.36	59.2	6.5	12.0	69	12.3	71.0
5-A x It (M)	9.6	23.9	60.8	69.4	0.37	60.0	7.0	13.5	71	12.7	72.0
7-A x It (M)	21.5	26.8	61.1	71.2	0.37	60.2	6.0	7.5	67	12.9	67.5
7-A x It (D)	25.7	27.6	61.5	66.7	0.35	58.8	6.0	8.5	66	12.6	71.0
1-B x It (M)	20.8	26.2	60.8	66.2	0.35	59.0	7.0	7.5	68	13.4	69.0
1-B x It (D)	18.2	26.1	61.2	69.5	0.35	60.8	6.0	11.0	65	12.9	70.0
2-B x It (M)	23.4	24.9	60.2	69.2	0.36	60.4	6.0	9.0	67	13.5	71.0
2-B x It (D)	19.4	26.5	61.0	69.9	0.33	59.5	6.5	12.0	69	12.5	70.0
3-B x It (D)	20.8	26.4	61.5	67.4	0.34	58.0	7.0	13.0	70	12.3	68.5
4-B x It (M)	21.8	27.0	61.5	72.0	0.38	59.4	7.0	10.5	69	12.9	70.0
5-B x It (M)	18.7	26.1	60.6	71.3	0.38	58.7	6.5	11.0	68	12.9	69.0
5-B x It (D)	21.0	26.9	61.3	67.1	0.36	58.0	5.5	11.0	66	12.2	69.0
6-B x It (D)	25.5	27.2	62.0	67.8	0.34	57.4	6.0	12.0	68	12.3	68.0
7-B x It (M)	27.0	28.1	62.2	63.1	0.35	58.0	6.5	12.5	69	11.8	67.0
1-D x It (M)	20.9	27.9	60.8	68.0	0.35	58.5	5.5	6.0	62	12.6	60.0
1-D x It (D)	25.7	28.5	62.1	68.9	0.34	57.4	5.5	8.0	64	12.0	65.0
2-D x It (M)	25.5	27.3	61.6	69.0	0.35	59.5	6.5	11.0	69	12.7	70.0
3-D x It (D)	24.0	27.2	61.7	69.6	0.34	60.8	7.5	12.0	72	12.7	69.5
4-D x It (M)	16.8	25.6	61.7	67.4	0.34	60.0	8.5	18.0	78	12.8	71.0
4-D x It (D)	20.2	25.3	61.8	68.6	0.35	59.0	8.5	21.0	80	12.8	70.0

Table 2 (cont.)

Variety	% on 6½/64	Kernel wt. mg.	Test wt.	Flour Yield %	Flour Ash %	Farinograph Data Abs. %	Peak (min)	Stab. (min)	Val.	Flour Prot. %	Sed. Val. c.c.
5-D x It (M)	22.4	27.3	61.8	67.4	0.34	60.3	7.0	12.5	71	12.6	68.0
5-D x It (D)	20.4	26.7	61.2	69.4	0.39	63.2	8.5	17.0	76	13.7	71.0
6-D x It (M)	7.5	24.5	61.1	67.2	0.37	61.2	7.5	18.0	74	12.6	69.0
6-D x It (D)	21.4	26.6	61.4	66.1	0.37	58.0	6.0	10.0	67	12.5	67.0
K MC-22-1	23.0	26.6	59.6	64.6	0.38	59.5	5.5	9.0	64	12.8	71.0
Itana-1	14.2	26.1	63.2	70.5	0.34	61.3	9.0	18.5	79	12.5	72.5
Grand Mean (n=3)	20.0	26.5	61.2	68.2	0.36	59.4	6.7	12.0	69	12.7	69.2
Monosomic Mean (n=11)	19.0	26.1	60.9	68.0	0.36	59.6	6.7	11.8	69	12.9	68.6
Disomic Mean (n=11)	20.7	26.7	61.3	68.6	0.36	59.4	6.5	12.0	69	12.6	69.3

CHROMOSOME SUBSTITUTION LINES FOR STUDYING THE INHERITANCE OF QUALITY FACTORS OF CHEYENNE WHEAT

Paul J. Mattern, Rosalind Morris, J. W. Schmidt, and V. A. Johnson

Wheat cytogeneticists and breeders at the University of Nebraska through special breeding materials (aneuploid stocks developed by E. R. Sears, 1954) produced seed stocks of 21 substitution lines. These 21 substitution lines have near identical composition in 20 pairs of chromosomes. However, the remaining pair consists of individual chromosome pairs from the Cheyenne wheat variety. Similar materials from different wheat varieties are being produced in Montana and Canada.

Figure 1 is a pictorial attempt to describe the process of producing these special seed stocks. Common bread wheat contains 42 chromosomes, thereby producing sex cells of half this number or 21 chromosomes. These are pictured in the upper left-hand corner.

The aneuploids of Chinese Spring used contained only 41 chromosomes, so sex cells containing 20 or 21 chromosomes are formed. In this work, only those progeny plants containing the 20 chromosomes from the aneuploid Chinese Spring and 21 chromosomes from Cheyenne were selected. Hybrid plants with the unpaired Cheyenne chromosomes are identified through microscopic techniques. Since there are 21 different chromosomes, 21 separate crosses were made using the identified aneuploid stocks of Chinese Spring.

The first cross has also resulted in a pairing of the 20 chromosomes from the Chinese Spring and the remaining 20 chromosomes from Cheyenne. For each of the 21 lines, it is possible to eliminate the 20 nondesired chromosomes from Cheyenne by continually backcrossing the F_1 hybrid, and the resultant backcrosses to the specific Chinese Spring aneuploid. This results in a continued dilution and removal of the nondesired Cheyenne chromosomes. The desired unpaired substituted Cheyenne chromosome is not affected. Seventeen of the lines used in this study were increases following the 4th backcross or Cns^5 x Cnn. The other four stocks or lines were as follows:

2A -- Cns^1 x Cnn (no backcross)
7A and 2B -- Cns^3 x Cnn (second backcross)
2D -- Cns^2 x Cnn (first backcross)

For the immediate study, these substitution lines were grown at Aberdeen, Idaho in 1963. Plantings were repeated at Fort Collins, Colorado and Aberdeen, Idaho in 1964. Data collected from the 1964 harvested material substantiate the 1963 data which are the basis for this report. The values shown are for a representative substitution line out of a number of lines for the same chromosome and not averages for all lines.

Experimental Milling

Samples of fifty and one hundred and fifty grams of each chromosome substitution line were tempered 24 hours to 13% moisture content. Preliminary experimentation indicated that the softer types milled satisfactorily at this moisture; higher tempering reduced milling yields with milling procedure being used. A constant tempering level was employed for a relative comparison.

Kernel count on each of the 50 g. samples was obtained using an Electronic Seed Counter.1/ Wheat was fed into the hopper of the Brabender Quadrumat "Jr." using a Syntron vibratory feeder at the rate of approximately 34 g. per minute. The sifter reel of the Brabender Quadrumat "Jr." was removed and the ground material from the 50 g. samples was sifted $1\frac{1}{2}$ min. using stacked 40 and 60 mesh standard brass sieves. Bran was collected on the 40 mesh sieve, course middlings on the 60 mesh sieve and flour in the collector pan below the 60 mesh sieve. Data from the 50 gram samples were used in calculating the yield of flour. The 150 g. samples were milled and sifted with the sifter reel (265 u openings) supplied as original equipment with the Quadrumat "Jr." This additional flour was produced for the micro baking evaluations.

Analyses

The moisture, ash, protein, maltose and MSA-Whitby centrifuge sedimentation methods were performed according to the procedures outlined in Cereal Laboratory Methods (1). All data is reported on a 14% moisture basis.

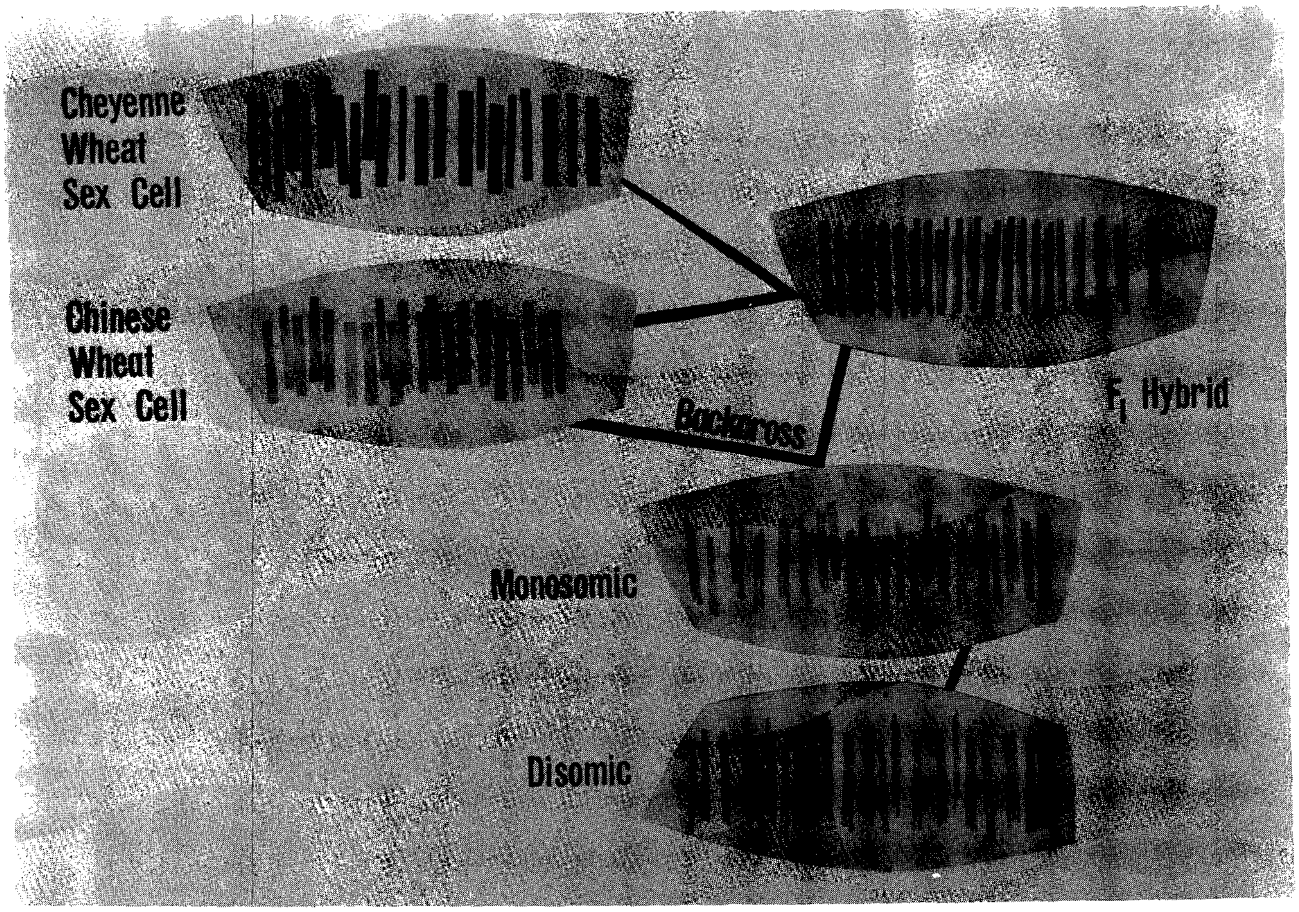
Baking

The micro baking procedure for 25 g. doughs described by Van Scoyk (2) was used with the A.A.C.C. basic formula with the sugar at 6%. Samples were baked with and without 1 mg. % $KBrO_3$. Only the bake with oxidation was reported. Absorptions were adjusted to optimum by an experienced operator.

Mixing Curves

Mixograms were recorded with the Swanson-Working Mixograph (National Manufacturing Co., Lincoln, Nebraska) using 30 grams of flour. Absorptions were identical to those used in the baking procedure. Room temperature was controlled to 25° C.

1/ Audiotronics, 37 Hopewell Avenue, Ottawa, Ontario, Canada.



Legend

Figure 1. Pictorial attempt to show production of chromosome substitution lines.

RESULTS AND DISCUSSION

Milling Characteristics

Milling data are listed in Figure 2. Chinese Spring and Cheyenne, the controls for the series, gave milling yields of 61.3% and 71.0%, respectively. Substitution line with Cheyenne chromosome 5D definitely approaches Cheyenne in milling yield. Samples 2B and 2D were at the second and first backcross, respectively, so a definite conclusion concerning their milling properties must await further backcrossing. Chromosome substitution line with Cheyenne chromosome 5D was the only sample with a vitreous appearing endosperm similar to Cheyenne.

Johnson and Hartsing (3) recently described the relationship between kernel count and milling yield. No substitution line had a kernel size as large as the Cheyenne control. Several, 7B, 4B, 1D, 5D and 7D, had smaller kernels than Chinese Spring; all others were equal or larger in size. In general, most samples had equal or improved milling when compared to the Chinese Spring control, except 6D, which had a lower milling yield. It had a large kernel with soft endosperm characteristics.

Plots for kernel count vs. milling yield tended to cluster for the A genome, while data for the B and D genomes were more randomly distributed.

The higher milling yields were, in general, associated with harder endosperm types. Higher maltose figures reflect increased "damaged starch" which accompanies "harder" milling types. The maltose figures should reflect relative differences in endosperm hardness inasmuch as all samples were milled at the same milling temper (13%) (Figure 2). Again 5D carries the major Cheyenne factor or factors for kernel hardness, producing a maltose value of 145.

Flour Particle Size

Although a simple micro-milling procedure was employed, individual Cheyenne chromosome pairs were affecting endosperm breakdown. The "mass median particle diameter"(MMD) of the flours ranged from 78u to 100u. The MMD point is the size at which 50% of the flour by weight is finer and 50% is more coarse. In general, a larger MMD size is associated with harder type wheat with larger milling yields (Figure 2). Only flour from chromosome substitution line 5D approached the MMD of Cheyenne, 100 u and 103u, respectively. Again, 2B (92u) and 2D (94u) with less backcrossing are midway in size between the MMD's of the Chinese Spring and the Cheyenne controls.

Individual Cheyenne chromosomes are having an effect on the particle size distribution of the milled flours. Only substitution line 1B (78u) had a smaller MMD value than the Chinese Spring control (81u).

Figure 2. Data for 1963 wheat grown at Aberdeen, Idaho.

Sample	Kernel count	Bran weight (g)	Coarse midds. (g)	Flour weight (g)	% flour yield	Micron size	Maltose	Ash		Protein		Mixing time	Loaf volume
								wheat	flour	wheat	flour		
1A Cns^5 x Cnn	1945	13.21	5.26	32.28	63.5	90	68	1.63	.752	12.80	12.00	1	146
2A Cns^1 x Cnn	1686	14.18	5.48	31.31	61.0	86	83	1.62	.520	11.80	10.65	3 3/4	164
3A Cns^5 x Cnn	1813	13.89	6.06	31.06	61.0	92	76	1.64	.702	12.70	12.75	1	140
4A Cns^5 x Cnn	1660	13.71	4.46	32.73	63.0	85	85	1.73	.774	12.75	11.55	1 2/3	136
5A Cns^5 x Cnn	1810	14.09	3.71	32.16	64.8	90	78	1.61	.764	12.55	12.05	1	120
6A Cns^5 x Cnn	1690	12.97	4.60	33.15	65.3	84	76	1.60	.532	13.00	11.75	1 1/3	134
7A Cns^3 x Cnn	2007	13.55	4.68	33.07	64.5	89	74	1.60	.506	11.80	11.05	1 2/3	130
1B Cns^5 x Cnn	1909	14.10	3.15	32.90	64.3	78	74	1.62	.490	12.90	11.80	1 1/3	148
2B Cns^3 x Cnn	1934	12.46	4.12	34.52	67.5	92	109	1.59	.612	12.10	11.45	1 2/3	127
3B Cns^5 x Cnn	1824	13.58	4.42	33.26	63.2	86	76	1.60	.780	13.00	12.15	1 1/3	148
4B Cns^5 x Cnn	2418	13.94	4.02	33.03	65.0	86	85	1.72	.532	12.80	12.35	2 1/3	170
5B Cns^5 x Cnn	1756	14.28	4.86	31.74	62.4	88	71	1.60	.556	13.20	12.10	1 1/3	132
6B Cns^5 x Cnn	1897	13.29	4.45	32.51	64.3	86	56	1.76	.488	11.70	10.40	1	142
7B Cns^5 x Cnn	2212	1352	4.00	33.16	65.4	96	90	1.61	.596	11.10	10.30	2 1/3	143
1D Cns^5 x Cnn	2278	14.94	4.88	31.92	61.7	84	78	1.61	.734	2.00	10.15	1 1/3	115
2D Cns^2 x Cnn	1680	12.30	4.33	34.32	67.4	94	96	1.62	.545	12.60	12.00	2 1/3	168
3D Cns^5 x Cnn	2069	13.95	4.61	33.20	64.1	93	68	1.59	.940	13.70	12.35	1	122
4D Cns^5 x Cnn	1985	13.32	5.04	32.78	64.0	90	88	1.63	.494	12.90	12.20	1	140
5D Cns^5 x Cnn	2418	11.90	4.34	34.52	68.0	100	145	1.68	.632	13.10	12.60	1 2/3	140
6D Cns^5 x Cnn	1596	15.69	6.86	28.93	56.7	88	78	1.72	.814	13.20	12.65	1 1/3	134
7D Cns^5 x Cnn	2525	15.26	5.13	31.06	60.4	84	85	1.81	.740	13.05	12.40	1	126
Cheyenne	1349	10.50	4.32	36.28	71.0	103	161	1.90	.495	13.75	12.65	3 1/3	175;
Chinese Spring	2071	14.59	5.17	31.26	61.3	81	75	1.73	.635	14.05	13.20	1 1/3	138

Protein and Ash

Wheat proteins ranged from 11.70% to 14.05%, flour proteins from 10.15% to 13.20% with most samples in the intermediate range. The protein levels of the flours were generally satisfactory for the baking evaluation.

Ash contents for all wheats cover a relatively narrow range, 1.59% to 1.90%. The flours ranged from 0.488% to 0.940%. The ash values are hard to interpret in view of hardness indications (maltose values) and milling yields. Although the milling temper (13%) was quite low, the harder endosperm types were not necessarily higher in ash contents.

Dough Mixing Characteristics.

One of the most important quality characteristics of a flour is its dough mixing time requirement. This chromosome substitution series of samples is particularly interesting inasmuch as Chinese Spring has a short mixing requirement and Cheyenne a long mixing time. However, any modification of mixing time due to a single chromosome pair from Cheyenne wheat could result in either a longer or shorter mixing time than Chinese Spring.

Reproductions of the Mixograph Mixing curves are pictured in Figure 3. Mixing curves for the substitution lines are designated by a chromosome number. Although there is a range in protein contents a satisfactory evaluation of the mixing time characteristics is possible.

Within limits, a medium-long to long mixing curve is desirable. This is true only because the desired quality of long mixing tolerance, or the ability of a dough to tolerate overmixing or extended mixing, is associated with long mixing time. Substituted line 2A is characteristic of a curve expected from a hybrid of Cheyenne and Chinese Spring for this line had not been backcrossed to Chinese Spring at the time of this study. The contribution of line 2D cannot be evaluated at this time for it had been backcrossed only once. Dough mixing characteristics of this line will not get any stronger as backcrossing continues and could become weaker. However, substituted lines 4B, 7B and 5D definitely are responsible for the strong dough mixing characteristics of Cheyenne. The fact that at least three and possibly more chromosomes contribute factors producing long dough mixing in Cheyenne helps to explain why a simple cross between long and short mixing time parents produces few segregates which have mixing properties equal to the stronger parent. 1D on Chinese must be carrying some mixing factor because this curve is representative of a number of 1D lines.

Effect of the Backcrossing Program on Mixing Characteristics

The backcrossing program which was discussed earlier removes the non-desired Cheyenne chromosomes. If a non-desired Cheyenne chromosome is affecting a particular characteristic, its removal (by backcrossing) should remove the particular effect. This phenomena in regard to mixing characteristic is readily apparent from an examination of mixing curves for several Cheyenne substitution lines which were at different backcrosses (Figure 4). In the case of 1A, 1D and 4D, chromosomes which were not carrying the long mixing factor, the mixing times decreased as the backcrossing program was extended. Substitution sample 1A was at a short mixing time by the second backcross (Cns^3 x Cnn). Samples with chromosomes 1D and 4D required the fourth backcross (Cns^5 x Cnn) to revert to the Chinese Spring mixing type. However, a chromosome substitution line which carried the long mixing factor, such as 5D, continues to exhibit the long mixing time although the backcrossing program is continued. It appears that by the fourth backcross, a reliable evaluation can be made regarding the contribution of a particular Cheyenne chromosome to the mixing characteristic.

Baking Evaluation

It is fortunate that Chinese Spring exhibits very poor baking quality. Substituting individual chromosomes from Cheyenne, an average quality wheat, into Chinese Spring permits differences to be easily discerned. Although loaf volume is an important quality characteristic, the more dramatic effect is in the variation of the characteristics of the bread crumb. Figures 5 and 6 are photographs of the exterior and interior, respectively, of bread produced from the Cheyenne substitution lines. An evaluation of 2A and 2D lines must await further backcrossing. At present, the remainder of the A genome from Cheyenne is not contributing significantly to baking quality (1A may be an exception). Chromosomes 1B, 4B and 7B appear to carry the baking properties of Cheyenne wheat. The D genome (with the previous elimination of 2D) appears unimportant, except for the possible significance of 4D and 5D which do improve crumb and grain characteristics.

Several loaves did not proof normally, although the baking formula was considered adequate in malt and sugar. It appeared that gas holding capacities, not gas production, was the limiting factor.

In summary, by the use of Cheyenne wheat chromosomes substituted into Chinese Spring we have assigned the major effect for kernel hardness and associated hard wheat milling characteristics to chromosome 5D. Additional but somewhat less effective factors are on other chromosomes. Dough mixing time and mixing tolerance were found to be controlled by major factors located on chromosome 4B, 7B and 5D and possibly by minor factors on other chromosomes.

Major loaf volume, external crust and internal crumb and grain factors were located on 4B, 1B and 7B giving above average performance. Additional minor factors may be present. The contribution of 2D cannot be evaluated at this time.

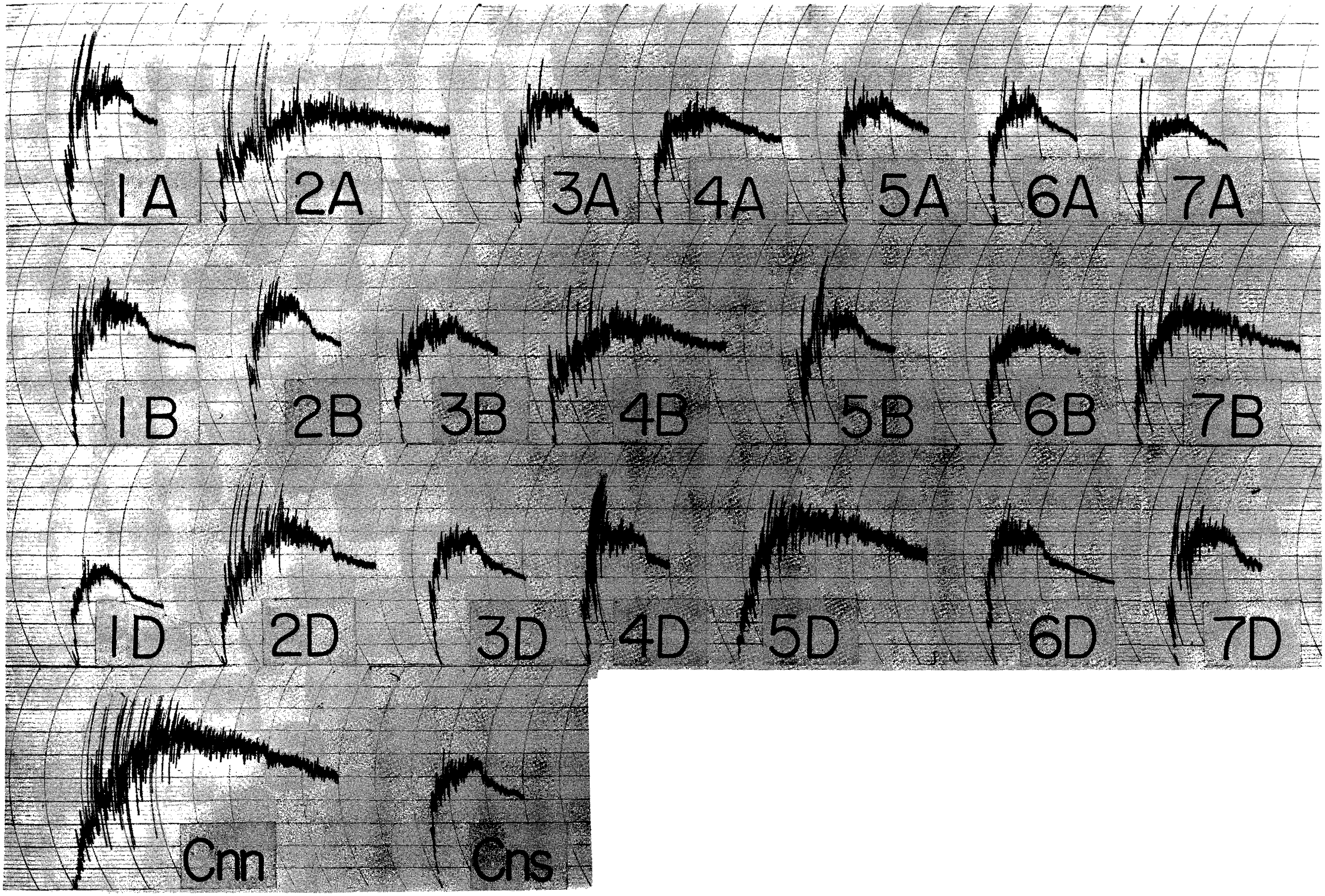


Figure 3. Mixing curves for Cheyenne substitution lines and the control samples.

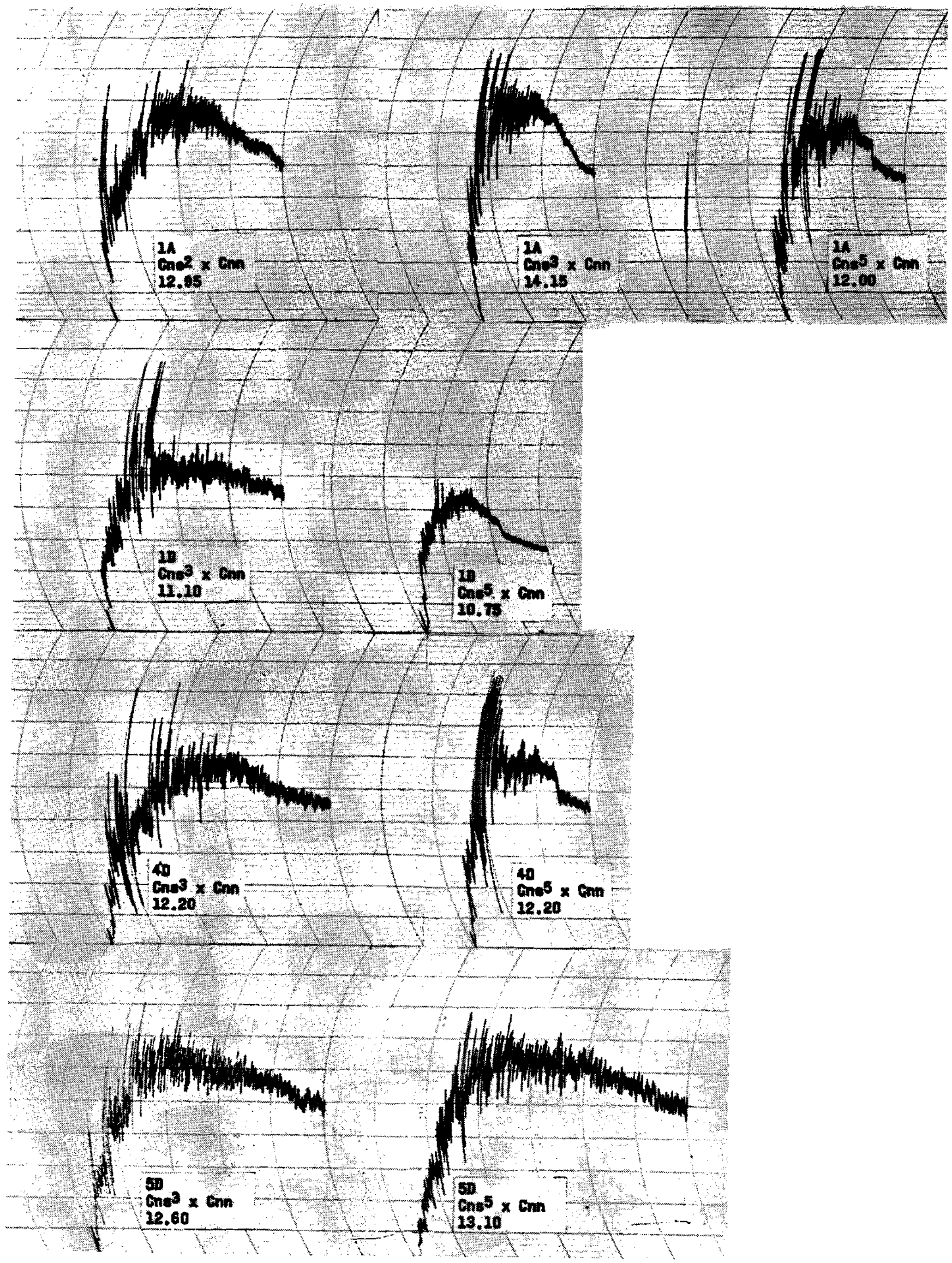


Figure 4. Mixing curves showing the effect of the backcrossing program on the mixing properties of substitution lines.

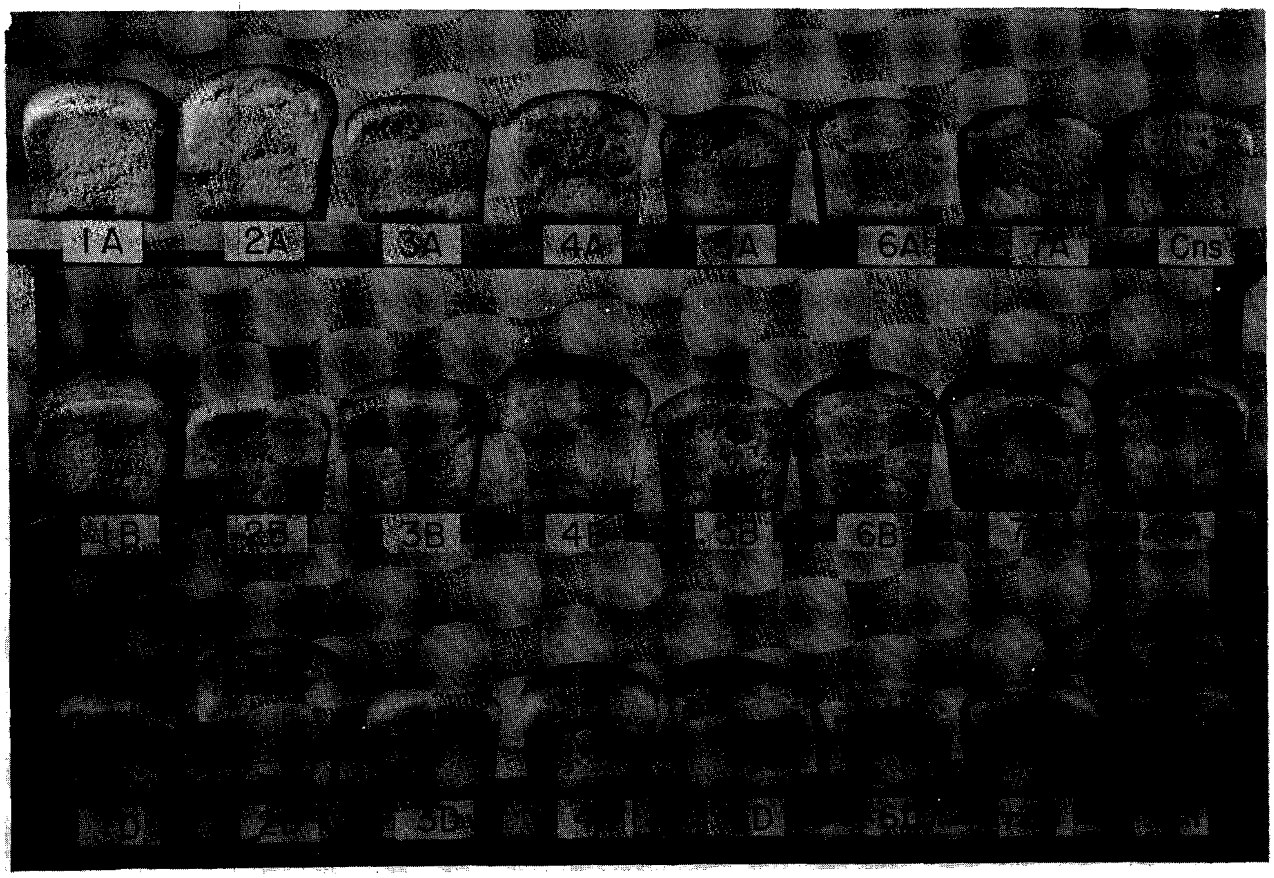


Figure 5. Photograph of loaves (external) baked from Cheyenne substitution lines and controls using micro (25 g) baking procedure.

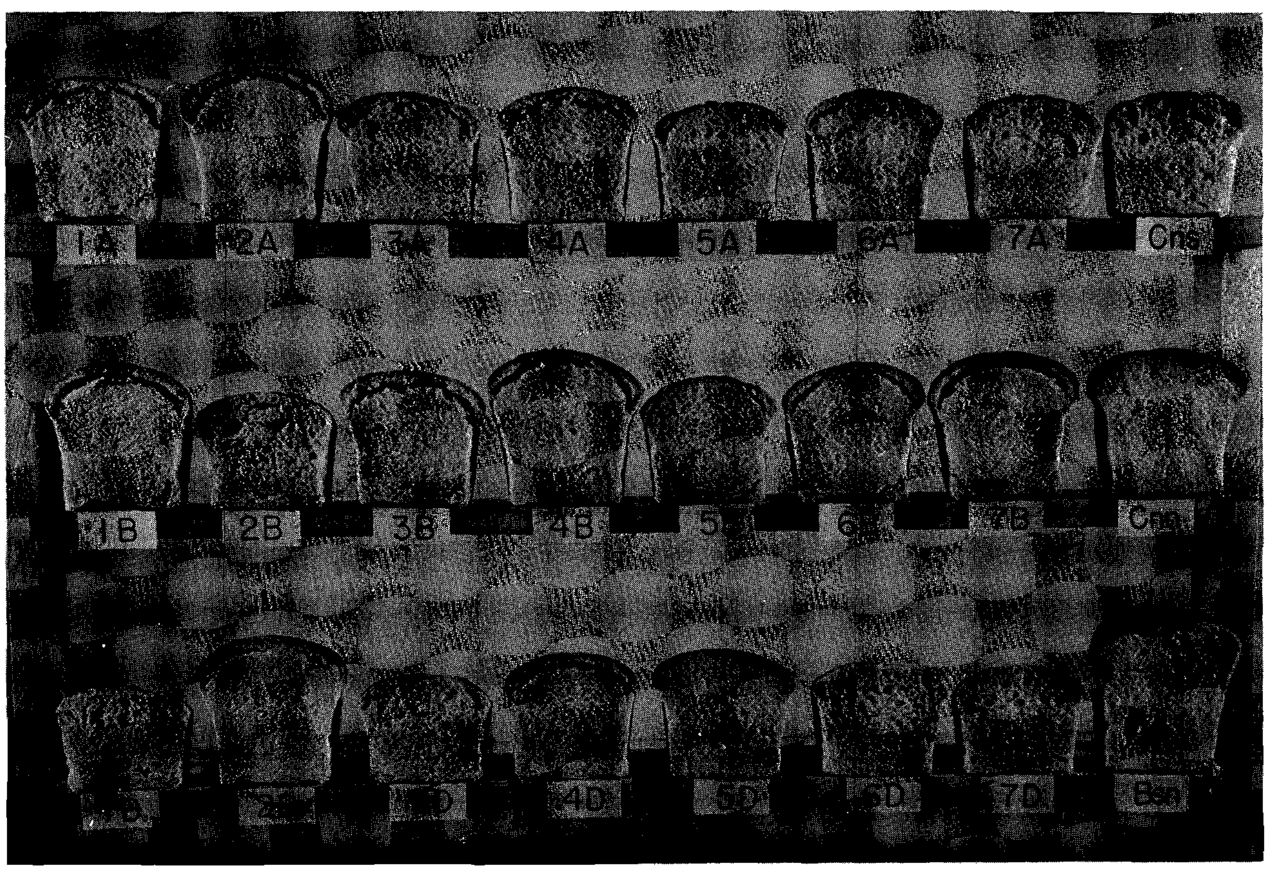


Figure 6. Photograph of loaves (internal) baked from Cheyenne substitution lines and controls using micro (25 g) baking procedure.

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PLANT DISEASES vs. WINTERKILLING OF WHEAT

(Abstract)

George W. Buchenau

The role of soil-borne plant diseases in the complex problem of winterkilling is not clear. Although plant pathologists are generally cognizant of the likelihood of a disease-winterkill relationship, few data are available to support such hypotheses.

In the fall of 1960 soil fumigation with chloropicrin strikingly increasd winter survival. Winterkilling was not severe in 1962 or 1963 experiments; consequently, no responses were evident. In 1964 chloropicrin again reduced winterkilling.

Attempts to analyze the nature of chloropicrin response have not been entirely successful. This fumigant kills fungi, nematodes, bacteria, insects, and weed seeds and also increases soil fertility. Fertilizer and insecticide applications have indicated that these factors were not responsible for the observed effects. Isolation studies have revealed high populations of the fungus Fusarium roseum in the crowns of wheat plants in the early spring. Greenhouse and cold chamber experiments have shown that inoculation with F. roseum markedly reduces recovery from cold injury. The extent to which these findings can be applied to field winterkilling, however, is unknown.

The role of nematodes in the problem has been studied, but results thus far are inconclusive.

TRANSMISSION OF SOIL-BORNE WHEAT MOSAIC VIRUS

(Abstract)

Myron K. Brakke

Rods of soil-borne wheat mosaic virus were easily detected by electron microscopy of root-dip and leaf-dip preparations. Their most frequent length was 160 mμ. They were found in roots of wheat in the fall 2-3 weeks after planting. Therefore, infection can occur soon after planting although few leaves have symptoms before spring. Inoculum was prepared by soaking infected roots or debris from infested soil in water. Wheat plants were infected by addition of inoculum to pots or petri dishes containing very young seedlings. Leaf symptoms appeared in 2 weeks at 20 or 25 C, in 3 weeks at 15 C, and after longer incubation periods at lower temperatures. The leaf symptoms were more pronounced at 15 than at 20 C and were transitory above 25 C. The optimum temperature for soaking source roots was 25 C if the soaking period was 20 min. The optimum temperature for inoculating seedlings in petri dishes was between 5 and 10 C when inoculum was left on them for 24 hr. Seedlings inoculated in pots in the one- or two-leaf stage did not show leaf symptoms within 2 months, but virus rods were found in their roots by electron microscopy. Use of source plants from dry soil or roots of plants treated with dilute formaldehyde or sodium hypochlorite gave little or no infection. Soil debris was a better source of inoculum if it was soaked for a few days before use than if used immediately after separation from soil. The infecting agent passed through a 325-mesh screen and was in the pellet after centrifugation for 5 min at 3,000 rpm.

Debris washed from infested soil was a good source of inoculum of soil-borne wheat mosaic virus, especially if it was kept wet for one day or more before being added to wheat seedlings. Wheat grown in infested soil did not show leaf symptoms as early or in as high a percentage of plants as did wheat inoculated with debris or with water in which infected roots had soaked. Debris from soil collected from the field from October through March was a good inoculum, but debris from soil collected from April to September was a poor inoculum. Thus the winter wheat plant is young and susceptible at a time when the inoculum in the soil is also highly effective.

Several cultures of the virus and its vector are being maintained in a growth room in an effort to select a culture that will prosper under these conditions. These cultures will be used for experiments on the properties of the vector.

The effect of time and temperature on the inoculation of wheat with this virus by exposing seedlings to soil debris has been determined.

CHEMICAL CONTROL OF WHEAT RUSTS

(Abstract)

J. B. Rowell

Two properly timed sprays of nickel sulfate plus maneb formulations have controlled leaf and stem rusts of wheat in various field tests and appear promising as a useful cultural practice. Control is achieved by delaying the development of the epidemic rather than by eliminating the disease so that time of application is critical.

The effectiveness of starting the spray schedule at various stages of epidemic development has been studied by means of an experimental design consisting of randomized, isolated plots separated by a minimum distance of 100 ft. This arrangement reduced the transfer of inoculum from badly diseased plots to adjacent plots by 90 percent. For both leaf and stem rusts, best control was obtained when the first spray of the schedule was applied at a disease incidence of 1 uredium/culm, good control when applied at 10 uredia/culm, and poor control when applied at 100 uredia/culm. Leaf rust, however, was controlled more completely than stem rust. Rates of rust increase vary with prevailing conditions in different years, and the days per 10-fold increases ranged from 3.6 to 8.3 for leaf rust and from 4.0 to 10.0 for stem rust. Thus, rust development must be followed closely when weather is favorable for fast rates of increase to determine the relatively short optimal period for application of first sprays.

An additional difficulty affecting the optimal time for application of first spray was encountered in the stem rust epidemic of 1964. The first spray of the schedule to start at an incidence of 1 uredium/culm was applied on June 25. The counted number of uredia present on that date was 0.8 uredia/culm, but four days later counts had increased over 100-fold to 123 uredia/culm, a rate of increase twice as fast as any previous observations in three years. This increased rate of infection probably was due to spore showers in conjunction with rains that occurred from June 16 to 18. The omission of a surfactant from the spray mix in these particular trials resulted in poor eradication of rust; therefore, disease control by this early spray schedule was little better than that obtained when initial sprays were applied at a disease incidence of 100 uredia/culm.

These results indicate the difficulties of determining the optimal time to apply sprays of nickel sulfate plus maneb formulations to a wheat field for the control of leaf or stem rust epidemics.

DRILL-BOX SEED TREATMENT OF WHEAT

(Abstract)

Earl D. Hansing

Extensive experiments have been conducted during the last 5 years on treating wheat seed directly in the drill-box. Applications with formulations in the form of powder have been more effective than when they were applied as liquids. Powders have been applied at the rates of 1, 2, and 3 ounces per bushel of seed. Effective coverage of the seed was not obtained at the rate of one ounce. Good coverage of the wheat seed was obtained at 2 ounces per bushel and there was little excess fungicide.

Fungicides which have been evaluated extensively and are recommended at the rates of 2 oz/bu as Drill-Box Seed Treatments in Kansas are:

Orthocide HCB (20% captan and 20% hexachlorobenzene)
Ceresan M-DB (1.93% Ethyl mercury p-toluene sulfonanilide)
Panogen PX (0.9% Methylmercury dicyandiamide)

QUANTITATIVE ANALYSIS OF RUST SPORE DEPOSITION

(Abstract)

R. W. Romig

Air sampling for rust spores was conducted during the 1964 crop season at 25 weather observation stations using simple impactor traps. A trap consisted of a microscope slide mounted in a near-verticle position, approximately 100°, on a weather vane device. The slide was labelled, coated with a thin layer of vaseline, and had an effective deposition surface of 2.5 square inches. Slides were changed daily at approximately 0800 local time, and the date of exposure was considered to be the day that the slides were placed on the vane. Daily counts per slide of stem and leaf rust spores were recorded.

The advantages of this sampling device are that it is inexpensive, requires no power supply, requires little skill on the part of the local cooperator, and it gives a measure of spore deposition rather than of concentration. The disadvantages are that only counts for a 24-hour period are obtained, there is no selectivity (dirt, pollen, and other spores often obscure rust spores), the efficiency is low, and the efficiency varies directly with the wind velocity. Despite these limitations, spore counts correlated well with local rust development.

Regression analyses of the logarithmic transformations of the cumulative spore counts were highly significant statistically. Regression equations were calculated using the full range of values from the first to last days spores were trapped on the slides. However, even with logarithmic transformations, cumulative spore count curves were S-shaped.

Thus, slopes of the regression lines calculated tend to be flatter than those which would be derived by using mid-range values or by using some other manipulation, such as the logit transformation.

The objective of these analyses is to evaluate correlations between spore count data and certain weather factors as a basis for predicting or forecasting rust development.

HARD RED WINTER WHEAT UNIFORM REGIONAL BUNT NURSERY

(Abstract)

H. C. Young, Jr.

A brief summary of the entries in the Uniform Regional Bunt Nursery over the last 15 years was compared with a list of varieties released to growers in the Hard Red Winter Wheat Region. The comparison indicated that while most released varieties had been tested for bunt reaction in the nursery, susceptibility to bunt did not serve to deter release of the variety. Some concern was expressed over the fact that considerable acreage in the great plains area is now planted to varieties susceptible to bunt.

There was some discussion concerning the advisability of continuing the Uniform Regional Bunt Nursery, but it was ultimately decided to retain it in its present form.

THE UNIFORM RUST NURSERIES

L. E. Browder

There are two Uniform Wheat Rust Nurseries--one for winter wheat and the other for spring wheat. These overlap to some extent in the locations at which they are planted. Both have the same objective. That objective is to provide as broad a sample as possible of the rust causing organisms for testing certain host varieties. In these nurseries, this objective is approached in two ways. The first is observation of rust response and severity in the field at the various locations. These observations are collected and summarized and made available to cooperators and other interested parties. These data provide some information as to the distribution of virulence to the included materials. These materials include mostly host lines of which something is known of their resistance capabilities.

The other approach taken to sampling the pathogenic potential of the pathogen population is greenhouse studies of cultures from designated varieties. A completely adequate sampling for these pathogenicity tests is probably never attained. Undoubtedly, the Uniform Rust Nursery collections make up the best sample available on a practical basis. Obviously, we must consider the time and funds available for use in taking samples and in making tests.

A comparison of race data of Puccinia recondita f. sp. tritici from the Uniform Rust Nurseries (URN), with those from non-URN collections, and from total pooled data reveal that the addition of non-URN data shows the total race prevalence to appear more nearly like that of the central United States. This is simply because the major portion of non-URN collections are made in the central United States while races show a marked difference in frequency in different areas of the United States. Should there be a greater portion of the sample from the central U.S.? Probably so, but the point is that the widest possible, yet a practical sample is that for which we strive. The Uniform Rust Nurseries provide that sample. We should consider the type of sampling used when we look at race frequency data.

Collections are made from both fully susceptible varieties and from varieties which we know are differentially resistant to races. The collections from completely susceptible varieties probably tell us most of the true race frequencies, while the collections from differentially resistant varieties yield the more rare races. In breeding for resistance, we should consider both the prevalent and the rare races. We should look at the rare races for they may be the prevalent races of years to come.

We have the tools to search out the rare to very rare virulences in the pathogen population. We have means of characterizing sources of resistance to such virulences. From that point the problem becomes one of incorporating those resistances into commercial varieties. That too, is within the limits of our present ability. I hope to have available fairly soon a fairly extensive list of "universally resistant" sources of leaf rust resistant materials. We need to diversify the resistance sources used in our breeding programs.

In conclusion, if I have not made it evident, we appreciate very much the cooperation of many of you in the uniform rust nurseries and ask you to continue sending in rust collections and data from the nurseries.

The Uniform Rust Nurseries are small, and for this and other reasons the International Rust Nurseries are a better place to put extensive lists of materials for screening purposes.

Regarding collections, generally we want only susceptible type pustules from the field for use in greenhouse studies. However, if you suspect a new virulence it should be sent to the proper laboratory for study.

THE UNIFORM SOIL-BORNE MOSAIC NURSERY

(Abstract)

W. H. Sill, Jr.

The soil-borne wheat mosaic virus regional plot was planted in infested soil at Powhattan, Kansas on October 5, 1965. One hundred and twenty-one entries were planted plus several hundred breeding lines from Kansas. These tests have been very successful in the past and we expect them to continue to be most useful. Resistance found at Powhattan has been equally outstanding in other areas in the Great Plains. Since only one strain of the virus has been identified in this region, we expect the response to the virus to be very consistent in a given variety when the environment is favorable for disease development.

THE REGIONAL WHEAT STREAK MOSAIC NURSERY

(Abstract)

R. C. Bellingham

In three years testing, Scout has been uniformly tolerant throughout the region. With one exception, the susceptible check, CI 12851, has been uniformly susceptible in five years' tests. The trend for most varieties, however, has been a mixed reaction, both for year to year tests at any one station and for one year's test across the region. While general trends for type of reaction can be picked out, it is not possible to predict a variety's performance from year to year or location to location.

The data available would be more valuable if reports could be obtained every year from every station.

UNIFORM AND INTERNATIONAL RUST NURSERIES

W. Q. Loegering and L. P. Reitz

Three nurseries for making rust tests on winter wheat are coordinated from Beltsville. They are the International Winter Wheat Rust Nursery, the Uniform Winter Wheat Nursery, and the International Stripe Winter Wheat Rust Nursery. Three spring wheat nurseries are also conducted that are the counterpart of the winter wheat units. The Puerto Rico Testing Program is a part of the International testing aspect of the wheat program and provides for tests on a large number of early generation materials with cultures of potentially dangerous North American *Puccinia graminis tritici*. Winter wheat remains in the rosette in Puerto Rico but we believe more winter wheat should be submitted for this test.

The International Rust Nursery program has as its objectives the finding of new genes or combinations of genes which will protect the crop against rust and to test on an international basis new varieties and promising selections developed by plant breeders and pathologists for resistance to rust. The 1963 winter wheat nursery was grown at 31 locations in 18 countries.

Considerable information comes in on all three rusts but in order to screen specifically for stripe rust resistance a special nursery was set up for this purpose. Western breeders are primarily concerned with this nursery.

The Uniform Winter Wheat Rust Nursery is a small nursery of carefully selected advanced strains and named varieties. The main objective here is to permit U. S. pathologists the opportunity to study the rust situation in greater depth, to keep track of what is going on in the field where rust spreads with respect to types of resistance involved, races, new cultures of rust, and to get more detailed rust information on new varieties as they come into production. Many of the entries are semi-permanent to provide information over a series of years.

The spring wheat nurseries were discussed at spring wheat workers' conferences.

Your regional improvement leader alerts key breeders and pathologists annually to the use of these nurseries and tells you when and how much seed to send. We would like to thank all who have contributed to these nurseries for your promptness and cooperativeness in responding. These nurseries are sent to many parts of the world and one or another is being seeded somewhere practically every month of the year. Hence, it is a continuous process and one year overlaps another. Consequently, we must set rigid deadline dates for seed to reach Beltsville. The reasons are obvious.

Two problems persist. One involves proper identification of entries. We urge you to be careful to give the exact pedigree and correct identifying number. Often the numbers are a mixture of row numbers, years, selection numbers, other station designations, etc., without any clue as to which is which. Besides being wrong in many cases, our indexing and cross reference work is thrown into utter chaos by sloppy pedigrees and entails a lot of correspondence that should not be necessary.

Another problem is loose smut in the seed. We enlist your efforts to reduce this still further.

PROGRESS REPORT ON HYBRID WHEAT RESEARCH AT COLORADO STATE UNIVERSITY

Larry D. Robertson and Byrd C. Curtis

Two studies on hybrid wheat are in progress at Colorado State University. One of these is an attempt to locate by monosomic analysis the genes derived from *T. timopheevi* x Marquis^{3} (1) for fertility restoration of the cyto-steriles derived from *T. timopheevi* crosses. The other is a study of allelism in five varieties (Lancer, Gage, Blackhawk, Crockett and Relief) that have been shown by Livers (2) to give partial restoration in F_1 hybrids of crosses with the cyto-sterile *T. timopheevi* x Bison^{7}.

In the monosomic study the 21 Chinese Spring monosomics have been crossed to *T. timopheevi* x Marquis^{3}. The F_1's from these crosses should be of two types, containing either 41 or 42 chromosomes. The 42-chromosome type will be discarded. The plants of the 41-chromosome type will be crossed to male-sterile *T. timopheevi* x Bison^{8} plants. Assuming there are two genes on separate chromosomes for fertility restoration (1), the genotypes for this cross would be $rf_1rf_1rf_2rf_2$ x $Rf_1rf_1Rf_2$_ or $rf_1rf_1rf_2rf_2$ x Rf_1 Rf_2rf_2 or $rf_1rf_1rf_2rf_2$ x $Rf_1rf_1Rf_2rf_2$, the latter involving non-critical monosomic families. Progenies from crosses involving non-critical families should have a 1:2:1 segregation ratio for fertile: part fertile: sterile. The segregation ratio for the critical families should be 48:50:2 for fertile: part fertile: sterile. At the present time the F_1 plants for the restorer x the 21 monosomics are growing in the greenhouse.

The purpose of the allelic study is to determine whether the genes for partial restoration are at the same loci in the varieties being studied and whether a line can be developed from them that will give full fertility restoration. This study is being conducted by a graduate student, Mr. Robert Pylman.

We are making A and R lines out of each of the varieties as follows:

A	R
Bezostaja 1^{2} (PI 282687)	Bezostaja 1^{2} (PI 282687)
Wichita^{3}	Wichita^{2}
Cnn x PI 178383-2^{2}	Cnn x PI 178383-2^{2}
Tmp x T.-*Ae*^{2} (CI 13523)	Tmp x T.-*Ae*^{2} (CI 13523)
Gaines^{3}	Gaines^{2}
Colorow^{3}	Colorow^{2}
Avon^{2}	Avon^{2}
Kaw^{3}	Kaw^{2}
Quivira Cross Seln. K62136^{2}	Quivira Cross Seln. K62136^{2}

HYBRID WHEAT RESEARCH IN KANSAS

Ronald W. Livers

In 1957 J. A. Wilson took over the wheat project at the Hays station. Collaborating with sorghum geneticist W. M. Ross, Wilson began serious attempts to develop in wheat a system of male sterility comparable to the one which had made hybrid sorghum a reality. Following the lead of the Japanese, Wilson and Ross planned a program of substituting the common wheat nucleus into a dozen species of wheat and Aegilops by repeated backcrosses using the variety Bison as the recurrent pollinator.

In 1961, after growing the cross of Triticum timopheevi x Bison5, it was concluded that T. timopheevi cytoplasm in combination with Bison nuclear factors had resulted in a new and promising kind of male-sterile wheat. Following this discovery Wilson took employment with DeKalb to devote full time to development of hybrid wheat. At this time the University of Nebraska requested a few seeds of the new male sterile. A year later in October 1962 Nebraska announced that after crossing the Kansas male sterile with a T. timopheevi derivative, N542437, a few fertile hybrid plants resulted.

Also in October 1962 J. A. Wilson gave to the Hays Experiment Station some fertility restoring material with the pedigree T. timopheevi x Marquis3 which he had developed during his first year with DeKalb. A selection from this material crossed on Bison male sterile produced fully fertile F_1 plants in the greenhouse. Two dominant fertility restoring factors, Rf_1 and Rf_2, were indicated in F_2 and backcross generations. Highly fertile F_3 material from this cross has been distributed by the Kansas Experiment Station to about 80 breeders to date. Since March 1963 the original Bison male sterile has been distributed virtually world-wide to about 125 breeders, many of whom have made active use of the material.

Present research in Kansas relating to hybrid wheat has four phases: (1) development, observation and increase of male-sterile stocks; (2) development and observation of fertility-restoring stocks; (3) studies relating to seed production in the field on male-sterile wheats subjected to cross-pollination; and (4) performance studies of hybrid wheats.

Kansas has about a dozen well-developed male-sterile varieties in Ae. ovata cytoplasm. In all cases the A-lines are definitely later in maturity than the B-lines, making these steriles difficult to propagate. Major emphasis is on development of varieties with the timopheevi type of sterility. Kansas has 50 named varieties and about 75 experimental strains and plant introductions in various stages of A-line development. Nine sterile varieties are now in small field increase blocks. From this experience it is clear that most of these common wheat strains convert to good sterile lines. Several, including Relief and Blackhawk, evidently possess dominant fertility factors which prevent full sterilization. A few, including Cheyenne, appear to have a recessive factor which conditions partial fertility when homozygous in T. timopheevi cytoplasm. No objectionable characters have yet been associated with timopheevi type of cytoplasm in common varieties.

Fertility restorer development in Kansas to date has been entirely based on *T. timopheevi* x Marquis[3] material of Jim Wilson. Currently 28 varieties are being converted to restorers. Of these Itana has twice produced one-gene segregation for high fertility in backcrosses, and no male steriles have been recovered. Evidently Itana possesses either Rf_1 or Rf_2. In restorer backcrosses Cheyenne again displays the behavior expected of a variety with a recessive gene for fertility. Conclusions on other varieties which refuse to be sterilized have not yet been reached.

Seed production on cross-pollinated male-sterile wheats in the field has been under observation in Kansas since 1961. Failures and near-failures have been observed several times, and can be largely attributed to failure of steriles and pollinators to coincide in blooming; and in some seasons to the failure of pollinators to extrude their anthers well and shed pollen freely into the air. Setting aside trials with poor timing between parents, the frequency of observations between 30 and 70% of maximum indicate that production in this range may be expected. These studies have all been made with large areas of pollinator material adjoining relatively small areas of male sterile. In two studies the distance between steriles and pollinators was a factor. There was no indication that distance barriers up to 22 feet were effective in reducing pollination.

Almost all experiments in wheat in which hybrid vigor has been measured have been conducted with widely spaced F_1 plants. It is questionable if the same results would be obtained if the same hybrids were grown with planting rates comparable to those employed in commercial wheat culture. An experiment with wheat hybrids planted at the recommended rate of 45 lbs. per acre was grown at Hays, Kansas in 1964 from hand-crossed seed. Individual plots were single rows three feet in length and spaced 12 inches apart. Red Chief was seeded at each end of every row so that the hybrid plot area would be fully surrounded by a full stand of wheat. Hybrids grown involved the parental varieties Scout, Bison, Tascosa, Triumph, C. I. 13285, Ottawa and Cheyenne. In the test these parents ranged in yield from 34 down to 27 bushels per acre as listed. Eighteen of the possible 21 hybrids were grown in two replications. Their yields ranged from 45 down to 33 bushels per acre, or from 149% down to 97% of their respective parent varieties. The average of all hybrids was 122% of the parents. The LSD at the 5% level was 24%. Half of the hybrids were significantly better than their parents. The better hybrids showed considerable heterosis also in number of heads per plot and in straw yield. Hybrids were generally similar to the higher parent in height, head size, seed weight and test weight. In heading date the hybrids were very close to the mid-point between parents. Hybrids from this group, if they continue to show high productivity, should be quite acceptable for use in Kansas. They are included in a 9-variety diallel study now being grown like the above experiment. A 5-variety diallel is being grown at three Kansas locations in 1965.

The following strains are now being grown in Kansas to develop sterile forms:

ms[t] x Ace 2
x American Banner[4]
x (Atlas-66)[4]
x Austin[4]
x Avon[2]
x Aztec[6]
x Baart[2]
x Bezostaja-1[2]
x Bison[11]
x Blackhawk[4]
x Blackhull[4]
x Brevor[4]
x Burt[4]
x Caddo[4]
x Cheyenne[3]
x Chul[2]
x Cimarron[4]
x Clarkan[4]
x Columbia[4]
x Comanche[5]
x Crockett[4]
x Dual[2]
x Gaines[2]
x Genessee[4]
x Iobred[4]
x Ioturk[4]
x Kanred[4]
x Kaw[4]
x Kawvale[3]
x Knox[4]
x Monon[2]
x Omar[4]
x Orienta[4]
x Ottawa[5]
x Pawnee[4]
x Purplestraw[4]
x Quadrat[4]
x Red Bobs[2]
x Red Chief[3]
x Redcoat[2]
x Scout[6]
x Steinwedel[4]
x Tascosa[5]
x Tendoy[2]
x Todd[3]
x Triumph[5]
x Westar[3]
x White RedChief[2]
x Wichita[4]
x CI 12406[4]
x CI 13285[6]
x CI 13548[4]
x 14 Experimentals[2]
x Scout[4] x 35 Scout Sel.[2]
x Ottawa[3] x 3 Ot Sel.[2]
x 20 plant introductions[2]

ms[o] x Amer. Banner[5]
x Bison[7]
x Blackhull[6]
x Cimarron[6]
x Kanred[6]
x Knox[7]
x Orienta[6]
x Pawnee[7]
x Purplestraw[7]
x Red Chief[6]
x Travis[8]
x Wichita[6]
x CI 13285[8]

ms[c] x Tascosa[6]
x Bison[2]

t = <u>timopheevi</u>
o = <u>ovata</u>
c = <u>caudata</u>

The following strains are now being grown in Kansas to develop fertility-restoring forms. The source of restoration in all cases traces to <u>T. timopheevi</u> x Marquis[3].

R x Atlas-66[2]
x Aztec[3]
x Bison[4]
x Blackhawk[2]
x Brevor[2]
x Burt[2]
x Caddo[2]
x Cheyenne[3]*
x Clarkan[3]
x Columbia[3]
x Comanche[2]
x Concho[3]
x Crockett[2]
x Gage[2]
x Itana[3]*
x Kaw[3]
x Knox[2]
x Lancer[2]
x Ottawa[2]
x Ponca[2]
x Relief[2]
x Scout[2]
x Tascosa[3]
x Orienta[2]
x Wichita[2]
x CI 12406[2]
x CI 13285[4]
x CI 13548[2]

HYBRID WHEAT RESEARCH IN MINNESOTA[1]

Earl C. Gilmore, Jr.

The status of our male sterile program is as follows:

Generation	Recurrent Parent
B_3F_1	Thatcher, Pembina, Selkirk, Justin, Crim, Lee, Marquis
B_1F_1	Experimental strains II-55-11, II-55-12, II-55-14.

Our restorer program has met with difficulties. We are using 5 sources of fertility restoration as follows: Nebraska Experiment Station - Kansas Experiment Station - Dr. Campbell at Winnipeg - Professor Shebeski - and our own crosses to T. timopheevi. At the present Professor Shebeski's material appears to be the most promising. We have used the same lines given above in crosses with these sources of restorers, but our main problem has been finding germplasm that gives fertile F_1's before backcrossing. It appears that more is involved than two dominant restorer genes. I suspect modifiers, perhaps recessive modifiers, are an important part of at least some of the genetic systems of stocks we have used in crosses.

1/ A portion of a letter received from Earl Gilmore.

MONTANA HYBRID WHEAT PROGRAM

J. R. Welsh and F. H. McNeal

The current activities of the hybrid wheat program in Montana are centered primarily around the production of standard winter and spring varietal lines of male-steriles and restorers. This program is being conducted by Mr. Leonard Joppa, who is working toward a Ph.D. in genetics. At present, it is anticipated that the lines, when completed, will be used as tools in basic research studies with little emphasis placed on hybrid variety production. The lines are currently in the second and third backcross.

A heterosis study involving three crosses between four hard red spring wheat varieties was carried out by F. H. McNeal and others in the summer of 1964 (Tables 1 and 2). The F_1, and F_2, and parent populations were grown in five replications at each of two locations. Evaluations were made for heading date, plant height, number of heads per area, number of spikes per head, kernel weight, number of kernels per head, yield, protein per cent, sedimentation, and the farinograph characteristics of absorption, peak, stability and valorimeter. With three exceptions, the F_1 and F_2 were intermediate between the two parents and in no case did they exceed the high parent by a significant amount. The quality characteristics of the F_1 and F_2 populations were no worse than the poorest parent and in some cases, tended toward the better parent.

Table 1. Agronomic data from a Heterosis study at Bozeman and Huntley, Montana, 1964.

Plant character	Expression of hybrid population: Low parent	Inter-mediate	High parent
Heads/8' row:			
F_1		4	2
F_2		4	2
Spikelets/head:			
F_1		4	2
F_2	2	3	1
Kernel weight:			
F_1		3	3
F_2		6	
Kernels/head:			
F_1		4	2
F_2	1	4	1
Bushels/acre:			
F_1		2	4
F_2		4	2

Table 2. Quality data from a Heterosis study at Bozeman and Huntley, Montana, 1964.

Quality Characteristics	Expression of hybrid population: Low Parent	Intermediate	High Parent
Protein %:			
F_1	1	2	3
F_2		3	3
Sedimentation:			
F_1	2	3	1
F_2	2	3	1
Absorption:			
F_1		6	
F_2		6	
Peak (min.):			
F_1		4	2
F_2		2	4
Stability (min.):			
F_1		3	3
F_2		3	3
Valorimeter:			
F_1	1	1	4
F_2	1	1	4

Hybrid Wheat Stocks Being Developed At Montana State University

1. Winter Wheats	2. Spring Wheats
Warrior[2]	Selkirk[2]
Winalta[2]	Justin[2]
Scout[2]	Santana[2]
Cheyenne[2]	B52-91[2]
Gaines[2]	B61-95[2]
Rego[2]	Centana[2]
Yogo[3]	Ceres[2]
Itana[2]	Rescue[2]
Nebred[2]	Thatcher[2]
Westmont[2]	

SUMMARY OF HYBRID WHEAT WORK
UNIVERSITY OF NEBRASKA

John W. Schmidt and V. A. Johnson

Cytoplasmic male sterility (Nebraska-ARS source) is being transferred into about 40 varieties and experimental strains. Additional promising experimental lines will be included in this program this winter. The most advanced sterile lines are with varieties such as Scout, Wichita, Lancer, Ottawa, etc. Backcrossing involving such varieties is proceeding in both the greenhouse and field concurrently. Most of the work is with winter wheats.

Male fertility restoration (Nebraska-ARS source) is being transferred to some varieties and especially to promising experimentals. From such crosses promising F_3 lines homozygous for restoration and other important characteristics may be tested as potential pollinator lines.

Fertility restoration has been compared on a small scale under growth chamber, greenhouse and field conditions. It appears to be best under field and growth chamber conditions and poorest under greenhouse conditions. Light intensity appears to be involved.

We now have information indicating that some of our common wheat varieties such as Cheyenne have potential for partial restoration. This is both good and bad. These additional factors for restoration can be used to bolster those factors obtained from <u>timopheevi</u> derivatives. At the same time it is obvious that not all common wheats will sterilize well.

Preliminary cross-pollination studies last year indicated seed set on sterile lines ranging from 45-65 per cent. These involved seed set on sterile plants pollinated by adjacent pollinator lines. While this gave no indication of the distance over which effective pollination would have occurred, this did indicate that cross-pollination was fairly good in a non-favorable year since weather conditions at pollination time were not considered to be favorable for cross-pollination.

Studies in progress (planted in the field in the fall of 1964 for 1965 season) include seeding rate studies at three locations, a replicated cross-pollination study at Lincoln with two varieties and a crossing block of seven male sterile or A lines with an apparent homozygous restorer line. The latter could provide F_1 seed in quantity for yield testing in 1965-66. It is not expected that these will result in commercial hybrids. They are being made up to learn more about restoration stability.

Varieties being converted to A lines (Nebraska sterile):

Wichita[2]	Hume[2]
Scout[2]	Gaines[2]
Gage[2]	Warrior[2]
Bison[3]	Aztec[2]
Omaha[2]	Winalta[2]
Lancer[2]	CI 13285[3]
Ottawa[2]	CI 12406

Many experimentals with one or two crosses.

Varieties crossed to Nebraska R line:

Cheyenne[2]	Scout
Kaw[2]	Gage
Wichita	Knox 62
Winalta	CI 12406

Numerous experimental mostly first cross.

WORK WITH MALE STERILE AND RESTORER LINES AT CLOVIS, NEW MEXICO

David B. Ferguson

Very little progress in the area of producing male sterile and restorer lines has been made at this station. The encountering of two primary disease problems, one a cool weather problem and the other a hot weather problem, has inhibited our work.

Wheat streak mosaic was encountered in a detrimental dosage during the summer period. Vernalized plants were removed from the cooler and planted in the field in June. The disease hit so severely that these plants were destroyed to the point that heading was not even accomplished. The only solution that can be offered at this time is to avoid this period of the year.

Damping off of young plants during the vernalization period has added a great deal of destruction to the young plants. The addition of panogen in small but effective dosages controlled the soil organizms. This control, however, was coupled with a toxic effect from the panogen or at least we suspicioned this to be the effect of the fungicide. At this time, we are trying a different fungicide to control the damping off, with apparently good results. Captan-Folet (Stauffer Chemical) has a low toxicity index and appears to be giving control.

We are now back into the Hybrid program thanks to the good offices of Dr. Porter and Dr. Craddock.

HYBRID WHEAT--NORTH DAKOTA

Karl Lucken and S. S. Maan

(Presented by K. L. Lebsock)

The hybrid wheat program at North Dakota was initiated in January, 1964, with two full-time personnel, Karl Lucken and S. S. Maan. This report presents a review of the various studies planned or under way.

Breeding Program. Advanced lines from the hard red spring and durum wheat projects in the area and several foreign spring wheats are being converted to A and R line status using both the Kansas and Nebraska sources of cytoplasmic sterility and restoration. For most, one or two backcrosses have been completed. These wheats will be tested in the field this summer to definitely establish their status as A and R lines and to determine further the effects of environment on the expression of sterility and fertility.

Small increases of a few A lines are planned.

Genetics and Cytogenetics. Both the Kansas and Nebraska restorer sources are giving two-factor segregation--usually. Exceptions (particularly with the Nebraska restorer) apparently represent cumulative restoration genes and/or recessiveness or incomplete dominance of certain restoration factors. These are being studied further.

The final cross of a monosomic analysis to locate the chromosomes carrying the fertility restoration factors of the *T. timopheevi* x Marquis^3 line obtained from Kansas now is being grown in the greenhouse.

A Chinese Spring monosomic set having *T. timopheevi* cytoplasm is about half completed (with three doses of Chinese Spring). We plan to complete the set by next year.

For his Ph.D. thesis problem, John Erickson is studying the biochemical basis of cytoplasmic male sterility.

Cross-pollination. Cross-pollination experiments were conducted this past summer using ms^t x Selkirk^3. Although seed set was quite good, interpretation of the data is difficult because of some self-fertility.

Simulated crossing blocks involving four or five varieties will be grown at several locations in the state this summer.

Hybrid Vigor. An eight-variety diallel cross will be grown by Pablo Larrea for his master's thesis research. Agronomic data will be taken but primary emphasis is on the milling and baking characteristics.

North Dakota--A and R Lines

A Lines*	R Lines
Conley^3	(T.t. x Mq^3) Conley^2
Crim^3	" Crim^2
Justin^5	" Justin^2
Lee^4	" Lee^2
Pembina^5	" Pembina^2
Selkirk^5	
Thatcher^3	
Lakota^5	
Wells^5	

*These lines have not been tested in the field to determine if their sterility is complete. The exception is Selkirk which sometimes has some self-fertility.

HYBRID WHEAT PROGRESS REPORT--OKLAHOMA

Ben R. Jackson and A. M. Schlehuber

Hybrid wheat investigations to date have been primarily concerned with increasing seed supplies, initiation of backcrossing programs and obtaining information on the degree of cross-pollination under field conditions.

Backcrossing Program

Twenty-two wheat varieties and selections are involved in the back-crossing program for the production of male-sterile counterparts. A majority of the lines under development contain the *Triticum timopheevi* cytoplasm; however, a few lines containing the *Aegilops ovata* and *Aegilops caudata* cytoplasms are also being produced (see separate list).

The Kansas source of fertility restoration (*T. timopheevi* x Marquis^3) is being transferred into ten varieties of wheat. Three selections from the Nebraska 542437 population that appeared to have good restoration ability have been crossed to eight different "B" lines. Further evaluations of the restorer selections are being made under greenhouse and field conditions.

Evaluation of Nebraska Lot 1 and Lot 2 Restorer

Detailed field observations were made on 26 plants from Lot 1 and 28 plants from Lot 2 in 1964. Plants in Lot 2 averaged one inch shorter, one day earlier, eight per cent more seed set (unbagged heads) and approximately 60 per cent more tillers, spikelets and seeds per plant than plants in Lot 1.

All plants in both lots exhibited a type four reaction to leaf rust; however, four plants in Lot 2 and two plants in Lot 1 had a 0 type reaction to stem rust while all other plants were type 4. Lot 2 contained three dwarf plants (24 to 27 inches in height) whereas all Lot 1 plants were of normal height.

Visual estimates of per cent seed set agreed quite well with actual seed set except for spikes with less than 70 per cent fertility in which case visual estimates were generally lower than actual counts. Fertility ranged from 60 to 100 per cent for Lot 1 and 45 to 100 per cent for Lot 2. In Lot 1, 50 per cent of the plants had 100 per cent seed set whereas Lot 2 had only 18 per cent in this class.

Screening for other Fertility Restorers

Thirty-three Sando wheat selections containing *Triticum timopheevi* in their parentage were test crossed to Bison male-sterile plants. The F_1 hybrids are presently growing in the field and the results will not be available until late spring.

Cross Pollination Study

Approximately 24 per cent seed set was obtained under field conditions in 1964 using a male sterile wheat containing the *Triticum timopheevi* cytoplasm. Wheat strains containing the *Aegilops ovata* cytoplasm produced seed set ranging from four to seven per cent. Heading dates of the pollinator parents coincided with the *T. timopheevi* sterile whereas the *Ae. ovata* male sterile lines flowered from seven to fourteen days later than the pollinator.

Present and Future Plans

1. Studies to compare the inheritance of restorer factors of Nebraska 542437 under greenhouse and field conditions using both seed set and pollen stainability as a basis for classification.

2. Extended studies on the amount of cross pollination involving different climatic conditions.

3. Studies of the influence of the different cytoplasms of *Ae. ovata*, *Ae. caudata* and *T. timopheevi* on characters of economic importance (in male-sterile lines of similar genotypes).

4. As a possible means of identifying promising hybrid combinations at a minimum expense, a study will be made of the relationship between heterosis in the F_2 and F_1 generations.

List of A and R Lines presently being developed in Oklahoma.

__Male-Sterile Lines__

Nebr. 542437[A] x Bison[4]
" x Super Triumph[3]
" x Tascosa[3]
" x Concho[2]
" x Crockett[2]
" x Kaw[2]
" x Pawnee[2]
" x Scout[2]
" x Triumph[2]
" x Tmp. X T-Ae.[2] (C.I. 13523)
" x Wichita[2]
" x C.I. 13285
" x Norin 16 x C.I. 12500 (C.I. 13678)
" x Novi Sad (P.I. 221366)
" x Probus (P.I. 263564)
" x R. Kolben (P.I. 201137)
" x Tmp. C.I. 12406 (Stw. 627169)
" x Tmp. C.I. 12406 (Stw. 627439)
" x Tmp. C.I. 12406 (Stw. 627530)
" x Yeoman[C] (P.I. 263564)
Ks. T. timopheevi[A] x Bison[8]
Ks. T. timopheevi[A] x Concho[3]
Tex. Ae. Caudata[A] x Tascosa[6]
Tex. T. timopheevi[A] x Wichita[3]
Wilson Ae. Ovata[A] x Early Blackhull[4]
" x Kaw[4]
" x Pawnee[4]
" x Tcs[4]
" x Wichita[4]

__Restorer Lines__

T. tim x Marq[3R] x Bsn[2]
" x Concho[2]
" x Norin 16-CI 12500[2] (CI 13678)
" x Super triumph[2]
" x Triumph[2]
" x Tmp-C.I. 12406[2] (Stw 627169)
" x Tmp-C.I. 12406[2] (Stw 627439)
" x Tmp x T-Ael.[2] (C.I. 13523)
" x Kaw
" x Tmp-C.I. 12406 (Stw 627530)
N.542437[R] (Okla.40R) x Kaw
N.542437[R] (Okla.31I) x C.I. 13285
" x Early blackhull
" x Kaw
" x Kaw x DS28A-Ponca
" x Pawnee
" x Tascosa
" x Triumph
N.542437[R] (Okla.35M) x Crockett
" x Kaw

HYBRID WHEAT--SOUTH DAKOTA

D. G. Wells

Yields of the F_1 hybrid in seventy-one crosses are being determined in spring wheat in field and greenhouse but the data have not been fully analyzed. Parents of some of the obviously better hybrids, however, were Pembina, Spinkcota, II53-661, CII3654, Lathrop, RL2938, CII3296, ND264, II53-733, and some South Dakota selections. A test of this kind in winter wheat was seriously damaged by barley yellow dwarf. Another test in winter wheat is being made.

In winter wheat, no clear distinctions were observed between the survival of parents and their F_1 hybrids at Brookings where survival was almost perfect and Watertown where killing was almost complete.

A spacings study in spring wheat was made using the cross Lee x II50-17. Spacings were 1½" and 6", 1½" x 12", 3" x 6", and 3" x 12" for hills and rows respectively. Analysis of the data is not complete.

Transfer through backcrossing of two restorer factors to Nebred is being made on a background of genes for spring growth habit. The donor parent had spring habit genes from Marquis and Lee. Eleven seeds of F_1BC_1 produced 11 plants in the greenhouse from September 4 seeding. All headed without vernalization but two of them were too late for crossing. Heading of the backcross plants corresponded with that of vernalized Nebred. Bagged heads on 7 of the 9 plants studied produced no seed. The other two plants yielded 19% and 66% seed sets from selfing corresponding with an expectancy of 1 fertile plant in 4. Spring habit genes in Lee are strong. In the F_2 of Lee x Nebred, all 39 plants headed in the greenhouse although two were late. In F_1BC_1 in an earlier greenhouse crop of Nb_2 x Lee, a ratio of 6:5:6 was obtained for spring, intermediate, and winter type plants without vernalization. Not having to vernalize BC progenies may save time in some programs when a spring wheat donor can be used and a continuing supply of the vernalized recurrent winter wheat parent is maintained.

The fertility of the Kansas R lines was 92% over 9 bagged heads from September 4 seedings in the greenhouse. The fertility of the Nebraska R line was 84% over 5 bagged heads under similar conditions. The difference may not be significant.

The fertility of the F_1 of R line x variety was much higher over numerous crosses in spring wheat than in winter wheat in the greenhouse. The Kansas R line parent was used in each instance.

Ten crosses onto A lines in winter wheat are being attempted to obtain enough seed for hardiness tests at two locations in the field.

In the winter wheat field nursery, Lancer heads were tweezer emasculated at Brookings in two different rows and allowed to be open-pollinated.

Distance to pollinator	No. heads	Total florets	Seed set
2 ft.	26	640	39.1%
4 ft.	30	794	35.0%

Tweezer emasculated heads in 5 varieties or strains were allowed to be open-pollinated in otherwise undisturbed rows at Brookings.

Variety or Strain	Total Florets	Seed Set
Cheyenne	100	36%
Yogo x Cnn	52	64%
Yogo x Rmr	150	67%
Gage	59	44%
Nebred	95	55%

Heads of Hume were tweezer emasculated and 4 artificially pollinated each day 2 days to 9 days later to test longevity of stigma receptivity of bagged heads. Seed sets were 98% for the check, 72% for 2 days after emasculation, and 53% after 9 days.

Additional tests of stigma receptivity in bagged heads were made in three nursery rows.

		Total florets and seed set %				
			Days elapsed between emasculation & pollination			
Name	Crossed with	Check	2	5	8	11
N63282	Gage	60-78%	24-88%	37-92%	41-20%	21- 0%
Sel. of PII334457	Gage	42-91%	58-59%	67-84%	60-40%	19-11%
Piold Karte	Gage	66-94%	46-57%	44-73%	42-71%	--

Winter Wheat

Conversion to A & R lines at the same time:

	Donor		Donor	Progress
Omaha$_1$	Ks R line	Lee	Ks R line	F_1BC_2
Pawnee$_1$	"	ND271	"	F_1BC_1
CI 13285$_1$	"	SD626	"	"
SD56-497$_1$	"	SD6210	"	"
Gage$_2$	"	SD6329	"	"
Hume$_2$	"	CI 13655	"	"
Pawnee$_1$	"	CI 13654	"	"
Winalta$_2$	"	CI 13751	"	"

	Donor
Sd56-758$_1$	Ks R line
N61603$_1$	"
N61608$_1$	"
CI 13864$_1$	"
N62337$_1$	"
N60227$_1$	"
N61359$_1$	"
N61355$_2$	"
N61358$_1$	"
N61623$_1$	"
N61648$_1$	"
N61660$_1$	"
N61663$_1$	"
N61919$_1$	"
N61924$_1$	"
N61930$_1$	"
N61942$_1$	"
N63265$_2$	"
N61976$_2$	"
N63282$_2$	"
Ottawa$_2$	"
N61954$_1$	"
N61975$_1$	"
N62310$_1$	"
CI 13684$_1$	"
N63265$_1$	"
K63171$_1$	"
Nebred$_3$	"

Conversion to A line

N61954$_1$	Nebr. A line
N61976$_1$	"
Ks60227$_1$	"
Hume$_2$	"

	Donor	Progress
Rushmore	Ks R line	F_1BC_1
Crim	"	"
Canthatch	"	"
Willet	"	"
Pembina	"	"

Conversion to A lines

ND137	Nebr. A line	"
II53-737	"	"
II50-17	"	"
I		

PROGRESS OF HYBRID WHEAT RESEARCH IN TEXAS

K. B. Porter, O. G. Merkle, I. M. Atkins,
M. Kherde & Keith Lahr

Hybrid wheat research has been conducted for several years using *Ae. caudata* and *Ae. ovata* type steriles. *Timopheevi* type steriles were included in studies during the last two years. Seed set studies have been given the primary effort, but research on vigor of sterile hybrids and pollen-restoration has been conducted or initiated during 1963 and 1964.

Seed Set Studies:

Seed set on male-sterile wheat, 1961-1964, has ranged from 3 to 61 percent depending on type of sterile, location and pollinator. Seed set on *caudata* and *ovata* type steriles (small crossing blocks in Northwest Texas, 1962 and 1963) varied from 3 to 18 percent. Seed set on male-steriles in small 4-row nursery plots of 45 different pollinators averaged 9, 30 and 31 percent for *ovata*, *caudata* and *timopheevi* types, respectively, at College Station in 1964. Seed set on *timopheevi* type steriles grown in plots of Supremo and Denton was 60 percent. Certain *Aegilops*, *timopheevi* and *Agropyron* derivatives also appeared to be relatively good pollinators. These pollinators also gave some of the higher seed set on *ovata* and *caudata* type steriles. Measurements indicated the different pollinators differed considerably in length of anthers. Whether or not larger anthers also indicate more pollen produced is not known.

Seed set on MS Bison (*timopheevi*) at Bushland, where Bison and the World Wheat Collection were used as pollinators, was 27 and 40 percent, respectively, and 49 percent on MS Wichita plants placed in a field of Wichita.

Hybrid Vigor:

Forage production of sterile hybrids involving essentially MS Tascosa having either *ovata* or *caudata* cytoplasm and the pollen parents Crockett, Knox, C.I. 13523, Concho and a composite of the World Wheat Collection was measured in a clipping test at College Station in 1964. Only (MS Crockett x $Tascosa^2$) x W.W.C produced significantly more forage than either parent while the forage yield of the other hybrids were equal to or less than that of the mean of the parents. MS $Tascosa^5$ produced 10% less forage than fertile Tascosa.

Pollen-restoration:

The Nebraska and Kansas restorers are being used in transferring restoration to other lines. Lot 1 of Nebr. 542437 and the *T. timopheevi* x Marquis[3] restorer obtained from Kansas appeared to be quite fertile in the greenhouse and F_1's of crosses of these with Warrior and C.I. 13285 were also highly fertile in the greenhouse. F_1 plants of the cross of Lot 1 x *T. timopheevi* x Marquis[3] were highly fertile and the anthers were plumper than those of either parent. It is believed that selected lines from this cross may have more factors for restoration than either parent. Progeny tests and test crosses are being grown to gain additional information.

Progeny of 6 apparently fertile plant selections made from bulk Nebr. 542437, which restore at least partial fertility, gave different expressions of fertility in the greenhouse and field. Progenies of five of these plants were only partially fertile and 1 was highly fertile in the greenhouse but all appeared fertile in the field. Forty lines from the progeny that was fertile in both greenhouse and field, Texas GH 1055, are being increased in the field and checked for pollen-restoration.

One thousand plants, progeny of MS Bison x composite of the W.W.C. and progeny of all crosses from the 45 different pollinators at College Station, are being grown to isolate any fertile types as well as to check forage production of these sterile hybrids.

Thirty to 40 lines from Lot 1 and from a selection of Nebr. 542437 received from R. W. Livers are being increased in the field.

Material anticipated in fall of 1965 and proposed studies:

One to two bushels of MS Bison[10], 2 to 3 pounds of MS Wichita[4], 1 to 3 pounds of MS Lee[5] and 1000 seed of several other A lines. These will be used to produce seed of fertile hybrids should selections of Nebraska 542437 be found to be adequate restorers and for more extensive seed production studies.

A limited amount of seed of hybrids of MS Bison, MS Wichita and MS Lee x GH 1055, Nebr. 542437, may be available for planting in 1965. These may not be completely fertile. Research concerning pollen production and dissemination, flower characteristics, combining ability and species crosses with male-sterile wheat is planned within the limits of available funds and personnel.

A Lines

Ks *T. timopheevi*[A]	x Bison[9]
"	x Concho[3]
"	x Imp. Triumph[3]
"	x Tascosa[3]
"	x Wichita[3]
"	x Knox[3]
"	x Kaw[3]
"	x C.I. 13684[3]

Pollen restoration:

The Nebraska and Kansas restorers are being used in transferring restoration to other lines. Progeny of Nebr. 542437 and the T. timopheevi [illegible] restorer obtained from Kansas appeared to be quite [illegible] in the greenhouse and F1's of crosses of these with male-sterile [illegible] were also highly fertile in the greenhouse. F1 plants of the [illegible] x T. timopheevi x Marquis³ were highly fertile and the anthers were plumper than those of either parent. It is believed that selected lines from these crosses may have more factors for restoration than either parent. Progeny tests and test-crosses are being grown [illegible] additional information.

Progeny of 6 apparently fertile plant selections made from Nebr. 542437, which restore at least partial fertility, gave different expressions of fertility in the greenhouse and field. Progenies from five of these plants were only partially fertile and 1 was highly fertile in the greenhouse but all appeared fertile in the field. Forty lines from the progeny that was fertile in both greenhouse and field, [illegible] 1055, are being increased in the field and checked for pollen-restoration.

One thousand plants, progeny of NS Bison x composite of the [illegible] progeny on all crosses from the 83 different pollinators of [illegible] Station, are being grown to isolate any fertile types as well as to check for seed production of these sterile hybrids.

Thirty to 40 lines from Lot 1 and from a selection of Nebr. [illegible] received from R. A. [illegible] are being increased in the field.

Material anticipated by fall of 1965 and proposed studies:

[illegible] two [illegible] NS Bison¹⁰, 2 or 3 pounds of NS Wichita⁸, [illegible] pounds [illegible] seed of several other A lines. These will be used to produce seed of fertile hybrids should selections of Nebraska 542437 be found to be adequate restorers and for [illegible] seed production studies.

A limited amount of seed of hybrids of NS Bison, NS Wichita and NS [illegible] x [illegible] 1055, Nebr. 542437, may be available for planting in 1965. These may not be completely fertile. Research concerning pollen production and dissemination, flower characteristics, combining ability and [illegible] crosses with male-sterile wheat is planned within the limits of available funds and personnel.

[illegible]
1a T. timopheevi x Bison²
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

HYBRID WHEAT WORK IN WASHINGTON

R. E. Allan and O. A. Vogel

1. The performance of 11 F_1 hybrids was compared to their parents and the variety Gaines during the 1964 crop year. This nursery was sown at a seeding rate comparable to 25 pounds per acre in rod-row plots subjected to a medium and high fertility level. The trial consisted of a late October seeding made under unfavorable soil moisture conditions. For the most part, medium to poor stands were secured. In general, F_1 hybrids had stands superior to either parent or Gaines; 9 of the 11 hybrids had stands superior to either parent, averaging 14 to 81% heavier. All hybrids exceeded the stands of Gaines and averaged 3 to 74% heavier.

2. All hybrids produced grain yields superior to Gaines. When yields of the fertilized and nonfertilized portions were combined, hybrids exceeded the Gaines yield by 3 to 50%; 4 of the hybrids exceeded the yield of Gaines by 22 to 50%. The average yield of Gaines was about 64 bushels at both levels of fertility. Most of the hybrids also exceeded the yield of their better yielding parent. In 5 of the hybrids the increase in yield was from 31 to 74% greater. Much of the increase in yield of the hybrids over Gaines or the better parent could be attributed to heavier stands and/or to more tillers per plot. Nevertheless, in several instances after differences in stand or tiller number were taken into account, considerable (20 to 45%) yield increase over the better parent was noted.

3. Like yields, straw weights were generally greater for the hybrids than for the parents or Gaines. Furthermore, the increase in straw weight of the hybrids over the parents or Gaines was greater than the corresponding increase observed in grain yield. Of the 11 hybrids studied intensively, 8 hybrids were from 11 to 42% taller than Gaines, whereas only 2 were comparable to Gaines in height level. Hybrids taller than Gaines may be at a disadvantage under conditions conducive to lodging.

4. Generally, test weights were found to be lower than the higher parent, but most test weights of hybrids exceeded or were equal to Gaines.

5. Data obtained on cross-pollination was secured from 4 crossing blocks involving Gaines, Selection 101, Marfed, and the world-wheat-bulk collection serving as pollen sources. *T. timopheevi* cytoplasmic sterile (common wheat background) served as female plants. Seed set obtained averaged 36, 31, and 15% for the Gaines, Marfed, and Selection 101 blocks, respectively. The yield on cytoplasmic sterile plants pollinated by the world wheat collection was about 13 bushels per acre. Yields on cytoplasmic sterile plants pollinated by Gaines, Marfed, and Selection 101 were estimated at 38.6, 45.7, and 9.2 bushels per acre, respectively.

Development of A Lines and R Lines in Washington

A Lines	R Lines
14 x 53-1	Burt
Gaines, C.I. 13448	Brevor
14 x 53-101, C.I. 13438	Itana
Marfed	Burt Kenya 70136
14 x Burt^5, Sel. 4	Marfed
Suwon 92-Burt^3	Gaines
	14 x 53-101

HYBRID WHEAT RESEARCH IN WYOMING

B. J. Kolp

We have started to develop some A and R lines. These are lines that I believe would be desirable in hybrids suitable for Wyoming conditions or lines that possess one or two desirable characteristics that I am interested in working with.

A lines*	R lines* (Kansas)
Early Blackhull[1]	Shoshoni[1]
Triumph[1]	Minter[1]
Sel. 152[1]	Yogo[1]
W.S.M.I.[1]	Turkey Red[1]
	(E.B. x Ssh^3)[1]
	C.I. 12711 (Tk x Cnn)

* I may develop both A and R lines in these groups.

WHEAT HETEROSIS EXPERIMENTS IN THE SOFT WHEAT AREA

L. W. Briggle

The winter wheat varieties Gaines (CI 13448) and Reed (CI 13513), and the spring wheat varieties Henry (CI 12265) and Lemhi 53 (CI 13068) were chosen as parents for production of wheat hybrids. Each of the 4 is considered a high-yielding variety in its area of adaptation. Each cross (spring x spring and winter x winter) represents the combination of the two widely different wheats.

Reed x Gaines F_1, Reed, and Gaines plants were grown in a split-plot experiment at Aberdeen, Idaho in 1963. Each plot, replicated 4 times, consisted of 3 rows, 3 feet long. The center 2 foot area of the middle row was harvested for yield as well as being used for component of yield determinations.

The 2-foot area of the plot harvested was bordered by one parent in 2 reps and by the other parent in 2 reps. Each of the 3 entries (F_1 and the 2 parents) was planted at 5 different rates, ranging from 33 seeds per foot to about 4 seeds per foot.

The same design was used for the spring wheat experiment with Henry x Lemhi 53 F_1, Henry, and Lemhi 53.

The two experiments were repeated in 1964. The only change involved addition of an F_2 entry in each. In 1965, F_3 populations will be included also.

In the winter wheat experiment the F_1 yielded 33.9% more than the higher parent in 1963, and 28.9% more than the higher parent in 1964. The F_2 produced less grain than any other entry in 1964.

In the spring wheat experiment the F_1 yielded 19.5 and 19.2% more than the higher parent in 1963 and 1964, respectively. The F_2, grown only in 1964, was midway in yield between the two parents.

All yield data reported are based on means over all 5 rates of planting. The F_1 populations, however, showed superiority over the parents at each rate.

Experiments Underway at Purdue University

Heterosis and gene action are being studied by Mr. S. Fonseca, under the direction of Dr. F. L. Patterson. An experiment involving a 7-parent diallel cross was grown in 1963. Hill plots at 3 rates (3, 6, or 9 plants) and 3 replications were used. Performance of F_1's ranged from 24% less to 72% more than the highest parent.

In a second diallel cross Mr. M. J. Bitzer and Dr. F. L. Patterson used single 6-foot long rows (without borders) replicated 3 times to test F_1's and parents. One rate, that of 15 seeds per foot, was used. F_1's produced from 31% less to 57% more in this series than the higher yielding parent. In no case, however, was the F_1 yield much greater than that of the best parent in the entire experiment.

Bitzer and Patterson tested crosses of 11 soft red winter varieties with the common parent Knox 62. Plots used were identical with the experiment just described. F_1 yields varied from 17% below the better parent to 15% above.

Bitzer and Patterson conducted an experiment on wind pollination of wheat. Pollinators were grown in large blocks (310 ft x 140 ft) with the female varieties in 3-foot rows in the center of the block, 3 feet from the pollinator. Pollen supply was assumed not to be a limiting factor. Spikes on the female varieties were hand emasculated and left exposed. Concurrent heading dates proved to be very critical. Delay of the female resulted in reduced seed set of a magnitude which would be critical in commercial seed production. Seed set ranged from 39 to 91% when female spikes were emasculated on the day that the first pollen was shed by the pollinator. Emasculations made later in relation to the time of first pollen production resulted in generally lower seed set.

Experiment at the University of Illinois

In a 6 replicate hill experiment at Urbana, R.O. Weibel tested 16 winter wheat crosses involving 7 parents. Yields of F_1's varied from 4% less to 31% more than yield of the higher parent.

More detailed information on all these experiments is included in the Proceedings of the Eastern Soft Wheat Workers Conference, which was held at Wooster, Ohio, October 22 and 23, 1964.

REPORT FROM THE SPRING WHEAT CONFERENCE

K. L. Lebsock

Nine states comprise the Spring Wheat Region, however, HRS and durum variety improvement and production are major enterprises in only four. About 10½ million acres of HRS and durum were harvested in Minnesota, Montana, North Dakota and South Dakota in each of the years, 1963 and 1964. Wheat researchers in the other 5 states are active in conference affairs and do research in proportion to importance of the crop. Close ties with scientists in Canada and Mexico greatly broaden approaches toward spring wheat improvement.

Federal and State scientists are doing both applied and basic research to make production of spring wheat profitable. Hybrid wheat development receives some emphasis at most stations. North Dakota has a vigorus hybrid wheat spring wheat program. All major stations are working with dwarfism genes.

Leaf and stem rust continue as major problems, especially in the eastern section of the spring wheat region, and investigators search continually for new sources of resistance to be bred into new varieties. Researches into diseases such as root rot, blackpoint, scab, and the smuts are more limited.

The major insect pest of HRS is the wheat stem sawfly. The Crops Research and Entomology Research Divisions, U.S.D.A. cooperate with Montana and North Dakota Agricultural Experiment Stations in the development of resistant varieties.

Maintaining high milling and baking quality is a major objective. Only under unusual circumstances is quality compromised for any other characteristic. State and Federal researchers cooperate with industry in final evaluation of potential varieties. Along with analyses of breeder's lines, cereal chemists are investigating the properties of starch, protein, and lipid components of HRS and durum wheat. Cereal chemists have cooperated in genetic studies of quality in HRS and durum.

Only a few investigators are assigned to full-time genetic research on wheat. Examples of genetic studies recently finished or underway are: 1) the genetics of host-pathogen relations (stem rust); 2) inheritance of quality factors; 3) chemical mutagenesis; 4) inheritance of resistance to leaf and stem rust; 5) inheritance of quantitative characteristics; 6) estimation of combining ability, and inheritance of stem solidness. Breeder geneticists combine variety development and genetic studies according to needs of their particular areas.

SUMMARY OF HYBRID WHEAT RESEARCH SESSION

Kenneth B. Porter

Reports of progress, summaries of work being conducted at 15 State or USDA research installations, were presented at the session on hybrid wheat research. The number of workers now actively engaged in hybrid wheat research, as compared to a relatively few at the time of our 1962 conference, is itself indicative of the progress that has been made in making hybrid wheat a reality. The development of the T. timopheevi type cytoplasmic male-sterile wheat by the Kansas Station was a significant breakthrough while pollen-restoration lines discovered by workers at Nebraska and the T. timopheevi x Marquis^3 restoration line by J. A. Wilson were significant contributions and added impetus to the interest in hybrid wheat.

Results reported by workers using the above sources of pollen restoration suggest that these restorers may not be completely adequate under all environments and that more information is needed concerning their inheritance. Fortunately, restoration factors have been found in other varieties and a search is being made for additional sources. Studies initiated concerning allelism, monosomic analysis of factors for restoration, additional inheritance and environmental studies should yield important contributions to our knowledge of the relationship among factors obtained from different sources, cytoplasmic effects and environmental influences on the expression of pollen fertility. Although problems remain, it appears that adequate restoration lines can be developed even if factors for restoration in lines now available prove to be inadequate.

Results of at least 12 recently conducted experiments concerning the vigor of wheat hybrids were reported by workers from the various wheat growing areas. Results of these relatively small scale tests may not truly represent results that may be obtained in larger and more realistic trials but they at least suggest the vigor of selected wheat hybrids may be in the same magnitude as that found in hybrids of other crops.

Assuming, with a rather high degree of certainty, adequate pollen-restoration and sufficient vigor of wheat hybrids seed production problems remain as the primary obstacle to commercial production of high yielding wheat hybrids. Seed set obtained on male-sterile wheat, as reported by a number of workers, ranged from about 20 to 70 percent. Even the higher percent seed set or yields of seed on steriles leaves much to be desired. The significant fact emphasized in the conference was the lack of knowledge of factors influencing seed set from wind borne pollen. Although a start has been made in studying some of these factors, such as studies on receptivity of stigmas and pollen dissemination, much still remains to be learned regarding floral characteristics and environmental factors affecting seed set and seed production.

Quality characteristics of wheat hybrids is of real concern. Only a few preliminary studies on quality have been conducted but results of others are anticipated in the immediate future. The effect of cytoplasm, genotype, the variability in endosperm characteristics of grain produced by hybrids as well as anticipated higher yields make it necessary that even greater attention be given quality characteristics of hybrids than in pure line varieites.

It was obvious as our discussions closed that we had only scratched the surface. Many questions, to mention only one, "Will loose smut and ergot be more serious in maintaining sterile lines and producing hybrid seed than in pure line breeding?", are still to be answered. The answers will come from basic studies to which we as public research workers can and must make our greatest contribution.

Progress made in the last few years is reason for us to expect significant progress in the immediate future and optimism comes from the fact that we have cleared our minds of some preconceived ideas that may have been the greatest deterrent to the reality of hybrid wheat. Although none of us were able to answer with a resounding yes the question "Is hybrid wheat a certainty?", many were still asking, with very few ifs, "When?"

STATUS OF GREENBUG RESEARCH IN OKLAHOMA
(Abstract)

E. A. Wood, Jr.

The trend in research on greenbug control has for many years been concentrated on natural control. Of these controls, the development of resistant varieties appears to be the most promising.

Insecticides are our chief means of control at the present but are generally considered unsatisfactory because of the expense and hazardousness of application.

Greenbug resistant germ plasm has been found by screening the world collection of wheat and has been successfully crossed to Ponca and backcrossed to Kaw and Triumph. Satisfactory agronomic characteristics are still lacking but the goal is much nearer.

The greenbug has produced a mutant within the greenhouse capable of destroying these selections; however, this strain of greenbug has not been found under field conditions.

A great deal of research, directed towards the nature of resistance, appears to be our next logical step.

ESTIMATION OF PHENOTYPIC PARAMETERS IN WINTER WHEAT
(Abstract)

D. B. Ferguson

The simple and multiple correlations with six dependent and one independent character of random populations of winter wheat were studied. Frequency distribution of three quantitatively measured characters is presented. Low correlation coefficients were found for most correlations among heading date, height, appearance, shattering, lodging, head attitude and 100 kernel weight. Correlations of some magnitude between appearance and the characters shattering, lodging, and head attitude suggest elimination of appearance indexing and the summing of the other indexed characters to obtain an overall value of anatomical features. Phenotypic distribution curves suggest that relative ease should be experienced in selecting for heading date, height, and kernel weight in early generations.

PROGRESS REPORT ON RESEARCH TOWARD A UNIFORM SYSTEM FOR REPORTING AND COMPUTER PROCESSING CEREAL TEST DATA

C. F. Konzak, F. H. McNeal and C. A. Watson

Fitting a code to data already collected is relatively simple if the method of recording can be interpreted. Numerous methods of recording data have been used over the years and reducing the data to comparability is sometimes difficult. Also, the proper interpretation of previously collected data is often difficult where different recording systems have been used. Most problems of interpretation can be overcome by adoption of a uniform system of recording field and laboratory data. A uniform coding system is proposed. The procedure for recording and analyzing data will be discussed.

Studies are continuing at Washington and Montana for developing a system for reporting and processing data from cereal variety trials. We are convinced that mechanical data sorting and analysis can markedly increase efficiency in cereal programs. Results of the devebpment of uniform procedures and the translation of data into computer codes suggest that standardized descriptions and codes for reporting data might be an exceedingly effective means for communication between scientists studying aspects of the same or similar materials. Furthermore, the coordination of systems that have standard procedures for recording agronomic, pathological, physiological, quality, and other types of cereal crop data could increase the effectiveness of the various programs and vastly broaden the scope of this form of communication. The system being developed in Washington and Montana allows for automatic computer analysis or hand analysis of data, automatic printing of data tables, and the results of statistical analysis. Variety master cards, prepared only once, are basic to the system. These cards constitute a permanent, readily retrievable source of pertinent information about a variety. Experiment description cards record data about each experiment, such as design, rainfall or moisture available, harvest data, treatments, soil type and other important information. The variety master cards are used to prepare seed storage lists, as well as data cards. The data cards can be used to print field record books, labels, seed bags, etc. in the desired arrangement, thus saving time and labor. Then the experimental data are added to these pre-punched data cards directly from the field record book. Information from the experiment description cards and data summary cards (produced during machine analysis) is merged to prepare tables of the summarized data for reports.

Coordination of systems used in the allied research programs might be accomplished by: (1) Use of the same descriptions and codes for reporting specific data. The description and coding should follow a standard form and be consistent insofar as possible with a uniform set of principles; (2) Use of a single format wherever possible for recording data of common interest; (3) Use of standard key information on data cards and in master card series within and between systems wherever possible so that the data from different programs can be integrated; (4) Evaluation of data according to standard principles.

As an example of (1) we used uniform criteria to translate the several kinds of plant response data to computer codes. That is, we measured plant responses as injuries; winter kill rather than winter survival, lodging rather than straw strength, are reported in percent. Thus, the plants having the lowest percentage of injury or the lowest coded reaction types (where reaction types can be distinguished) would then represent the best breeding material.

An example of (2) might be: (a) General use of a single reasonably flexible format for reporting data in the field and for computer processing. A tentative format now being used for cereal variety trials in Washington and Montana incorporates some of the desired features; (b) Cross reference of records and data between fields of research might begin with the adoption of a standard variety description master card format which organizes data of prime importance to all interrelated programs. This format might include identification data required by the Plant Introduction and Crop Variety Classification and Maintenance programs; (c) Use of a standard format for the experiment description for illustration would facilitate the recording, thus help to assure availability of information for the evaluation of products of experiments (such as in the quality studies of wheat and barley), and for the relating of pertinent environmental data to varietal responses.

A summary of potential benefits of such an effort might be: (1) Duplication of effort by members of different programs could be avoided; (2) the distribution of and the cost of obtaining pertinent data could be markedly reduced--for example, variety identification and description data cards could be reproduced by one agency so that this standard format would be available at a minor cost to all those who had coordinated programs; (3) with uniform codes costs of translating data into terms commonly understood would be minimized; (4) members of coordinated programs would have access and be able to compare, correlate and analyse a wide variety of information pertaining to descriptions, origins, pedigrees, environmental and disease responses, etc., on all collections. Descriptive data, once recorded, would be retrievable at any time; (5) cooperation between workers and programs would be facilitated by the lower costs and reduced effort required for duplication and evaluation of information; (6) a standard system such as proposed could also lead to much needed improvement in uniformity and completeness of note taking, analyses and reporting of data; (7) sets of standard computer programs could be developed and made generally available, markedly reducing the costs of processing data.

YIELD BARRIERS IN WHEAT IN THE GREAT PLAINS

A. M. Schlehuber

All of the research whether basic or applied and regardless of the discipline, be it breeding, genetics, cytogenetics, quality, pathology, nutrition, etc. should ultimately be directed toward factors related to quantity and quality of the product. In wheat production one of the chief factors related to efficiency in production is related to yield per acre. Obviously highest yields possible must be produced economically in order to aid the producer. However, even now yields are produced which only a few short years ago were considered uneconomical.

In view of the extremely high wheat yields in some parts of the United States along with the publicizing of this information wheat growers and others interested in efficient wheat production are asking questions which pertain to possible yield barriers in this area.

Do we have drastic yield barriers? If so, are they of a genotypic or environmental nature? Some of our wheat genotypes will produce 100+ bus/acre under more favorable growing conditions. On the other hand, other genotypes have produced higher yields than the typical hard red winters and hard red springs. Still it would appear that the major yield barriers are of an environmental nature. But which ones? Can we identify these and spearate them into those which can and those which cannot be resolved? Is it not time that we attempt to combine our resources so that critical experiments can be devised to resolve at least the major factors?

SOUTHERN REGIONAL PERFORMANCE NURSERY

Byrd C. Curtis

Prior to the conference a number of state wheat research personnel were asked to evaluate the SRPN. They were asked to be frank in their comments on the maximum number of entries, check varieties being used, nature of material being entered, requirements for entering a variety (such as purity, amount of previous testing required, etc.) and any other matter that might improve the SRPN. A response was received from each person contacted. My remarks are based on the contents of these responses.

Number of Entries

There was general agreement that the maximum number of entries should be about 25 and not larger than 30, and that the size of the nursery in recent years has not been too burdensome.

Check Varieties

There was general agreement that Kharkof should be retained as a long-time check.

Three people suggested that no changes in check varieties be made since the varieties Kharkof, Comanche and Early Blackhull are widely adapted and encompass a wide range in maturity, winterhardiness and quality which should bracket most entries in this nursery.

Three people suggested that except for Kharkof the check varieties be changed from time to time to maintain more representative or comparable checks. Three stated that we definitely need something different than Early Blackhull and Comanche. Scout and Warrior were suggested as substitutes by one person. Another suggested that Comanche be replaced by a slightly earlier variety.

The conference voted to continue Kharkof, Comanche and Early Blackhull as check varieties.

Number of Test Years

Two people commented that a variety should not be tested longer than three or four years. It was recognized that certain varieties assumed the role as temporary checks and should not be restricted in number as long as they serve a purpose.

Nature of Material Being Tested

The present type of material being tested seemed satisfactory to most. The material falls into two general classes:

a. Strains that have potential as varieties.

b. Strains being used to investigate a scientific principle or a gene(s) response in many different environments.

Examples - Isogenic lines such as the Kanred x Clarklan strains (awned vs. awnless) and Bison^5 x C.I. 9058 (greenbug resistant gene).

A potential third class now exists, i.e., hybrid wheat.

Requirements for Entry

It was generally agreed that a strain being entered as a potential variety should undergo considerable local screening before entry into the SRPN. One response was that we were all a little guilty in entering material before it has been properly screened. Another person suggested that earlier testing on a regional basis could be accomplished through the use of a regional observation nursery like the one used for semi-dwarf wheats in 1960 and 1963.

It was suggested that new entries should be free of loose smut.

Purity

The general consensus was that new strains being entered should be reasonably pure but not necessarily pure enough for increase as varieties. Kenny Porter made the statement, "Get them purer than at least one of Texas' recent entries before entering them".

Description

One particularly good suggestion was that a brief varietal description should accompany each new entry. This might include information on maturity, chaff color, awnedness, quality, kernel texture, etc.

Role of the Coordinator

In one of the letters received a question was posed, "What should be the role of the Regional Coordinator in the Hard Red Winter Wheat Regional Program?". This question was presented to the conference participants during the meeting. Much free discussion precipitated as a result of the question and several specific suggestions about the coordinator's activities were made. Some of the comments from the floor that were recorded were as follows:

1. The coordinator should spend less time on state breeding and other state-oriented assignments.

2. He should spend more time on planning of new regional trials and new regional research.

3. He should spend more time at the cooperating stations, especially at new stations or where new personnel have come into the program.

4. He should spend more time helping to integrate across-discipline research.

5. He should study more thoroughly and analyze more completely the data from regional nurseries, especially uniformly grown entries included for many years.

6. An interesting comment was that "over-coordination is seen in Soil and Water Conservation regional research and an opposite extreme is seen in Crops Research Division regional research". One western

man said, "Out in our region, we like it the way it is". Still another man said the eastern regional coordinator (Dr. Briggle) is more ideally situated to do uncomplicated regional work because he is not stationed at a State Experiment Station and had no direct assignment to breed and release new varieties.

Dr. L. P. Reitz made several comments in response to the question on the role of the coordinator. Several of these comments were summarized in a follow-up letter to Dr. Byrd C. Curtis. Excerpts from this letter appear below.

"I pointed out that for many years (at least 25) the regional coordinator's activities have been part-time assignemants, seldom taking more than 40% of a man's time. We have deliberately written into each job assignment basic and applied research responsibilities that would be compatible with the needs of the region and State in which the coordinator was located. This latter has varied considerably but we discourage work that might be construed to be purely state oriented. We have not imposed 100% compliance. However, the assignments are, in my judgment, as truly region-oriented, as the average federal employee who is not a coordinator (for example, pathologists and geneticists in many states work on and contribute directly to state projects). Furthermore, we foster termination of work and positions which appear to be solely or largely state limited.

"I detected a reaction of surpise to the above facts and philosophy, so we have failed to give adequate information to cooperators about our regional leaders. I'm sorry about this and trust what I said will help clarify our present position and lead to improvements."

THE NORTHERN REGIONAL PERFORMANCE NURSERY

B. J. Kolp

Several questions were submitted to cooperators growing the Northern Regional Performance Nursery prior to the conference. Only a few people responded, probably indicating general satisfaction with the nursery as it is now handled. The questions together with responses received are listed.

Would it help you in reading the report if the varieties and parents were listed along with C.I. numbers in table 5 (1963 report)?

1. Yes.
2. Leave them in the same order in all tables.
3. I do not think it would help to list the varieties and C.I. numbers on page 5. As you know, these are listed on page 41, and I think this is adequate for reading the report.

Would the report be easier to read if only one characteristic was reported in a table such as yield or test weight or winter survival, etc.

1. Not necessarily.
2. Yes and no.
3. I don't think there should be any change in the way these tables are set up. Personally, I would rather look at all the data from one station rather than have to pick out the data from separate tables for a particular location.

In table 6 (1963 report) are the state averages meaningful?

1. No.
2. Probably not.
3. The averages listed in table 6 may not be too meaningful. However, I like them as they are. I would suggest that no change be made here.

Can we send punch-cards to Virgil when reporting our data? Once the data has been punched on cards it is very easy to duplicate the deck.

1. We should work on a uniform note-taking system and coding system.
2. If we can come up with a uniform note-taking system and coding system.
3. I think it is a good idea to report our data on punch-cards. I think we should strive to attain this goal in the very near future. As you point out, it would be very easy to set up an extra deck for submitting the data. It seems to me that this would also allow the regional coordinator to process the data in a much more efficient manner. I was glad to see that you brought up this point.

Should we take a long, hard look at the locations, years and replications now being used in the N.R.P.N. by the method outlined by Rasmusson and Lambert, Variety x Environment inter-actions in Barley Variety Tests. Crop Science I: 261-262. 1961.

1. This will be possible when we put our data on punch cards
2. I would favor more analyses, especially a look at certain inter-actions.
3. Unless we go to punch-card system I rather doubt that we should try to obtain the variety x environment interactions. This would represent a considerable amount of calculator work which might not be justifiable in terms of what is gained from this. However, if we have the punch-card system then these interactions can be computed rather easily and would be worth while, since it doesn't take much time to get them.

Are we using too many, not enough, or the right check varieties?

1. Retain Kharkof--use other checks as requested by states who have entries in the nursery.
2. One long time check--others should rotate.

UNIFORM WINTERHARDINESS NURSERY

D. G. Wells

The organization and objectives of the nursery were discussed. The usefulness of various stations growing the nursery in terms of frequency of differential winterkill was considered. There was no conference action with reference to the nursery.

RESOLUTIONS

The following resolutions were adapted unanimously by the conference:

The HRWW Improvement Committee recognizes the desirability of close cooperation among federal, state, and commercial research groups, therefore:

Whereas there are occasions when reports and discussions of all interested wheat research workers are made at open sessions--

Whereas there are occasions where state and federal wheat research workers can best conduct planning and discuss their mutual problems among themselves, and--

Whereas on most occasions, to reduce travel and other expense, open and closed conferences can be arranged at the same time and place--

Be it resolved that when future HRWWW conferences are planned, open sessions be organized except where it be deemed expedient to restrict participation to duly recognized cooperators.

Prepared by E. G. Heyne
John W. Schmidt
Harry Young, Jr.

Be it resolved:

That the Hard Red Winter Wheat Workers express their appreciation to the administration of Colorado State University, its Conference Planning Service, the National Seed Storage Facility, the Department of Agronomy, and especially Dr. B. C. Curtis for providing the excellent planning and facilities for this conference.

Further that the Conference members commend the Program committee E. G. Heyne, Chairman, H. C. Young, K. F. Finney and B. C. Curtis for formulating interesting and instructive sessions.

Also that the members express their appreciation to Dr. A. M. Schlehuber for his work as Chairman of the Hard Red Winter Wheat Improvement Committee.

Finally that the Secretary be instructed to write a letter of appreciation to the Colorado Seed Growers Association for providing refreshments at coffee breaks.

Respectfully submitted, The Resolutions Committee

Bernard Kolp
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