L. P. Reitz

REPORT

of the

SIXTH HARD RED WINTER WHEAT IMPROVEMENT CONFERENCE

Stillwater, Oklahoma

January 23-25, 1950

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Administration

Bureau of Plant Industry, Soils, and Agricultural Engineering

and cooperating

STATE AGRICULTURAL EXPERIMENT STATIONS

in the Wheat Belt

Agricultural Experiment Station

Lincoln, Nebraska

158 CC - March 1950

FOREWORD

The Sixth Regional Hard Red Winter Wheat Improvement Conference was held January 23 (9 a.m.) to January 25 (noon) at the Oklahoma Agricultural and Mechanical College, Stillwater. Dr. Henry G. Bennett, President of the College, greeted the conferees just before adjournment. The conference was authorized by State Agricultural Experiment Station Directors on the recommedation of the regional Advisory Committee on Hard Red Winter Wheat Improvement.

The objectives of the conference were (1) to review research work done and in progress and (2) to make plans for research to be undertaken in the years just ahead. Mosaic, the rusts, and other diseases, insects, quality, characteristics of the plant related to growing conditions and production practices, and other topics were discussed. The regional program was evaluated and recommendations made governing future policies.

Leaders were chosen for the various program headings as shown in the table of contents. The conference was attended by 83 workers. Twelve states and the U. S. Department of Agriculture were represented.

This report includes abstracts of the formal papers which were presented at the conference, summaries of informal statements as recorded by our conference secretary, recommendations by various persons and committees, and comments made in answer to questions. Dale E. Weibel served ably as conference secretary and assembled the material in the present report. Numerous editorial changes have been made in the original abstracts submitted to accomplish some degree of uniformity and for the sake of brevity. It is hoped that the main points have been retained.

I would like to express appreciation and thanks to all who participated in various ways in the conference. As a consequence of our deliberations I feel confident that the wheat crop will be more dependable in the future because of the stimulus here given to productive research. Requests for additional copies of this report should be addressed to me.

L. P. Reitz
Regional Coordinator

PROGRAM AND TABLE OF CONTENTS

Monday, January 23, 1950

Tuesday, January 24

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*Names and addresses of all personnel on the program and those registered are listed alphabetically at the end of this report.

CONFERENCE REPORT

Dale E. Weibel, Conference Secretary

MONDAY MORNING, JANUARY 23

Dr. H. H. Laude of Kansas called the conference into session with introductory remarks as follows: "It has been 5 years since this group met in a conference similar to this one. Perhaps 5 years is too long an interval but for various reasons it seemed necessary or advisable to defer this conference until the present time. At the meeting in Manhattan, Kansas, 5 years ago you asked that the experiment station Directors appoint a committee who would have some responsibility regarding your interests during intervals between the times you could come together. This committee attempted to sense your wishes and weigh all factors that had a bearing on the matter of holding a workers conference and at the appropriate time set in motion the plan for a conference. That was done and this meeting has resulted. We hope you will consider this to be your meeting and that each of you will enter freely into the discussions and will express yourselves on all matters of concern to you." He then asked a representative from each state to introduce those present. The following states were represented: Texas, New Mexico, Colorado, Montana, Minnesota, Wisconsin, South Dakota, Nebraska, Kansas, Washington, Oklahoma, Indiana, and Plant Industry Station, Beltsville, Maryland.

A resolutions committee and a committee on recommendations were appointed.

The meeting was turned over to Dr. A. M. Schlehuber of Oklahoma who was leader of the Leaf Rust Symposium.

LEAF RUST SYMPOSIUM

Leader: A. M. Schlehuber, Oklahoma

Present status of breeding for leaf rust resistance, changes in the prevalence and distribution of physiologic races, new sources of resistance, and future plans were discussed. Abstracts and minutes on the discussion follow:

Leaf Rust in Texas

I. M. Atkins

The leaf rust problem of the present day presents an even greater problem than it did 20 years ago when this program was started. With the widespread distribution of varieties having similar or the same source of disease resistance, shifts in importance of races of rust become increasingly important. Under these conditions a race, once considered minor, may become a major race and spread throughout a large area. In Texas a continued attempt has been made to control this disease by distributing new varieties which at the time of release appeared highly resistant but in each case minor races have increased on the new wheat. Starting in 1926 we distributed Denton, a strain of Mediterranean, followed in order by Tenmarq, Comanche, Austin, and Westar. These varieties were resistant in some degree to the races of leaf rust prevalent when they were distributed. The continued seriousness of this disease is indicated by the estimated loss of 12,400,000 bushels in Texas alone in 1949.

The 1949 leaf rust epidemic in Texas was the result of several unusual conditions. The north half of Central Texas experienced a record dry fall season in 1948. Probably not more than half the small grain in this area emerged until February of 1949, and what did emerge made little growth. This resulted in a late maturing crop. On the other hand the southern part of Central Texas experienced an unusually favorable fall season with small grains producing an unusual amount of winter pasture. This is indicated by a return of $44.00 per acre from winter oat pasture at our Beeville Substation. This acreage of wheat in South Texas was practically all Austin wheat susceptiable to the races of leaf rust prevalent in the spring wheat area and carried down by north winds in the fall. Ample spring moisture throughout almost the entire state, provided the spring conditions favorable for leaf rust. The severity of the disease in South Texas was such that we had frequent letters during the spring asking if Austin wheat would even head. The amount of inoculum is indicated by rust showers of 3,000,000 spores per square foot per day on April 14 at Chillicothe, Texas, before any rust developed at Chillicothe. These were undoubtedly coming from the acreage of Austin wheat in Central Texas and the southern part of the Rolling Plains.

I shall not go into detail here about our immediate and long-range breeding plans for control of leaf and stem rust as they will be covered in a later discussion.

BREEDING FOR LEAF RUST RESISTANCE IN WHEAT

E. R. Ausemus, Minnesota

Hope, H-44 and their derivatives were used as the main sources of leaf rust resistance in our breeding program, previous to 1944. When these varieties became heavily infected in the field, it was observed that a group of winter wheats including *T. timopheevi* x *vulgare* selections and Blackhawk received from Wisconsin and certain spring wheats including Timstein, Red Egyptian, Frontana and several wheats from Argentina were resistant in the field. Selections from crosses of commercially grown varieties with the *T. timopheevi* x *vulgare* selections have not been satisfactory because of their lateness and there appears to be a linkage between earliness and susceptibility. Crosses with Blackhawk as the resistant parent are now being studied but progress has been slow due to winterkilling.

Intensive studies showed Hope to be susceptible to a number of physiologic races in the seedling stage and it was found that Timstein, Red Egyptian, Supreza and Frontana were resistant to a large number of races to which they were tested. With the finding of wheats with seedling resistance to many races our program has been planned to add physiologic resistance to as many races as possible to the resistances already found in our present wheats.

Since 1943, approximately 200 varieties have been tested for their seedling resistance to all available races at the time of the test and for their adult resistance in the field, in cooperation with Drs. Stakman and Levine. It has not been possible to test the varieties to all of the 43 races isolated in the epidemiology work by Dr. Levine during the six years, but about 20 races have been available each year for the seedling tests and the same races were used in creating artificial epidemics in the field.

Only one winter wheat, La Prevision received from Argentina, was found to be highly resistant. It has been resistant to 30 races to which it has been tested in the seedling stage. The following spring wheats have been found to be highly resistant to a large number of races in the seedling stage and in the field under artificially induced epidemic conditions:

Variety	Source	Reaction Seedling No. of races Res.	Sus.	Field
Klein H211-t-1422-Apulio x Progress	Canada	21	0	
Klein Titan	Argentina	20	0	R
McMurachy-Warden English x Redman RL 2325	Canada	21	0	R
" " RL 2327	Canada	21	0	R
Anaversario	Argentina	10	1	-
Exchange	Canada	29	0	R
Frontana	Brazil	32	0	R
Gabo	Australia	20	0	-
Lee C.I. 12488	U. S.	33	1	R
Premier x Bobin^2-Gaza II-39-2	U. S.	22	1	R
Supreza	Argentina	19	8	R
Timstein	Australia	23	5	R
Timstein x Newthatch II-42-22	U. S.	22	0	R
Wabash x American Banner 3369.61.1.1.1.1.6.1	U. S.	14	0	-
Warden x Leap 32142-1-3	U. S.	14	0	-
Warden x Pinka 2973441-12	U. S.	14	0	-

Our plan is to cross La Prevision, certain of the spring wheats having seedling resistance, including Frontana, Timstein derivatives, and Klein Titan with our winter wheat hybrids having the Hope type of leaf rust resistance.

Present Status of Breeding for Leaf Rust Resistance, and Future Plans

R. M. Caldwell, Indiana

Two general sources of mature plant resistance to leaf rust were used extensively in the soft winter wheat breeding program during the period 1930-1940. These were Hope-Hussar (C. I. 11682) and Wabash (C. I. 11384) and sister selections. Recently resistance derived from these sources has been inadequate against the prevailing races of leaf rust.

The variety Vigo, deriving resistance from a sister selection of Wabash, is now grown on a considerable acreage in Indiana. It is in the slow rusting class but has often shown leaf rust of 75 percent severity at maturity. Races 76 and 58 are usually found to predominate on this variety.

Resistance from the spring wheat Chinese (C. I. 6223) has been receiving minor attention for a considerable period of years in the Indiana project. From this work have come Purcam and a number of hardy and promising related lines now showing usually only traces to 2 percent of leaf rust under servere epidemics. However, in 1949, Purcam was reported to have 20 percent infection at Athens, Ga., and 75 percent of a 0-2 type at Fayetteville, Ark.

The resistance of Chinese has been excellent wherever observed by the writer. However, it has a record of being severely infected on a number of occasions in the uniform cereal rust nursery (1931-38) although it usually is in the highly resistant classification.

Because of the generally excellent resistance of the Chinese derivatives and the high yielding capacity of early lines from this source, considerable effort is presently being given to this source of resistance for soft red winter wheats.

The Australian white spring, Warden, is the leaf-rust-resistant parent in a number of highly resistant soft red winter lines and in spring wheat Exchange (Warden-Hybrid English). Thus far, Warden has shown high resistance to most races tested at Lafayette with an intermediate reaction to one culture of race 65 and to two cultures of race 76.

Exchange, Warden-Leap, and Warden-Purkof have shown resistance to all races at Lafayette, Manhattan, St. Paul, and Winnipeg, involving 24 different races with the exception of a 3 reaction of Warden-Leap to race 43.

Warden has a somewhat questionable record in the uniform nurseries. It frequently shows considerable infection on the lower leaves. However, reading of 80 and 90 percent at Manhattan, Kans., and Wooster, Ohio, respectively, in 1935 are cause for concern. The writer has never seen these Warden derivatives severely infected in the field or giving the susceptible type reaction.

Mature plant resistance to leaf rust derived from the Brazilian wheats, Frondoso, Fronteira and Supreza, has been promising in the Indiana project. No significant infection of varieties having resistance from this source has been observed since they were first introduced into crosses at Lafayette in 1939. Some of the highest yielding soft winter lines have resulted from crosses with Frondosa. Each of them is completely susceptible to a number of races as seedlings but have shown different levels of resistance to others. The mature plant resistance of Frondoso and Fronteira appear quite similar to that of Chinese in that very distinct necrotic areas, usually without sporulation of the rust, are manifest.

Several selections of extremely high resistance have been obtained from certain lines of the cross 3369, Wabash x American Banner. These have been resistant in the seedling stage to all of the 24 races against which they have been tested at Lafayette, Manhattan, St. Paul, and Winnipeg. The plant reaction seldom exceeds a 1- type. This seedling resistance far exceeds the combined resistance of the parent varieties.

Emphasis is being placed on seedling resistance in planning the future program. The dominant gene in Malakof for resistance to races 15 and 76 and many other races, is being transferred to the Vigo variety by the backcross procedure. The dominant gene of Webster for resistance to race 5 and others is being transferred to soft winter types. Seedling resistance of Warden and Anniversario are also being extensively used.

Mature plant resistance, however, will not be abandoned, since good varieties carrying this type of resistance may very well be used as recurrent parents in a backcrossing program whereby seedling resistance is introduced and maintained by tests of seedlings.

Q. C. O. Johnston asked Dr. Caldwell why he was interested in seedling reaction.

A. Dr. Caldwell replied that there were several reasons:

1. Space is too limited in the green house to do mature plant testing.

2. Cannot control races or the degree of infection by each race outside.

3. Can control races and use individually with more exactness in the greenhouse.

4. Seedling resistance carries through to maturity in nearly all cases.

E. R. Ausemus stated that you may put out equal amounts of inoculum of 20 or 30 races into the rust nursery at the start of the season, but that at the end of the season you may be able to reisolate only 5 or 6 races.

Breeding for Resistance to Leaf Rust in Kansas

C. O. Johnston, Kansas

About 1935 it was discovered that selections of Mediterranean x Hope had high combined resistance to leaf rust and stem rust. They were immediately used in crosses with hard winter wheats and segregates have been studied intensely since that time. These selections maintained their high resistance to leaf rust very well until 1946 when they rapidly began losing it. This is well illustrated in the following table by the average reaction of one selection from each of four crosses involving Mediterranean-Hope with Pawnee, Comanche, Nebred, and Oro in the uniform rust nurseries in Texas, Oklahoma, Kansas, and Nebraska during the period 1945-49 inclusive. The Oro hybrid was not included in 1945.

Average coefficients of leaf rust infection.

	1945	1946	1947	1948	1949
Texas	4.1	3.9	38.8	5.2	60.0
Oklahoma	5.7	9.1	26.0	4.3	14.3
Kansas	0.7	2.0	10.5	0.4	50.0
Nebraska	2.3	7.0	15.0	19.5	41.3
Kharkof, same stations	66.7	63.2	78.7	38.2	65.0

There obviously was a large increase in leaf rust on Hope hybrids in 1947, especially in Texas and Oklahoma. Leaf rust infection was very low throughout the hard red winter wheat area in 1948 and only at Lincoln, Nebr., did heavy infection develop. However, very heavy leaf rust infections developed in 1949 and there was a further increase in leaf rust on the Hope hybrids, as shown by the table.

The evidence presented above shows very clearly that Hope and Hope hybrids can no longer be depended upon as adequate sources of resistance to leaf rust. Resistance must come from other varieties and those varieties should have resistance to many races. Experiments conducted at Manhattan, Kans., have shown that the varieties La Prevision 25, Aniversario, Titan, Apulia x Progresso H211t1422, Rio Negro, Frontana, Frondoso, Fronteira, and Surpreza from South America, Warden, Exchange, and selections and backcrosses of the cross (McMurachy x Warden-Hybrid English) x Redman from Canada have been resistant to all races with which they have been tested including all of the important ones in the hard red winter wheat area. In addition there are many varieties which have resistance to several races such as Gabo from Australia and Maria Escobar from Peru. Some of our own hard winter wheats such as Westar, Kawvale-Marquillo x Kawvale-Tenmarq (C. I. 12128), and selections of Marquillo-Oro x Oro-Tenmarq have resistance to most of the important races. Low percentages of leaf rust have been observed on these wheats in field sowings during recent years.

Crosses have been made at the Kansas station involving resistance from Timstein, La Prevision 25, Aniversario, Titan, Apulia x Progresso H211t1422, Frontana, Rio Negro, Frondoso, Surpreza, McMurachy-Exchange x Redman R. L. 2327, McMurachy-Exchange x Redman^3 R. L. 2564 and others. These have been crossed with adapted varieties such as Pawnee, Comanche, and Tenmarq, as well as C. I. 12128, and Mediterranean-Hope x Pawnee (C. I. 12141). It is our intention to make further use of some of the winter selections from Hope crosses because of their high resistance to stem rust. Of the selections listed above only the McMurachy-Exchange x Redman selections and Mediterranean-Hope x Pawnee have high resistance to stem rust. Also, studies are being made at Manhattan on large numbers of segregates of _T. vulgare_ x _T. timopheevi_ and _T. vulgare_ x _Agropyron_ sp. These are extremely complex as to parentage due to the necessity for backcrossing with common wheats to establish fertility. It is too early to determine what may be derived from such crosses but some interesting types with good fertility and strong resistance to leaf rust have been isolated.

Leaf Rust Research

D. F. Wadsworth, Oklahoma

There are two wheat leaf rust projects at this station. The Botany and Plant Pathology Department has a project on Etiology and Epiphytology of wheat leaf rust, and the Agronomy Department has a project on The Breeding of Disease Resistant Wheats adapted to Oklahoma with Botany and Plant Pathology as a cooperating department.

Though Etiology and Epiphytology of wheat leaf rust includes a number of objectives, perhaps the one that you are most familiar with is the Oklahoma Wheat Leaf Rust Forecast. The major purpose of this project is to determine each year the late-winter rust and weather relationship in preparation for the annual Oklahoma forecast.

Recording of weather data, and examining fields begins the first of February. Field inspections are made at 10-day intervals through March to determine the amount of rust present and its increase. Since this information is taken only at Stillwater it is necessary to make a survey of rust intensity in the major wheat growing countie particularly the southern counties. It is felt that a rather accurate picture of the rust situation can be had by April first and a farmer can still put in an alternate crop if a severe epiphytotic is likely.

Also included in this project is the annual collection of approximately 100 leaf rust samples from susceptible, semi-resistant, standard, and hybrid wheats, and, so far as possible, the rust races are purified and identified. Several of the most prevalent races are used in greenhouse varietal tests. Field readings are made on some 800 field and nursery plots as a means of assisting the plant breeders.

Breeding for Resistance to Stem and Leaf Rust of Wheat

H. A. Rodenhiser, Beltsville, Md.

Great progress has been made in the development of stem rust resistant spring wheats and to a limited extent in the hard red winter varieties. Both the Hope and Thatcher genes have been widely used and although adequate for practical control of the now prevalent races of stem rust, they are ineffective against several races of leaf rust that are generally prevalent throughout the United States and Canada. As a result our leaf rust problem has become acute. What may be expected following wide distribution of small grain varieties having limited sources of germ plasm, has likewise been experienced with oats. Obviously the need is for a thorough search for widely different germ plasms which may be combined to control not only the races of pathogens currently prevalent, but in addition, the uncommon races that may "build up" as varieties are distributed.

In the southeastern program, factors for resistance to leaf and stem rust from a number of different sources are being combined. These involve the South American wheats, Frondoso, Fronteira, Surpresa, Frontana, La Provision 23 and 25, and Rio Negro. Other sources include, Timstein, Steintim, Chinese and Kenya. Seedling tests with the early generation hybrids are made in the greenhouse at Beltsville, Md. with the prevalent rust races and supplemented with field tests under induced epidemic conditions. Many segregates which are found to be susceptible as seedlings, are resistant in the mature plant stage. There is obvious need for additional information on seedling vs. mature plant reaction.

The variety Atlas (strain 50 and 66), selections from a cross between Frondoso-Redhart-Noll 28, has recently been released by the North Carolina Station. In this wheat there is present the Frondoso resistance to rust in a more usable form than the Frondoso parent itself. Both strains are resistant to the races of stem rust prevalent in the southeast. Strain 66 has a higher type of resistance to leaf rust than does strain 50.

Chancellor, combining the resistance of Carina, Mediterranean, and Kanred in a Purplestraw type wheat, recently released by the Georgia Station, appears to have adequate seedling and mature plant resistance to leaf rust but is susceptible to stem rust.

Considerable progress has been made in the development of rust resistant hybrids in Mexico. Supremo, which was selected by the Rockefeller Foundation workers in Mexico, from a bulk hybrid population (Surpresa-Hope-Mediterranean) supplied by Mr. McFadden, has the combined factors for resistance to the Mexican races of leaf, stem and stripe rust. Well over 100,000 acres of this variety are now being grown in Mexico. Under some conditions excessive shattering is a weakness of the variety.

In a recent report of results of tests on the reaction of wheat varieties to leaf and stem rust at Winnipeg, Manitoba by T. Johnson, R. F. Peterson, and A. B. Campbell, two wheats are particularly promising as regards resistance to the virulent stem rust race 15B, namely; (McMurachy x Exchange) x Redman, Can. 3631 and Golden Ball x (Iumillo x Mindum), Can. 3671. At the present time according to reports by Drs. Stakman and Loegering, "race 15B is isolated occasionally from barberries in the United States but has not become generally established". It is, however, potentially, a dangerous race. These above wheats are likewise resistant to the common races in the area and should prove valuable as sources of resistance for wheat breeding work throughout the United States.

In an extensive search for additional germ plasm to control rusts and other diseases, the Cereal Division, in cooperation with the Division of Plant Exploration and Introduction and various State Experiment Stations are processing some 8,000 wheats; 1,600 have already been tested in Ecuador and Mexico and smaller numbers at several stations in this country. A number of the wheats show promise. Information on the resistance of these lines, as well as seed, will be made available for breeding stocks to those who are interested.

Q. Does seedling resistance to leaf rust assure adult plant resistance?

A. Dr. Rodenhiser: Yes, as a rule. However, Steintin is resistant as a seedling but becomes completely susceptible to some races in the adult stage.

Changes in the Prevalence of Physiologic Races of Leaf Rust in the Hard Red Winter Wheat Area

C. O. Johnston, Kansas

During the period 1926 to 1948 inclusive a total of 61 physiologic races of leaf rust have been isolated from collections made in the hard red winter wheat area, but many of them are relatively unimportant and 9 have been found only once. Each year about 10 races are isolated but several generally are similar races so that the number of important races that are abundant and widely distributed in the area comes down to about 6.

For the past 15 years 6 large groups of physiologic races have on the average comprised more than 90 percent of all isolates made from collections obtained in the area each year but there has been a distinct change in the comparative abundance of those six race groups. These points are well illustrated by the following table:

Average percent by 5-year periods of all isolates represented by the most important physiologic race groups of the leaf rust.

Race group	1934-38	1939-43	1944-48	Similar races included
5	3.9	6.5	10.5	
9	69.7	45.7	34.6	10, 13, 19, 20, 31
15	8.0	14.7	10.7	2, 3
58	8.2	7.8	14.1	33, 44, 65, 76
105	0.4	3.7	3.3	80
126	3.2	13.6	21.6	28, 37
128	0	0.1	2.4	
Total	93.4	92.1	97.2	

Race 128 is not an important race in the hard red winter wheat area but is included here because it was at one time thought to be one of the important races responsible for the declining leaf rust resistance of the Hope hybrids. Studies that have been under way since 1926 have revealed that many of the described physiologic races are very similar and probably are only variants or biotypes of well known races. For that reason similar races were included with the most abundant race in preparing the table. The most abundant race of the group is shown at the left and those included with it at the right. During the period 1934-38 race 9 was by far the most abundant race with an average of 69.7 percent of all isolates. It was at its peak in 1934 when it represented 83.3 percent of all isolates. It has declined in prevalence in each succeeding 5-year period but still is the most abundant race and must be considered in any program of breeding for resistance. Fortunately there are more varieties resistant to race 9 than to any other. The table shows that as race 9 decreased in abundance other races such as 5, 58 and 126 increased sharply. In 1944, 1945, and 1946 race 126 increased very rapidly reaching a peak of 29.7 percent of all isolates in 1945. Since that time it has decreased slightly but it still is a very important race. Although the table does not show it clearly race 5 has become very important in recent years. It was second in abundance in 1947 and again in 1948. The isolations made to date from collections obtained in 1949 indicate that race 5 is still gaining in abundance and that race 105 which was relatively unimportant even in 1948 was more abundant than ever in 1949.

The change in the abundance of physiologic races during the 15 year period, and especially during the last 5 years probably can be partially explained by the distribution of Austin in Texas and Pawnee in Kansas and adjoining states. Both of those varieties are resistant to race 9 but more or less susceptible to races 5, 58, 105 and 126. The change apparently started before Austin and Pawnee were distributed but certainly was accelerated afterwards. This is emphasized by the fact that during the period 1944-48 15 collections of leaf rust on Austin have been analyzed, yielding 10 races (42 isolates), but 42.8 percent of the isolates were race 5 and 21.4 percent were race 126. The first few years Austin and Pawnee were grown commercially they showed considerable resistance to leaf rust but in 1948 and 1949 they seemed to have little resistance. The foregoing discussion throws considerable light on the cause of their apparent loss of resistance.

Prevalence and Distribution of Physiologic Races of Leaf Rust in the Hard Red Spring Wheat Area

M. N. Levine, Minnesota
(Presented by E. R. Ausemus)

Of the 130 physiologic races of leaf rust of wheat now known, about one third have thus far been isolated from field collections made in the Upper Midwest region. Notable among those appearing more or less regularly are races 5, 9, and 15. While still present to a considerable extent in the collections obtained in this area in the course of the last half decade, these three races are by no means the most commonly present or most widely distributed. During the last several years, races 35, 49, 126, and 128 have occupied high positions in frequency among the various races isolated. Each of them is capable of producing rather severe infection on a number of varieties that had previously been considered to be highly resistant to leaf rust.

Races 35 and 49 were found for the first time in the Upper Midwest area in 1940. Race 126 was first isolated from collections obtained in the spring wheat area in 1941. Race 128 was first isolated from collections made in 1942. The isolation of this race caused added concern because of its virulence on Henry as well as on such reputedly resistant varieties as Cadet, Merit, Mida, Newthatch, Pilot, Regent, Renown, and Rival.

In 1942, race 128 constituted only 2.3% of the total number of isolate identified; in 1943, the percentage rose to 11.5%; in 1944, it reached a peak of 31.1%; in 1945, it dropped to 23.9%; in 1946, there was a further drop to 17.9%; and in 1947, the ratio was reduced to 8.2% of the total. It is rather interesting that a similar distribution curve prevailed in the frequency occurrence of race 128 in the Prairie Provinces of Canada during the past four years.

In 1944, the first year of any record of race 128 in the Prairie Provinces, it constituted 20.0% of the total number identified from that region; in 1945, the percentage attained a height of 31.4%; in 1946, that dropped to 12.0% and in 1947, it reached an all time low of 4.7%.

The apparent diminution in the prevalence of race 128 in the Upper Midwest and in the Prairie Provinces is in itself quite encouraging, but other virulent races are either maintaining their position or are actually on the increase.

On the average, some 15 physiologic races are isolated from each year's collection obtained in the Upper Midwest region. In 1947, an even 20 races appeared to be responsible for the leaf rust epidemic in this area. Most common were races 5, 37, and 126. Together, these three races made up over 1/3 of all the isolates identified, although they constituted only 1/7 of the races identified.

Among the 21 races isolated from the leaf rust collections obtained from the Upper Midwest region in 1948, the three most common ones were races 126 (26.8%), 5 (11.8%), and 35 (11.0%); race 37, which was the second most common race in 1947, constitution 15.5% of all the isolates identified that year, made up only 0.8% of those identified in 1948; race 128, on the other hand, was not isolated even once.

In 1949, race 128 was again absent among the isolates identified, and so was race 37. The three most commonly isolated races in 1949 were 5, 52, and 126. This year race 5 commanded first place with 32.7%; race 126 occupied second place with 19.4%; whereas race 52 stood third with 11.2%. There were only 12 leaf rust races present among the 1949 collections. Race 35 trailed along in ninth place with a mere 3.1% of the total.

Changes in the Prevalence and Distribution of Physiologic Races of Leaf Rust

R. M. Caldwell, Indiana

Annual surveys of races of leaf rust in the eastern soft wheat areas were made at Lafayette, Indiana during the period 1931 to 1948. In 1931, race 65 was by far the most frequently collected race, with race 76 second. In 1932, these two races were found with equal frequency. Race 15 was found only in the southern states in 1931. By 1933, it was the most abundant race and maintained that position each year through 1943, with the exception of 1938 and 1942 when race 76 was most frequently found. Since 1946, race 76 has been the most commonly found race. Race 76 and race 58 are similar or biotypes of the same races.

Through the 16-year period, 1931-46, race 15 represented 22.3 percent of the isolates; race 76, 19.0%; race 65, 12.6%; race 9, 9.6%, race 80, 7.4%. These constituted 70.9 of the cultures identified. Rank by regions was as follows:

Distribution of leaf rust races (1931-46).

Region	Rank of P.r. No. 9	15	65	76	80
North-central	4	1	3	2	5
N.E. & N. Atlantic	6	2	3	1	4
South Atlantic	4	1	3	2	7
South-central	3	1	4	2	5

During 1947 and 1948, 47 cultures from Indiana only were identified. Of these, 13 were race 76 and 11 race 30. Race 30 had been found in most years since 1935 but not abundantly.

It would seem that new biotypes of known races have much to do with the break down in resistance of new varieties. Race 76 undoubtedly has attacked Vigo and Wabash seriously for several years. However, this race was recognized as one of the most abundant races during the early 1930's when Wabash was fairly resistant. Apparently, new biotypes of race 76 are now able to attack Wabash more seriously than could the race 76 present in the early 1930's.

A wide range of races including races 15, 30, 31, 65, 80, 101, 103, and 104 have been isolated from the Hope and H44 derivatives. Race 65, for example, was repeatedly isolated from these wheats in 1944 and especially in 1945. Yet race 65 is an old race. The biotypes found more recently seem to possess increased capacity to attack Hope derivatives as compared with those biotypes presented earlier.

Q. Mr. McKinney asked if old cultures of leaf rust could be used to check rust collections to determine if new biotypes have arisen.

A. Dr. Caldwell replied that no old culture is available since there is little effort anywhere to preserve them as seed for more than a few years and most workers who keep cultures have had a refrigerator failure or something similar that resulted in a complete loss of stored material.

DISCUSSION:

C. O. Johnston emphasized that it is a time-consuming and expensive undertaking to increase and keep pure many races of rust all at the same time because of the amount of work involved and facilities required.

R. M. Caldwell stressed the need of varied sources of resistance in breeding for leaf rust resistance to avoid having such a large commercial acreage from a single source.

STEM RUST SYMPOSIUM

Leader: I. M. Atkins, Texas
(Opening remarks)

Stem rust has been a major pest of small grain for hundreds of years. Not only is it the most dreaded disease of wheat in this age of large scale production but it was the cause of major losses in grain raised by our forefathers. In one of the earliest recorded observations of agriculture in Texas, as found in the Texas Almanac of 1869, there is this statement, "Rust is the dreaded enemy of the wheat crop in Northern Texas---- if the crop is attacked early enough it is apt to result in a total failure". Most of you remember the terrible losses caused by this disease in 1935, estimated at 160 million bushels or 23 percent of the crop. The disease was again important in the mid-west in 1944 and in 1949. For Texas in 1949, we estimated the loss from stem rust at 6 million bushels. Much breeding work and considerable progress has been made in the Hard Red Winter Wheat Region, but in general, the rust resistant strains developed have been deficient in yielding ability, drought resistance, winter hardiness, quality or some other characteristic considered sufficiently serious to prevent their distribution. Minter has been distributed in Minnesota and Austin, a soft red winter wheat, has been distributed in Texas but no stem rust resistant variety has been distributed in the central areas.

Texas plays an important part in the early development and spread of rust epidemics because a considerable part of the over-wintering of the disease and the major part of the early "build-up" of inoculum occurs here. Therefore, the varieties grown in Texas are of concern to everyone. Austin wheat, developed from the cross of Mediterranean x Hope, was distributed in 1941 and found favor in Central Texas for several years, increasing to as much as 500,000 acres in 1947. During the last few years this variety has been seriously damaged by low temperatures in the northern part of Central Texas and by races of leaf rust which now attack the variety throughout the area so that Austin has lost favor rapidly. More recently Sea Breeze, developed from a cross of Mediterranean-Hope x Gasta, was distributed primarily for grazing in extreme South Texas. Its importance to this conference lies only in its influence on the over-wintering of rust.

At the close of the 1950 harvest, we expect to distribute Quanah. This will be the first resistant hard red winter wheat available in Texas. Quanah was developed from a cross of (Comanche x Honor-Forward) x (Mediterranean-Hope x Comanche). Quanah combines some of the good characteristics of Comanche wheat, such as bunt resistance and good quality, with resistance to stem rust. It is superior to either Comanche or Austin in leaf rust resistance, superior to Comanche but not equal to Austin for winter grazing, and is equal or superior to Comanche in test weight, straw strength, and adaptation to combine harvesting. Quanah has several serious faults which will limit its adaptation. It is susceptiable to loose smut, is lacking in winter hardiness, and probably in drought resistance. It will be recommended for the Rolling Plains and Central areas of Texas which are the major offenders in the early build-up of rust inoculum.

Red May wheat has been grown in the Dallas area since about 1850. There continues to be quite a sizable acreage which is an important factor in the development of stem rust in that area. Ready for increase and distribution are strains from the cross (Fronteira x Red May) x Red May. These are similar to Red May agronomically but have fine rust resistance. While their quality will not be equal to hard wheat, preliminary tests indicate they will be farily satisfactory for bread purposes. Final decision on these strains will be made this year.

For the south half of Central Texas, we may distribute Supremo which was developed by Mr. McFadden from a cross of Trigo-Supreme x Mediterranean-Hope. A number of strains from this cross and others was sent to the Rockefellow Foundation in Mexico. One strain was found satisfactory and was grown on several thousand acres in Mexico in 1949. This has been named Supremo and may be made available to replace Austin here next season.

With these three new stem and leaf rust resistant varieties available in Texas we believe we can make a significant reduction in the overwintering and early spread of rust in Central Texas. This will be of value and importance not only to our farmers but to each of you. We do not have stem rust resistant varieties ready for distribution in the Panhandle area but, many strains are under test.

Breeding work in progress involves all of the new sources of disease resistance we have been able to learn about. We have used several of the Latin American varieties, the Kenya strains, Marquillo-Oro, and Red Egyptian. Last winter common wheat derivatives of (Triticum dicoccoides x Aegilops squarrosa) x Austin and of Triticum timopheevi x Aegilops squarrosa as developed by Mr. McFadden were crossed to Comanche to improve their quality.

New Sources of Resistance to Stem Rust and Leaf Rust

E. S. McFadden and George W. Rivers, Texas

New parental material of promise in breeding for rust resistance, which is now available at College Station, Texas is of three general classes: (1) Vulgare wheats of foreign origin, (2) segregates from crosses between vulgare wheats, (3) synthetic rough allohexaploids and their derivatives.

Class (1) Forty-three common wheat varieties of foreign origin have been found to carry varying degrees of resistance to stem rust. Thirteen of these are also resistant to leaf rust. Data on the 43 varieties are given in U.S.D.A. Circular No. 814, entitled "New Sources of Resistance to Stem Rust and Leaf Rust in Foreign Varieties of Common Wheat". Several other foreign varieties appear promising from the standpoint of leaf rust resistance.

Class (2) Segregates from crosses between vulgare wheats that have resistance to both rusts are:

(a) Hope x Mediterranean selections crossed with the Latin-American varieties such as Fronteira, Frondosa, Surpresa, Triunfo and Renacimiento have given segregates highly resistant to both rusts. These include such segregates as the now Supreme variety which is derived from Hope-Med. x Surpresa, and has considerable resistance to stem rust, leaf rust, stripe rust, loose smut, mildew and Septoria nodorum.

(b) Hope-Med. x McMurachy segregates appear to have both early and mature-plant resistance to stem rust combined with considerable resistance to leaf rust.

(c) Crosses of the Kenya wheats with the Latin American varieties have given high yielding segregates that are resistant to both rusts.

Class (3) The rough allohexaploides that appear especially promising as parental materialin breeding for rust resistance include the following forms:

Series I. The C genome of Aegilops squarrosa added to the A and B genome of various rust resistant tetraploid wheats has given rust resistant hexaploids that produce, in most cases, highly fertile hybrids with T. vulgare. The following forms of this series are now available:

(a) Triticum dicoccoides x Ae. squarrosa. This form carries a gene, or genes, for resistance to certain physiologic races of leaf rust derived from the wild emmer parent. Otherwise it does not appear to have value as parental material. (b) T. Dicoccum (Vernal) x Ae. squarrosa. This comparatively new form is a typical T. spelta. It has been grown only two years at College Station, Texas. It is a very vigorous form with high fertility, but it is slightly less resistant to stem rust and leaf rust than the Vernal emmer parent. Compared with Hope wheat, it is less resistant to stem rust but possibly more resistant to leaf rust. It should produce highly fertile hybrids with most varieties of T. vulgare and T. spelta. It is now being used as a parent in the breeding of disease resistant forage-type spelt wheats for southern Texas.

(c) T. timopheevi x Ae. squarrosa. This form is highly resistant to both stem rust and leaf rust under field conditions. Theoretically it also carries genes from timopheevi for resistance to several other disease, but it is not known how fully the effects of these genes are expressed in the presence of the C genome. The F_1 hybrids of this form with T. vulgare are usually fairly self-fertile, but higher seed setting can often be obtained by back-crossing to the vulgare parent. Numerous vulgare-like segregates that are resistant to both rusts have been selected from crosses of this form with several varieties of T. vulgare.

(d) & (e) T. durum (Carleton) x Ae. squarrosa and T. durum (Pontad) x Ae. squarrosa are being grown in the field at College Station this year for the first time. They both carry genes for resistance to stem rust and leaf rust derived from the durum parents. Their hybrids with T. vulgare should be highly fertile.

Series II The tetraploid wheats added to various Aegilops genomes have given the following hexaploid forms that appear promising as parental material in breeding for rust resistance:

(a) T. dicoccoides x Ae. uniaristata and umbellulata have produced forms which have considerable resistance to leaf rust and are very prolific under southern Texas conditions, but their hybrids with T. vulgare are only slightly fertile. In crosses of vulgare wheat with this form, Sears has recently reported success in adding a single pair of chromosomes carrying leaf rust resistance genes from the umbellulata genome to T. vulgare, but their segregates are not stable due to a tendency for the umbellulata chromosomes to become lost.

(b) T. dicoccoides x Ae. speltoides is highly resistant to stem rust and leaf rust. It is not entirely stable cytologically or morphologically due to homologies of speltoides chromosomes with those of the A and B genomes. At least four of the speltoides chromosomes are able to pair with members of the Vulgare C genome, and consequently its F_1 hybrids with T. vulgare are fairly fertile, and seed setting is further increased by back-crossing to the vulgare parent. Free-threshing stable segregates resembling T. vulgare and highly resistant to both rusts have been obtained from this form by two different methods: (1) crossing with T. vulgare and (2) crossing with T. persicum. Some of the disease resistant segregates from each of these crosses appear to be stable except for a strong tendency for natural crossing with T. vulgare.

(c) T. dicoccum (Vernal) x Ae. sharonensis is only moderately resistant to leaf rust, but is highly resistant to stem rust. It is doubtful if it contains any genes for resistance to leaf rust that do not occur in Hope wheat.

(d) T. timopheevi x Ae. speltoides is highly resistant to both stem rust and leaf rust. <u>It probably constitutes the greatest reservoir of disease resistant genes yet obtained in a hexaploid wheat.</u> However, it has thus far bloomed too late to be crossed with the wheat varieties used in the breeding program in southern Texas. Furthermore, it is not anticipated that its hybrids with T. vulgare will be highly fertile because of poor homology of several chromosomes in at least two of the genomes.

Unfortunately, little is known concerning the reactions of the new parental materials to specific races of stem rust and leaf rust. However, it is known that most of the new stem rust resistant materials have remained essentially rust free in the field in the presence of such physiologic races of stem rust as 17, 38, and 56, to which Hope wheat is susceptible in the seedling stage, and Austin wheat gives a localized susceptible reaction on the sheathes just above the nodes. Also, most of the leaf rust resistant materials have remained essentially free from leaf rust in the presence of such leaf rust races as 5, 9, 15, 19 and 126, and under conditions that have caused the Hope and Austin varieties to give a completely susceptible reaction in the field.

Progress in Stem Rust Breeding

E. G. Heyne, Kansas

No stem rust resistant varieties are available for commercial growing in Kansas. The value of three to four days earliness in a variety probably is significant in that such varieties may escape serious damage from rust. Pawnee, Comanche, Wichita, and Triumph were on about 9-10 million acres in Kansas in 1949. Damage from leaf rust in 1949 should have been higher than estimated but the few days of earlier maturity of these varieties probably reduced the potential loss. No stem rust of serious amounts has been present since these varieties have become dominant on Kansas farms.

New sources of stem rust resistance in the breeding program are Medit. x Hope, Kenya selections, Timstein, and *Agropyron* species x *Triticum* species.

Breeding for Disease Resistance in Colorado

T. E. Haus, Colorado

The problem of breeding for disease resistance includes combining stem and leaf rust resistance with bunt resistance. Stem rust races that are being used in artificial epiphytotics are 17, 38 and 56. Leaf rust races being used are 9 and 15. Bunt races being used are 3, 4, and 8 of *Tilletia foetida*.

Atmospheric conditions for a stem rust epidemic are present every year at Ft. Collins for high humidity. An automatic sprinkler is used to create high humidity F_2 and later generation selections are tested for seedling reaction of stem rust in the greenhouse after selection and prior to planting time. This eliminates many susceptible or segregating selections. During the winter, selections are tested for seedling reaction to leaf rust in the greenhouse.

The Hope and H44 derivatives and McMurachy have been used as parents. At the present time Timstein, Red Egyptian, C. I. 12315 (Merit x Pilot), and Shands' Timopheevi are being used as a source of rust resistance. Bunt resistance is being obtained from Marquillo x Oro and Oro-Turkey-Florence selections.

Sources of Stem Rust Resistance

E. R. Ausemus

The Hope and Thatcher types of resistance to stem rust have been extremely valuable, especially since Thatcher is grown on such a large acreage and Hope because of its wide use as a source of resistance in the production of new varieties. Both of these wheats have excellent resistance in the adult stage, in general, yet in certain experiments where environmental conditions have been favorable to infection and in some localities considerable rust has developed on these and other resistant varieties.

With the finding of several wheats, such as Timstein, Kenya 58 and 117A, Red Egyptian, McMurachy and Frontana, resistant to a large number of physiologic races in the seedling stage, these wheats have been used as additional sources of resistance in our breeding program. Every effort is being made to obtain wheats having resistance to as many physiologic races as possible and to combine these resistances with those in the wheats now grown. In crosses of Timstein with Thatcher, Newthatch and Mida, several F_4 lines have been obtained by Koo (Ph.D. Thesis, 1949) which combine the physiologic resistance of Timstein to 20 individual races with the adult plant resistance of Thatcher, Newthatch and Mida, respectively. Only one line carries the Thatcher type of field resistance, four that of New thatch, and nine that of Mida.

A summary of the seedling reaction to physiologic races, giving the number of the races to which each variety was resistant or susceptible, was published by Drs. Stakman and Loegering in the Report of the Eighth Hard Red Spring Wheat Conference, in 1948. Timstein has been resistant or moderately resistant in the seedling stage to 30 different races and was susceptible, so far as tested, only to 15B. It has had as high as 60 per cent infection in the adult stage in the field where a collection of rust races was used to create an artificial epidemic. Other wheats, such as Hope, Thatcher and Newthatch have had moderately heavy infection but were somewhat more resistant than Timstein. This infection may be due to the effect of temperature, light and other factors or to such a race as 15B. Kenya 58 and 117A, and Red Egyptian and Frontana have been more resistant in the field while Timstein, Thatcher, Mida and Newthatch have been moderately susceptible in the 15B rust nursery. As these four varieties carry moderate resistance to 15B in the seedling stage, there is some reason to believe 15B is responsible for the heavy infection of Timstein under field conditions.

Other sources of resistance include Timstein derivatives, Rio Negro received from Argentiana, T. timopheevi x A. squarossa from McFadden and Agropyron-wheat hybrids from Shebeski in Canada.

Hybrid varieties are now available in rod-row tests between crosses of Kenya 58 and 117A, Red Egyptian with Mida, Newthatch and Thatcher which were more resistant when tested to 15B in the field than the resistant parents.

F_5 hybrids of Frontana crossed with Thatcher, Newthatch and Mida, which are resistant to 15B in the seedling stage, are also available.

In winter wheat, varieties having the Hope type of resistance have been satisfactory to date.

E. C. Stakman and W. Q. Loegering

(Presented by H. A. Rodenhiser)

Stem rust of wheat was light for the country as a whole in 1949. Fewer spores were disseminated from the south toward the north than in the average year, as shown by examination of slides exposed at 39 stations. There was a very heavy stem rust epidemic on wheat in northern Mexico, from Piedras Negras to Monclova, and rust was heavier than normal in the Saltillo area. There is circumstantial evidence that urediospores may have been blown from the Piedras Negras and Saltillo areas to wheat in Texas and northward in a band along western Oklahoma, Kansas, and Nebraska, and into south-central South Dakota. Stem rust caused considerable damage in Texas, but a combination of diseases other than stem rust apparently caused greater losses than stem rust in Oklahoma and Kansas.

Results of the identification of physiologic races of wheat stem rust confirm results of previous years, showing that the number of prevalent races has decreased where barberry eradication has been nearly completed. In 1949, only races 56, 17, and 38, in order of prevalence, were important in uredial collections in the country as a whole. For the twelfth consecutive year these three races comprised more than 90 percent of the isolates. Race 56 was almost exclusively present in the Great Plains area; elsewhere the three races were fairly uniformly intermingled, except in barberry areas of the Pacific Northwest and Eastern United States, where many other races were isolated. From aecial collections, 14 races were obtained from Oregon, 11 from Washington State, 10 from Virginia, and 11 from Pennsylvania. The isolates from Pennsylvania and Virginia included race 15. Results from a special study of races near barberries in Lebanon County, Pennsylvania, are not yet available.

It is evident that at present wheat is being exposed to infection by only a few races. Near barberries, however, many races still are appearing including races 11 and 15, the most virulent races so far found in North America. As race 11 has been prevalent at various times and in various areas in the past, there is no reason why it should not become prevalent again. Moreover, race 15 has been more prevalent than it now is and could become prevalent as did race 56 of wheat stem rust and race 8 of oat stem rust; consequently it is important that attempts be continued to obtain varieties resistant to these potentially important races.

As far as can be foreseen now, the only real menace with respect to the development and dissemination of new and virulent races are the barberry ares of the United States and possibly contiguous acres of Canada.

Q. Is not the testing of strains in the field with so virulent a race of stem rust as 15B and its biotypes a dangerous procedure even under the best possible conditions?

A. Dr. Rodenhiser explained that at present 15B is being used at St. Paul, Minn., Manitoba, and also in ~~[illegible]~~ S.A. Since so little material is available with resistance to 15B and since its use seems dangerous from the standpoint of contributing to its spread, recommendations were made at the last Spring Wheat Conference that 15B should not be distributed for testing. It has been suggested that material that is to be tested for its reaction to 15B or similar biotypes be sent to an area where that race is now prevalent. However, the need of testing a given strain under the conditions where it will be grown is recognized.

Dr. Ausemus commented that tmeperature is a very important factor in the reaction of wheat to races of rust and pointed out that certain strains were resistant under Minnesota conditions but susceptible under warmer climates.

Mr. Reitz reported that in the Uniform Yield Nursery the Hope hybrids had an average yield less than the average for all entries for the same area each year from 1946 to 1949. In the northern area (Minnesota and South Dakota), Minter (a Hope hybrid) has yielded satisfactorily.

Comparison of yields of Hope hybrids to the average of all entries in the Uniform Yield Nursery over the Nebraska, Colorado, Kansas, Oklahoma, and Texas areas show the following:

Year	No. Hope Entries	Bu. per acre less than av. of all strains tested
1946	four	0.91
1947	six	1.80
1948	five	1.69
1949	four	1.72

Future Plans for Rust Control

After some discussion, E. G. Heyne made a motion that investigators in the area compile the reaction on seedlings and mature plants for races of wheat rusts on varieties and strains of possible breeding value. Motion seconded by R. E. Atkinson. Carried.

It was suggested that a committee composed of one man from each state make up the initial list. Each man would handle the assembling of data from his station going back to 1943 or thereabouts. All the data should be assembled and distributed to interested workers. Later, new information could be disseminated by L. P. Reitz in the annual regional report on hard red winter wheat.

D. W. Robertson recommended that a list of F_2 and F_3 material (also bulks) be made available to all breeders so that early generations of hybrids could be grown and selections made under the conditions where they will be used commercially. Mr. Reitz mentioned that a list of material was distributed two years ago and that such a list could be brought up-to-date. Most all agreed that this should be done.

H. A. Rodenhiser explained that collections of specimens for rust identification should be made more carefully. About three leaves folded once and slipped flat into a glassine envelope is best. A large wad of material packed into a glassine is useless. He stressed the need of a uniform manner in reporting the rust infection on the uniform rust nursery, asking that the instructions which always accompany the nursery be read and followed. He desires a percentage figure for the severity of infection and a type of infection reading from all locations so that comparable notes are recorded.

C. O. Johnston reemphasized Rodenhiser's remarks especially in regard to the manner of making the collections. He mentioned that the collection should not all be made from one variety since such a collection will not reflect the races present in the area but rather the races to which the particular variety is susceptible.

H. A. Rodenhiser announced that the results from the identification of rust collections will be published each spring following the winter's work by Rodenhiser and Johnston.

D. W. Robertson expressed a desire to have the Germ Plasm List revised and brought up-to-date. L. P. Reitz was requested to take the lead in this.

L. P. Reitz expressed the following needs in connection with rust problems: (1) more basic research; (2) more qualified men to work on rust; (3) breeding for resistance to races not necessarily dominant at the moment; (4) diverse germ plasm is needed--the Hope hybrids may soon make a solid belt of varieties from south to north which would be an unhealthy situation; (5) perhaps varieties should be released in pairs or threes in the future, each with different resistance as insurance against a race building up.

MONDAY AFTERNOON, JANUARY 23

INHERENT INSECT RESISTANCE AND OTHER CONTROLS

Leader: R. G. Dahms, Oklahoma

Hessian Fly Resistance in Wheat

Reginald H. Painter, Kansas

Since the last wheat conference, the variety Pawnee has spread to occupy a larger wheat acreage than any other variety in Kansas. In two papers dealing with the hessian fly resistance of Pawnee, Painter and Jones (1945 and 1948) have pointed out the several characteristics by which Pawnee differs from fly-susceptible wheats. About half the young larvae which reach the feeding position on Pawnee do not feed, or if they do grow, often make smaller flaxseed than on susceptible plants. This effect on the insect has been reflected in the decrease of the fly population in Central Kansas in 1945-1947 despite highly favorable weather conditions for an outbreak. The unfavorable fall of 1947 was responsible for an extra decrease in the spring 1948 fly population. However, there are still indications that the portion of the fly population able to develop naturally on Pawnee may increase and thus in some areas, the variety will appear to have increased in susceptibility.

The possibility of a shift in biotypes of fly and the desirability of higher levels of resistance has led to a use of other sources of fly resistance. Fly resistance from the sources listed below has been transferred or is in the process of transfer to winter wheat types. So far, one of the most promising strains in several respects has been Kawvale-Marquillo X Kawvale-Tenmarq (C. I. 12128). The relationships of this strain to parental types are indicated on the chart.

One problem in connection with the distribution of a fly resistant type may require solution. There has been ample evidence in studies on insect resistance that plants of a variety may appear to be alike morphologically but differ in insect resistance. Practical methods may have to be devised for detecting and eliminating fly susceptible strains in a fly resistant wheat variety.

Sources of Fly Resistance Transferred or in Process of Transfer:

Spring Wheat (Common)

Marquillo	
Centenario	
Ill. #1W38	) all probably carry only H_3
Kearney C. I. 6585	) gene for fly resistance according to
Triunfo	) W. B. Cartwright, U.S.D.A.
P.I. 56206-8	) Probably resistant to the laboratory
P.I. 94549	) strain of fly able to infest Ill. #1

Uruguay Wheats Originally From Boerger

Renaciminento sel.
IV cl ÷ # C.I. 12034
IV y gelou C.I. 12001

Winter Type

P.I. 119344-7 (Fly resistance nearly equal to 94587) White seeded Turkish.
Kawvale

Spring Wheat (Durum)

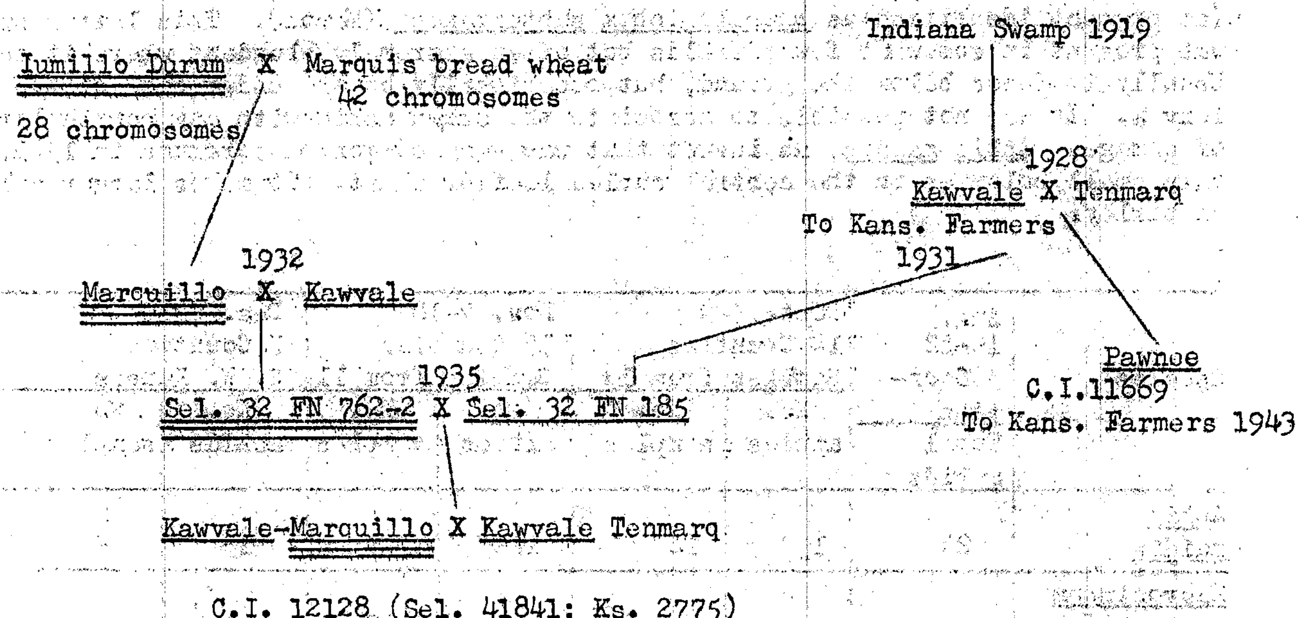
P.I. 94587
P.I. 56244-4 (appears equal to 94587 in fly resistance and much better in adaptibility)

Wide usage of Pawnee seem to be related to the decline in recent years in spring infestation of wheat by hessian fly as shown by the following estimate:

Crop Year	Total acres of winter wheat	Total acres of Pawnee	Average % of stems infested by hessian fly* South central	North central
1944-45	14,145,000	40,000	13	16
1945-46	14,149,000	800,000	22	11
1946-47	14,994,000	3,700,000	16	7
1947-48	14,480,000	5,100,000	3	2

*From Painter and Jones (1948) with the additional data for 1947-1948 from the same sources as that of the preceding years.

The diagram below shows the origin of Pawnee and several other selections bred for fly resistance:



Wheat Insect Problems-Greenbugs

I. M. Atkins, Texas

Greenbugs have not been a major problem in Texas since the destructive infestation of 1942. Our observations on resistance in that season have been reported to this group. A small infestation last season and local infestation in the Denton area within the past few weeks have permitted some tests with the newer insecticides. Experimental tests have been conducted using Benzene hexachloride (3% gamma), parathion (1%), and tetra-ethyl pyrophosphate. Weather conditions were none too favorable but fair control was effected with parathion. The BHC appears to be greatly influenced by weather conditions and requires fairly high temperatures with little wind. We at first thought we had obtained good control with TEPP but later counts indicated that some bugs recovered. This insecticide has been used effectively on spinach and other greens in South Texas and is the safest one tested.

Following the 1942 infestation of greenbugs and our observations on resistance, we made a number of crosses attempting to transfer the resistance to greenbugs found in Smooth Awn 86, (C.I. 6268) to our Texas varieties Wintex and Texan barley. Although under green house conditions, Dr. Dahms has not found Smooth Awn 86 as highly resistant as certain other varieties, its resistance was quite effective in 1942 and again in our variety test at Iowa Park in 1947. In a local infestation, Smooth Awn 86 produced 41.8 bushels of barley per acre whereas Tennessee Winter produced 19.0 bushels per acre and Wintex 28.0. Normally Smooth Awn 86 is less productive than Wintex.

Aphids on Wheat in Western Kansas, - Fall, 1949

Reginald H. Painter, Kansas

In connection with a study of possible vectors of the Western Wheat Mosaic in Kansas, several survey trips were made in counties in the area where this disease was severe last year. These were made at approximately monthly intervals, with the results that appear in the tabulation below. The corn leaf aphid, _Aphis maidis_, was the most wide spread species but had fewer individuals than the crown aphid (at present identified as _Rhopalosiphum subterraneum_ (Mason). This latter species was present in somewhat fewer fields but often extremely abundant where it occurred. Usually it feeds below the ground, but occasionally on the under side of the lower leaves. It was not possible to associate the crown aphid with any particular type of damage. _Aphis maidis_, an insect that was very common on sorghums in 1949, makes only small colonies in the central curled leaf of wheat. It makes larger colonies on barley.

Species	Aug. 10-12 3 Counties	Sept. 5-9 14 Counties Samples from 13		Nov. 7-10 17 Counties Samples from 11		Dec. 8-10 7 Counties S. W. Kansas	
	Total aphids	No. aphids	No. samples	No. aphids	No. samples	No. aphids	No. samples
Aphis maidis	24	150	12	115	9	13	5
Macrosiphum granarium	—	—		12	3	—	
Rhopalosiphum prunifoliae	—	—		45	6	—	
Rhopalosiphum subterraneum	2	442	9	257	14	17	7**
Histeroneura setariae	1	—		—		—	
Toxoptera graminum	9*	5*	1	105	11	52	7
Aphis gossypii	13	—		—		—	
Myzus persicae	—	—		2	2	—	

* Only 1 colony found each time

** Rhopalosiphum spp.

The green bug, Toxoptera graminum, was represented by only a single colony found on each of the first two trips. Characteristic green bug spots were found on a few leaves at several other localities on the second trip. By November, the green bug had nearly caught up with the corn leaf aphid in respect to numbers of individuals and was present in one or two more localities. To judge by samples from the southwestern area not previously visited, the green bug was the most common species present in December. The crown aphids present at that time probably were not adequately sampled by the method used.

As is noted on the accompanying list, six species of aphids were recorded as forming colonies on wheat and at least five more species were present but not seen reproducing in numbers on this crop plant.

Aphids forming colonies on wheat included the following:

Aphis maidis (Fitch) or corn leaf aphid. A blue-green aphid with black tail spots and black legs. Scarcely able to survive on wheat, but was abundant at the time of the surveys.

Macrosiphum granarium (Kirby) or English grain aphid. A black legged form. Frequently is found at the crowns.

Rhopalosiphum prunifoliae (Fitch) or apple grain aphid. The young are olive-green but the adult or winged form is black. Frequently is found at the crowns.

Rhopalosiphum subterraneum (Mason) or crown aphid is orange or tan colored (adults dark) and works mainly at the crown in fall sown wheat. Very abundant this fall.

Toxoptera graminum (Rond.) or green bug. This aphid is dark green in color with a dark stripe down its back and green legs. Wings have one-branched veins. It reproduces at very low temperatures, even under snow. Extensive damage may be caused.

Aphids collected sp radically on wheat were:
- Aphis gossypii (Glov.) or Cotton aphid or melon aphid.
- Myzus persicae (Sulzer) or Green peach aphid.
- Forda olivacea (Rohwer)
- Anoecia querci (Fitch)
- Macrosiphum pisi (Kalt.) or Pea aphid.

Histeroneura setariae (Thos.) or rusty plum aphid was also mentioned. Assistance in identifying the species was given by J. B. Kring and L. M. Russell. Colored slides were used to illustrate the insects and some of the damage caused.

Resistance of Wheat Varieties to the Greenbug

R. G. Dahms

Greenhouse tests have been made to determine the reaction of approximately 200 varieties and selections of wheat to greenbugs. Three aspects of resistance have been considered: (1) The preference of greenbugs for certain varieties as determined by adding the number of aphids counted on the different varieties each day for the first 4 days of the test. (2) The tolerance of the varieties to greenbug attack as determined by the number of days required to kill the plant. (3) The rate of reproduction of greenbugs when feeding on different varieties.

Although differences in resistance have been observed between wheat varieties none has been found that is as highly resistant as some of the barley varieties. Some of the wheat varieties that appear to be least preferred by greenbugs are: Hope, Shinchunaga P.I. 155281, National 62 P.I. 149107 and Quanah. The difference in tolerance of the various varieties to greenbugs has not been very great. The varieties that have consistantly shown some degree of tolerance include: Kawvale-Marquillo X Kawvale-Tenmarq (C.I. 12331), National 62 P.I. 149107, Marquillo X Oro 37 RN 1433-6 and National 483 P.I. 149109. Several Rye X Wheat selections have been very unfavorable to greenbugs for reproductive purposes.

Records were also taken on the reaction of 80 wheat varieties and selections under field conditions to a light greenbug infestation. Under these conditions several selections of Nanking, Hope, and Hope Hybrids and a few Marquillo X Oro hybrids showed some resistance.

Several head selections of wheat were made in the spring of 1949 from areas where the surrounding plants had been killed by greenbugs. Many of these selections when tested under greenhouse conditions were no more resistant than the check varieties, but two selections from a field of Triumph and one from a field of Clarkan showed indications of being much more resistant than the check varieties.

Resistance of Spring Wheat Varieties to Grasshopper Attack

E. R. Hehn, Montana

Observations by various workers prior to 1941 indicated that grasshoppers, show a preference for certain varieties of spring wheat. In the summer of 1941 and winter of 1942, controlled experiments were conducted with <u>Melanoplus bivittatus</u> (Say) to determine preferential feeding on the eleven varieties of spring wheat, Triunfo, Clarendon, Thatcher, Marquis, Reward, Quality, Pilot, Ceres, Hope, Rival, and Nordhaugen. A second objective was to study the mechanism of resistance.

In the 1941 field test there was a striking difference between varieties in grasshopper damage as measured by the percentage of heads clipped from the culm. The percentage of heads clipped in Clarendon was 36.3 as compared to 90.7 in Marquis. The 1942 greenhouse tests indicated similar differences in susceptibility. The field and greenhouse data were positively correlated ($r = +0.62$).

Histological studies of the peduncle were made in each of the eleven varieties. It was found that the resistant varieties had a larger area of mechanical tissue abutting the epidermis than did the susceptible varieties. In the field test the correlation between percentage of heads clipped and extent of mechanical tissue was -0.91, and in the greenhouse it was -0.84. The extent of the mechanical tissue abutting the epidermis has been suggested as a criterion of selection for grass-hopper resistance.

The effects of resistant and susceptible wheat plant diets upon the reproductive capacity of the grasshopper would be a worthwhile and an exceedingly interesting study. See also Agron. Jour. 41: 467-469. 1949.

Factors Associated with Grasshopper Resistance in Four Spring Wheat Crosses

J. E. Grafius and E. R. Hehn

In an earlier paper strong negative correlation coefficients were obtained between the amount of mechanical tissue in the upper part of the culm and resistance to Melanoplus bivittatus (Say). The number of heads clipped was used as the measure of resistance. Although the mechanical tissue measurement eliminated the need for artificial infestations of grasshoppers in the early generations of selection, it proved too laborious for more than a few observations. It was reasoned that mechanical tissue could be estimated by the strength and the diameter of the culm section. Such proved to be the case, with r values of 0.64** and 0.42** for diameter and breaking strength, respectively.

The diameter and breaking strength of the dried culm sections taken just below the peduncle were studied in four cross involving resistant and susceptible parents: Clarendon x Thatcher; Thatcher x Triunfo; Reward x Thatcher; and Clarendon Reward. Clarendon and Triunfo had previously shown resistance to M. bivittatus (Say), while Thatcher and Reward were susceptible.

The F_3 means of the resistant x susceptible crosses exceeded the means of the susceptible x susceptible cross by a significant difference ($P < .01$) for both the diameter and breaking strength measurements. Two resistant x susceptible crosses were carried in the F_4 and significant correlations were established between the means of the F_3 and F_4 families for diameter and breaking strength.

As a final test a total of twenty F_5 families from two resistant x susceptible crosses were subjected to grasshoppers (M. differentialis, Thomas,). A correlation coefficient of -.48 ($p < .05$) was obtained between the breaking strength of the dried culm and the percentage of heads clipped by grasshoppers. No relationship was found ($r = -.06$) between the diameter of culm and grasshopper damage which may have been due to the influence of leaf rust.

Organic Insecticides for Control of Wheat Insects

Don Ashdown, Oklahoma

Insecticides for control of wheat insects have been developed principally in the last 10 years. Materials in use prior to that time were chiefly of botanical origin or of an arsenical source, and were expensive, of short residual action, subject to temperature limitations (in the case of nicotine, the chief aphicide) and were applied with machines having limited capacity.

DDT was the first of the synthetics to be extensively tested against wheat pests, and it introduced a new set of versatile properties: synthetic origin, therefore not a limited product, a long residual killing power, low cost, high potency and fewer temperature limitations in its effectiveness.

BHC, and its purified gamma isomer now known as lindane, was the next of the synthetics to receive wide usage. This has given effective control of the greenbug on wheat under some conditions, but is toxic to barley.

Toxaphene, formerly known as chlorinated naphthlene, is a synthetic made from plant products. It has been useful in the control of grasshoppers, chinch bugs (in experimental plots) and the armyworm, (*C. umpunctata*). Last year about 15,000 acres of wheat were treated in Cotton and Tillman Counties in Oklahoma. An estimated saving of $150,000.00 was effected in this program.

Chlordane, a chlorinated hydrocarbon is outstanding in control of grasshoppers, armyworms, and white grubs. In the latter case, it may be mixed with fertilizer before application, or applied as a diluted dust in a fertilizer drill. A single application has been completely effective for several years.

Chlordane's little brother, Aldrin, formerly known as Compound 118, and Deldrin or 497 are worthy of careful experimentation.

The organic phosphates, first called HETP and later TEPP, and parathion are now our keenest tools against aphids and other insects with sucking-piercing mouth parts. Although this group of insecticides is extremely hazardous to use, observance of published precautions can render their use by competent personnel reasonably safe. It is important that arrangements for first aid treatment be provided where these materials are used.

TEPP has been effective at a rate of 0.3 lbs. per acre when air temperatures are above 75° F. and the foliage is dry. These limitations exclude it from many situations in greenbug control; parathion has been more satisfactory under less favorable temperature and moisture conditions. TEPP hydrolyzes almost immediately when put in water. It has been used safely on leafy vegetables.

Parathion, used as a 1 percent or 1½ percent dust, or in a spray made from the wettable powder, and applied at a rate of 0.2 to 0.25 lbs. of actual material per acre has given excellent control in Oklahoma.

Recent experiments in Wisconsin indicate that parathion might control wireworms if applied to seed wheat before planting as was done with corn with encouraging results.

Another organic phosphate "Gearphos" containing the dimethyl analog of parathion in an emulsion has been outstanding in late fall tests against greenbugs. This formulation eliminates some suspension problems encountered in the use of wettable powders where the materials are to be applied by aircraft.

The future of chemical control of wheat insects and other pests is indeed bright. Caution and reasonable care in the use of these materials will be necessary to realize the maximum benefits without unfortunate casualties.

Discussion: Workers from several states reported on the successful use of various insecticides in the control of greenbugs and grasshoppers. DDT used on pale western cutworms in New Mexico gave variable results.

Insecticidal Treatment of Wheat Insects

Reginald H. Painter -- Kansas

Insecticidal treatments have been made in Kansas for the control of several wheat insects.

On June 6, 1949 Mr. W. W. Franklin stationed at Hays, reported excellent results from an aerial spraying for green bugs near Walker, Kansas. TEPP was applied at the rate of ½ lb. in 4 gal. of oil per acre. Twenty-four hours later few live aphids could be found.

Mr. Del Gates, Kansas extension entomologist, supervised an experiment for control of crown aphids in southwestern Kansas this fall. Parathion was used at ½ lb. of the 27½% emulsion concentrate per acre sprayed. The infestation of the treated area after 48 hours was about 50% as high as the unsprayed check. Some yellowing of the wheat occurred within a few weeks in the areas of the application.

An attempt was made to control hessian fly by use of BHC (1% gamma), 5% DDT and 3% Chlordane dust in the fall of 1947 without success.

MOSAIC AND ROOT ROTS OF WHEAT

Leader: E. D. Hansing, Kansas

Wheat diseases caused a higher loss in Kansas in 1949 than in any previous year since records were first taken in 1915, and probably the highest annual loss since wheat was first grown in the state. The total loss from wheat diseases was 26.5% or 59 million bushels valued at 109 million dollars. Leaf rust caused a loss of 10% or 22,341,000 bushels of wheat. This was the second highest annual loss being surpassed only by a loss of 12% in 1938. If we had grown the same varieties as were grown in 1938, it is estimated that we would have had a loss of 18% or 33 million bushels. Fifteen percent of the acreage of wheat was planted to the early varieities Wichita and Triumph, which escaped high losses. Fifty-six percent of the acreage was planted to the moderately early and tolerant varieties, Pawnee and Comanche, which also rusted heavily but partly escaped high losses.

Mosaic was generally distributed in western Kansas and more severe than in any year in the past. This disease caused a loss of 7% or 15,639,000 bushels of wheat. Prior to 1949 mosaic was considered of minor importance, although it had been very destructive in local areas.

The bacterial diseases black chaff and basal glume rot caused losses of 2 and 1% respectively or a total of 7 million bushels. Only in 1929 when the spring was wet and cool was a higher loss recorded for these diseases.

Scab, powdery mildew, and septoria glume blotch caused losses of 0.5, 0.2 and 0.2% respectively or a total of 2 million bushels. They ranked first or second in severity as compared with other years.

Stem rust, bunt, loose smut, septoria leaf blotch, and take-all were not severe. They caused a combined loss of only 0.6% or 1 million bushels.

Unidentified crown and root rots were very common and destructive. It is difficult to determine the loss caused by these disease, however a conservative estimate would be 4% or 9 million bushels. Unidentified fungi and bacteria were also very common on the stems, leaves, and heads of the plants. Many of these were probably weak parasites which cause losses especially under wet humid conditions. A conservative estimate of the loss caused by these would be 1% or 2 million bushels.

Mosaic in the Winter Wheat Belt

Hurley Fellows, Kansas

Western type wheat mosaic has been reported in Nebraska, Kansas, Oklahoma, Texas, Colorado, and likely in the Dakotas.

History in Kansas:

1929 Experimental plots at Manhattan.
1930 Rawlins and Sheridan counties, several hundred acres.
1932 Saline county
1941 Locally in central Kansas and at Manhattan.
1943 850 acres in Meade county.
1948 3000 to 5000 acres in Decatur and Morton counties.
1949 Over a wide area in western Kansas, principally the western four tiers of counties.

In the past, mosaic has been erratic in distribution and sequence of appearance. It may appear once in a field and never be seen there again.

All past research work done in Kansas has been field work. Attempts were made to eliminate mosaic in local areas by eliminating insects. Varietal tests were made for resistance. A complete fertilizer was used on sick plants to see if they would recover but fertilizers did not help the plants.

We have estimated that the loss from mosaic in Kansas last year was 15,000,000 bushels. I don't know how much was lost from impaired quality. Test weights in affected areas were lower than elsewhere. Present research includes two things. Varietal tests are being made in three places in western Kansas. Dr. Painter, of the Entomology Department, and myself are attempting to find an insect vector principally among the aphids. We have made 26 attempts to transfer mosaic with the green bug (Toxoptera graminum), six with the corn leaf aphid (Aphis maidis), seven with the crown aphid (Rhopalosiphum subterraneum), ten with the English grain aphid (Macrosophum granarium), and 13 with the apple grain aphid (Rhopalosiphum prunifolium). To date we have seen no signs of transfer by any.

Three surveys were made this fall. No mosaic was found except in southwestern Kansas. Actual transfer was made proving the presence of mosaic. Plants brought in from the field and potted can be checked for mosaic by examining the new growth for symptoms of the disease.

Western Wheat Mosaic

R. E. Atkinson

The discovery of western wheat mosaic in Colorado in 1946 led to studies of its cause and methods of artificial transmission. Diseased plants were ground in a mortar and pestle, water added, and the juice filtered through a Berkefeld W filter. The bacteriologically sterile filtrate was inoculated into the growing point of healthy plants with a hypodermic needle. The region of the growing point was then punctured repeatedly with a number 10 needle. Relatively low percentages of infection were obtained, but inoculations with the juice of healthy plants produced no symptoms on inoculated plants. It was concluded that the disease is caused by a virus.

In 1947 wheat mosaic occurred in epiphytotic proportions in three areas of Colorado. Experiments were set up to determine how virus is transmitted. Seed from healthy and diseased plants were grown in the greenhouse and field without showing mosaic symptoms. Similarly, plants were grown in soil from infested fields and compared with plants grown in soil from uninfested fields. No evidence of soil or seed transmission was obtained.

When diseased wheat plants were brought into the greenhouse they were infested with a green aphid that spread to winter wheat lines being tested for stem rust reaction, which then became infected with mosaic. These aphids and aphids from healthy plants in the field were used in transmission experiments. Successful transmission of mosaic virus by viruliferous aphids was obtained in three separate experiments in which 42, 50 and 60% of the plants developed mosaic. Non-viruliferous aphids used as controls failed to transmit the virus. Miss Miriam Palmer (Emeritus Assistant Professor of Entomology, Colo. A & M College.) identified the aphids at the beginning and the end of the experiments as Toxoptera graminum.

In the search for resistant varieties, selections of healthy plants from badly infested fields were made in 1947 at Bennett and at Akron, Colorado. These have been tested in the greenhouse and field for resistance to mosaic. Some lines of each variety which remained healthy are currently being retested in the greenhouse and field.

Possibilities of sources of resistance in spring wheats are being investigated. The following varieties have been inoculated by the carborundum method: Hope, Thatcher, Ceres, Marquis, Timstein and Reward. All have proved to be susceptible in some degree. Pilot x Merit (C.I. 12732) which yielded well at Akron in 1949 in the presence of mosaic, was susceptible to artificial inoculation. Vigo, the soft red winter wheat resistant to Eastern mosaic, and T. timopheevi are also susceptible.

In studying the epidemiology of mosaic, seeking a possible source of the virus that infects the early planted fields, corn, barley, oats, sorghum and millet were artificially inoculated. Corn, barley and oats developed mosaic symptoms but no symptoms appeared on sorghum or millet. The corn aphid, as well as other aphids, are being studied as other possible vectors.

Experiments under way in the field include tests of wheat varieties and experiments to determine the effect of date of inoculation on the severity of the disease. Plants were inoculated at Akron and Fort Collins in September and October, 1949 and others will be inoculated in April and May, 1950. The effect of mosaic on tillering, size and number of heads, number and weight of kernels will be determined.

From fields said to have dry land foot rot, typical plants were selected and were shown by inoculations to be carrying the wheat mosaic virus. This indicates that a relationship may exist between the disease known as dry land foot rot and western wheat mosaic.

Mosaic and Foot Rots

J. E. Livingston, Nebraska

Dr. Livingston noted the fact that mosaic and foot rots may and often do occur in the same fields and that symptoms of both may appear in the same plant. This raises the question whether mosaic is part of the environmental complex predisposing plants to foot rot infection. In any case, causes of discoloration in wheat must be carefully diagnosed if a correct analysis is to be made. Last summer mosaic transmission was effected from most of the suspected collections. However, soil from a badly infected field was brought in to the greenhouse for foot rot tests. The sterilized portion gave normal growth to wheat while the non-sterilized soil gave plants that were abnormal and resembled mosaic infected plants in outward symptoms but mosaic could not be transmitted from them. The roots of these plants were badly rotted.

Preliminary evidence of insect transmission was obtained by the departments of Plant Pathology and Entomology when a collection of several insects was placed on wheat plants resulting in mosaic infection. The particular insect vector has not been identified.

He emphasized the need for intensive studies of (1) insect transmission, (2) host range, and (3) symptomology.

Diagnosis of Root and Crown Roots

G. W. Bruehl, South Dakota

The ability to diagnose these diseases is based upon three fundamentals: (1) adequate knowledge of the major pathogens and their effect upon the hosts; (2) careful field and laboratory observation of diseased materials to determine their condition; and (3) judgement in comparing what was observed with the standard or typical symptoms of the given diseases.

Pathogens make a more or less distinct type of attack upon the host. For example, Fusaria and _Helminthosporium sativum_ attack both crown and root tissues, working in both directions from the seed level. _Pythium_ spp. with lobulate sporangia attack root tissues, and _Rhizoctonia solani_ is virulent only on plumular tissues.

The condition of both above ground parts and lower crown and roots should be carefully determined. Severe crown and root rot tends to hasten maturity, cause shriveled grains, non-filling tillers, and occasionally death of the main culms. Browning root rot (_Pythium spp._) tends to delay maturity and cause a local necrosis of the roots beginning as a watery soft rot and gradually becoming brown as invasion by secondary organisms progresses. The root above the lesion is usually white and clean. Brown, soft stubbs are often left when such roots are pulled from the soil. The presence of ossspores in the stubs and lesions would verify the diagnosis.

Judgement enters into the diagnosis as you may not encounter an uncomplicated occurrence of one disease, but two or more together, or one virulent pathogen with different secondary organisms. The problem is to determine the main effects.

"Rootrots and Footrots of Cereals in Washington", Popular Bulletin No. 192, by Dr. Roderick Sprague of the Washington State Experiment Station, Pullman, Washington, contains a key and brief description of these diseases.

Oklahoma Report on Wheat Mosaic

D. F. Wadsworth, Oklahoma

Wheat mosaic has not yet become a problem in Oklahoma. However, mosaic has been found in Oklahoma from time to time, always erratic, rarely recurring from year to year, nor necessarily in the same field. It would appear that transmission of the disease is not through infested soil in Oklahoma. Furthermore, we don't know what the vector is nor its source of inoculum.

Some time ago Dr. McKinney suggested that the reservoir or virus might be in some of the native grasses near diseased plants, and a careful search produced two suspicious grasses, but I was never able to get transmission from them. Still this possibility is well worth a more thorough examination.

Wheat-Mosaic Situation for Wyoming

G. H. Starr, Wyoming (Presented by E. D. Hansing)

Although we have no laboratory research as substantial proof, we are assuming that some wheat mosaic did occur to a limited extent in Wyoming, particularly in the eastern part. A number of samples were brought in or sent in by county agents and some of the samples showed characteristic symptoms of wheat mosaic. In addition, a limited field survey waw made in eastern and northern Wyoming, at which time plant specimens were collected. The most infection observed, occurred in a few fields north of Fort Laramie, in east-central Wyoming, where the infection reached approximately 50 percent in Cheyenne winter wheat and in Thatcher spring wheat. The owner later reported that the yield was very poor in these fields.

At the time of the field inspection in August, numerous plant samples were collected together with soil samples taken immediately around these plants. Later on a quantity of seed was obtained from the worst field which was used in greenhouse tests to determine if the seed might carry mosaic or at least if it would be suitable for planting again for the 1950 crop. Similarly, the soil was used to test any possible carry-over of the disease. To date, no symptoms of mosaic have been observed in any of the tests.

Wheat Mosaic in South Dakota

J. T. Slykhuis, South Dakota

Mosaic was found on wheat in four southern counties of South Dakota in 1949. In early October plants were collected from winter wheat and also from volunteer spring wheat stands and transplanted into pots in the greenhouse. Plants that showed no mosaic symptoms grew to maturity normally, but of those that showed mosaic symptoms when collected many died, others were stunted and failed to head or headed abnormally, and a number produced extra leaves from some of the nodes. Even branch culms bearing spikelets occurred. The mosaic was transmitted manually to all the varieties of wheat recommended for South Dakota. The durums were most severely affected and the hard red spring wheats were next while the hard red winter wheats showed the least severe mosaic symptoms.

Wheat Mosaics in the United States

H. H. McKinney, Beltsville, Maryland

Two general types or species of mosaic viruses are known to occur in the hard red winter wheat area: the wheat streak-mosaic virus and the plains wheat-mosaic virus. Both species have strains which differ in their ability to impair the chlorophyll in the foliage, and the two species differ in their infection characteristics.

Streak-mosaic virus has been much more prevalent than the plains wheat mosaic virus. In 1948 and 1949, 52 collections of wheat mosaic from Arizona, Colorado, Kansas, Nebraska, So. Dakota and Oklahoma, were tested for the presence of virus. All but 10 of these collections were viable. All viable collections were found to infect wheat and sweet corn, but not bromegrass, when all three plants were cultured in a greenhouse at summer temperatures. These 42 viable collections are regarded as being wheat streak-mosaic virus or close allies with it. The 10 collections that did not infect, may represent, in part, the plains wheat mosaic virus which infects only at cool temperatures. Some of these may involve unfamiliar viruses, mistaken identity of mosaic in the original collection of dead virus.

Since the collections were from many areas, and 80.77% of them contained viable virus, it is highly unlikely that mosaic has been confused to any extent, with the several types of chlorosis caused by foot rots, root rots, malnutrition, cold, wet soil, insect damage etc.

As yet, no wheat has been found to be highly resistant to the strains of the streak-mosaic virus. The wheat relatives and several wild grasses that have been tested, have been found to be susceptible. Barley and oats have shown more resistance than wheat, and rye is highly resistant or immune.

The soil-borne wheat mosaic viruses common in the soft wheat area have not appeared in the hard red winter Wheat Area. These mosaics are controlled effectively through the use of varieties that are highly resistant or immune in the field. However, these field immune and resistant wheats become infected, and develop mosaic when they are grown in a greenhouse and inoculated by manual methods.

The very destructive rosette reaction which is caused by a particular strain of soil-borne mosaic virus in a few wheat varieties like Harvest Queen, Missouri bluestem, Clarkan and certain other Clark lines, is eliminated completely in the rosette-free wheats. The wheats are immune from the rosette reaction no matter how the plants are inoculated, but they are not immune from the virus nor from the mosaic expression when they are inoculated by manual methods.

Tests conducted in cooperation with the Illinois Agricultural Experiment Station, show that Pawnee, Comanche and Triumph are susceptible to the soil-borne mosaics, but not to rosette.

Dr. Hansing read reports from workers in states not represented at the Conference as follows:

<u>North Dakota, W. E. Brentzel</u>

I believe this is a more serious problem in winter wheat than in spring wheat. I have been expecting some trouble in this section from the mosaic virus, but apparently it has not developed to any considerable extent, if at all in this region.

<u>Missouri, C. M. Tucker</u>

Mosaic occurring in Missouri is practically all or all of the eastern type.

<u>Iowa, H. C. Murphy</u>

Wheat mosaic definitely was present in southwestern Iowa, but it was not of major importance insofar as the winter wheat crop of Iowa was concerned in 1949. Dr. Reddy is of the opinion the mosaic symptoms were most severe along the edges of the fields and that the disease may have been spread from infected grass or weed hosts along the fence rows.

DISUCSSION:

Considerable discussion occurred, following which Dr. Hansing appointed a committee to get a set of recommendations to go into the conference report on future plans.

TUESDAY MORNING, JANUARY 24

HARD RED WINTER WHEAT QUALITY

Leader: E. R. Ausemus, Minnesota

New Varieties Grown in 1949 Have Promising or Outstanding Hard Wheat Milling and Baking Properties

J. F. McCammon, Kansas

Three varieties in the Uniform Yield Nursery were good to very good with respect to all milling and baking properties. They included Martin-Tenmarq x Kharkof (C.I. 12147), Marquillo-Oro x Pawnee (C.I. 12505), and Blackhull-Oro x Pawnee (C.I. 12516). The loaf volume potentialities of Hard Fed. Hybrid (C.I. 12515) were outstanding but its water absorption and mixing properties were about average.

The water absorption and mixing properties of Kawvale-Marquillo x Kawvale-Tenmarq (C.I. 12128) in the Central District Uniform Plot Composites were very good, and its loaf volume potentialities was satisfactory. The composites of C.I. 12128 from North and Northwest and from South and Southwest Oklahoma had excellent water absorption, mixing, and dough handline properties. Loaf volume and other milling and baking properties were satisfactory.

The slightly soft milling properties of Hard Fed. Hybrid (C.I. 12515) from Woodward and Cherokee probably would not represent a serious criticism against this variety. Other milling and baking properties for C.I. 12515 were excellent. Comanche x Chey.-Blackhull (Wd. 43h3-81) had good to excellent milling and baking properties.

Four varieties from Stillwater, Oklahoma of particular promise included Hard Fed. Hybrid (C.I. 12515), Comanche x Chey.-Bkhl. (Wd. 43h3-81), Com. x Bkhl.-Hd. Fed. (Wd. 43h2-315), and Com. x Bkhl.-Hd. Fed. (Wd. 43h2-329).

Chiefkan x Mqo.-Oro (244-46-9 and 244-46-13) appeared as promising new varieties from Chillicothe, Texas.

Chiefkan x Oro-Tenmarq (C.I. 12518) from Hays, Kansas has outstanding milling and baking properties.

Two varieties from Denton, Texas, Sinvalocho-Wichita x Hope-Cheyenne (208-46-22) and (Sinv.-Wich. x Hope-Chey.) x Wichita^2 (237-46-23-1), had promising to outstanding baking properties. Their grinding and bolting properties were undesirable, however, and will warrant special attention in future tests.

Improved Blue Jacket 40-H-10, appeared of promise in quality.

N. P. Turkey (C.I. 12143) from North Platte, Nebraska was excellent.

Turkey (11530) x Oro Sel. 205, 208, 216, and 221 from Moccasin, Montana had very good milling and baking properties.

The loaf volume potentialities of nearly all the varieties from Brookings, S. D. were excellent but all were low in protein and had subnormal water absorptions.

(See also Hard Wheat Quality Lab. report for 1949.)

Prequisites for a Good Milling and Baking Wheat

K. F. Finney, Kansas

A new variety, to be of good milling quality, should have normal bolting or sifting properties. The wheat should be neither unusually hard nor soft. If too hard more power and additional breaks and reductions may be required. If too soft the flow will be altered by an unusually high quantity of break flour. If the above requirements are met and the wheat gives a normal yield of flour having a normal quantity of ash, it will almost invariably be a good milling wheat.

A flour of good baking quality should produce a dough having a high water absorption and with a medium to medium-long mixing requirement. A flour with a medium to medium-long mixing time almost invariably will have desirably elastic properties and be stable throughout the entire baking process. If the flour, in addition, has good loaf volume potentialities, considering protein content, and has good internal crumb grain and color, it possesses, as a rule, the requirements of a good baking quality wheat.

Although the above enumerated milling and baking properties are desirable, it is often necessary to compromise by accepting a wheat that is somewhat inferior in one or two respects. For example, when Pawnee was approved for distribution it was the only wheat available that could compete agronomically against Chiefkan. Chiefkan was undesirable in many respects. It was too hard and gave flour that usually had a grey cast. It had an extremely short mixing time, a very poor mixing tolerance, and produced a dough that was unstable during fermentation. In addition, it gave a loaf having inferior crumb characteristics and decidedly poor loaf volume potentialities. Pawnee met all the requirements of a good milling and baking wheat excepting that its water absorption requirement was low and its mixing requirement was short. These inferior properties of Pawnee, however, were far overshadowed by its superior agronomic properties.

Thus in interpreting the milling and baking data given in mineographed and other special reports of the Hard Wheat Laboratory, properties labeled as questionable could be tolerated, in all probability, if the wheat in question was superior agronomically. Kawvale-Marquillo x Kawvale-Tenmarq (C.I. 12128) has all the milling and baking properties or a good quality wheat, excepting that it is slightly below the best in loaf volume potentialities. This selection, however, has a high water absorption requirement, a medium-long mixing time, and very stable dough during fermentation. Thus this variety would be an improvement over one such as Pawnee.

Wheat Varieties and Needs of the Trade

Lawrence Iliff, Wichita, Kansas

Wheat is grown primarily to eat - and to eat in the form of baked products. The manner in which it performs in the mills of the processors, and the results and success which the baker secures in preparing the bread and rolls and cakes; the pies and cookies and crackers that people consume, are of fundamental importance in considering qualities of wheats grown now, for this is certain and sure: It must satisfactorily fill the purpose for which it's intended if it be called "good." This will be just as true with the varieties released in 1960, '65 or even 1970, which are now being bred and selected by agronomists. Ideas of quality do change, and to aid in evaluating future quality requirements, this discussion is about the considered opinions from many millers, chemists, and bakers of the demands upon their raw material, wheat and flour, with some reasonable development of the possible or probable milling and baking characteristics in the years ahead. Since this is a hard winter wheat conference, the discussion should be limited to the hard wheats grown in the Southwest and the industries utilizing them.

The 1920's saw the change from slow-speed mixing, to so-called "high speed" methods, using fast mixers, more streamlined and in some cases, more automatic equipment. Thus began the production of the puffy "Balloon" or "Jumbo" bread by the average wholesale plant, although a more compact loaf was still on the market. The Turkey varieties then available with their rugged gluten quality tending toward snappy, tough doughs sometimes actually bucky, long mixing times, and requiring a longer, vigorous fermentation, were suited to these methods. Also into that period came the dough-break, with procedures using slight mixing, long sponge fermentation and intensive mechanical treatment to condition the dough for the pan; this too required a tough strong flour and was quite popular in this area.

A new shift in loaf types and production methods appeared in the 1930's. The attempt to avoid irregularities and large holes of the giant loaf resulted in the "Twist" bread with fine, even grain and soft tenacious crumb. It soon became clear that a flour of different nature was needed for efficient and trouble-free operation, a flour giving a very pliable and plastic dough, easily handled and molded.

Then an event occurred, which might have been predicted, the Second War, but with some unforeseen results for bakeshops: War Food Order #1 in the early 40's forbade "twisting" of bread, trying to save time and labor for the war-effort. Bakers returned to plain-top bread, and through the impetus of the war years generally continued to the present with that kind of loaf. Meanwhile costs of labor and operation have increased enormously, along with intensified production demands. With universal high-speed mixers and with highly mechanized shops, the baker requires for economic and efficient operation, flours of only moderately long mixing time but much mixing tolerance, more tolerance to fermentation, and various mechanical and shop conditions, and a smoother, more mellow dough type. Time is money, tolerance his insurance, and poeple must like and buy his product.

The historical development has been from slow and manual to rapid and mechanized, but still definitely batch methods. Possibly, or even quite likely, in the near future may arise baking processes both completely automatic and continuous, for not only bread, but other baked goods as well. Indeed, cake production in many plants is already from a continuous process, with ingredients streaming into one end of a machine which extrudes the homogenized batter into pans traveling to the oven - all in one operation.

Now the variety that furnishes flour for processes like these, or methods even more highly refined or mechanized, must of necessity have an extension of all the desirable features of present flours, plus greater tolerance to mixing, fermentation, and handling. With limited time allowed for development, mixing time should not be excessive - fermentation requirements likewise must not be lengthy, but rather on the short side. That doughs be very smooth and mellow, easily worked and handled, will be mandatory; above all, the dough will be dry, with no trace of sticky tendencies or wet surfaces, that could jam the production line at mixers, dividers, rounders or other points. A reserve gasretention power will be inherent in this variety - volume capacity will be sufficient to produce the well-rounded more compact loaf of today and probably tomorrow, rather than the expanded loaf with high-shred popular before; for one thing, the more-rounded loaf cuases less trouble in feeding through bread-wrapping machines. Consumer preferences, too, are pointing toward a delicate but stable crumb of fine and even grain, tender and smooth to the palate; the structure of such grain of course, should resist the shocks and bruises of merchandizing.

We can see signs of such trends, for example, with variety shifts in the spring wheat area. The older types, Marquis, Thatcher and Ceres, very strong wheats, in some cases of a bucky nature, are yielding to the more mellow varieties such as Mida and Rival; indeed, Mida now leads all the others in amount grown in the spring wheat region.

Further changes in the buying and eating habits of the American consumer can be expected. The shift continues, from the 70% of flour bought and used by the housewife years ago, to the commercial baker himself now purchasing and baking 70% of all flour milled. Even the home-consumed flour still sold is gradually changing in character, away from stronger flours for home-baked bread to the tenderer types better adapted for pastries and cakes. An instance of a sudden development with unforeseen possible results in changing baking and eating habits, is the new Brown 'N Serve process. Had the statement been made in October to any group of millers, bakers, or wheat specialists, that within three months some millions of little blonde rolls, appearing to be so-called "half-baked", would be made and sold, the reactions expressed, to be merciful, would have been rather incredulous. Not only is this new technique still rapidly expanding, but adapting to other products - notably, several shops already are experimenting with, or marketing a Brown 'N Serve bread. Pale, but baked to the point of crumb firmness, with greatly increased shelf life over conventional loaves, ready to be oven-browned either in its cellophane wrapper or portions of the loaf as desired, or even to be dropped in the old family toaster - it sends to the table what people usually talk so nostalgically about - fresh bread! We are still too close to the advent of just this one new item in the whole scheme of wheat and flour consumption to foresee its extent or to predict just what changes it may bring about. So far, this may be said: attributes desired in the flour of now and the future apply as well to this process.

Certainly there should be no implication here for the breeding and propagation of weaker wheats, of which we have an excess now over much of the area. The improvement associations yet have the Chiefkans and Early Blackhull and Red Chief remnants to scotch from the fields. There are more than enough varieties as Triumph, for example, to furnish the all-purpose flour required. The variety of the near future, to satisfy the miller and baker, who in turn must satisfy the people who are the cause for growing wheat at all - must not lack in strength, as we know it. A variety similar in strength to Comanche, must be flanked with dough properties dry but easily worked, mellow but lively - the ability to produce good bread over a range of mixing, mechanical handling, and various fermentation and shop conditions - and gas-retentive power with gluten quality to yield a fine and tender grain and texture in a loaf of normal volume. Not tough harsh rigidity, but pliant tolerant strength is the keynote of this future bakers' flour, the flour that increasingly mechanized and automatic bakers will be forced to seek.

For actual milling value, the variety desired now and more so in the future will furnish a good recovery, particularly of patent flour. Especially will it avoid any semblance to present Red Chief; difficult to condition properly, the release of hard gritty middlings whose vitreous nature requires more power and over-grinding to reduce to flour, and bran that chops badly, contributing both high ash and dull color. Rather will the miller want a variety resembling, at least as far as milling properties are concerned - Triumph, which takes conditioning normally, carries a coherent bran coat, with a mellow endosperm reduced easily to a bright lower-ash flour. However, equally to be avoided will be any tendency toward too much fluffiness requiring extra bolting or a susceptibility to flaking. Whether flour granulation which the mill supplies its bakery customers will change, is yet to be determined. However, a more uniform granulation than now secured will probably be desired, if such can be found as a variety characteristic.

Another important quality characteristic of any flour is absorption. This water-binding power is inherent within a variety, although actual flour absorption is influenced by other factors. While the increased bread yield from higher true absorption is a distinct advantage to a baker, he will be much more concerned with the state of his doughs; any flour after having been mixed to the desired consistency, which tends to slacken or even to stiffen considerably as it passes through fermentation and handling to the pan is going to be condemned; with the greater the degree of mechanization in handling, the more the aversion. We are not yet certain of the top limit for true absorption. It may be not too far above present levels for Southwest hard winter wheat, protein considered. For one thing, the limit will be set by over-soft crumb as well as a maximum bread moisture given by law. Clearly though, the qualities valued more in flour from new varieties will be those giving dry, tolerant and mellow doughs rather than higher absorption levels.

Mechanical dough-testing devices have been widely used in recent years to evaluate physical properties of flours, such as consistency in terms of absorption, resistance as dough forms, and the span of this maximum resistance. Among these, the Brabender Farinograph is increasingly used not only for comparative varietal measurements but also in control and commercial determinations of "strength" or "quality". But many of us know that the "curve" recorded does not reflect total "quality" in the end product, a loaf of bread, and that in some cases cannot accurately predict the mixing time or tolerance. After all a commercial dough is not flour and water, but composed of many essential and supplementary ingredients, all with some influence upon mixing and fermentation.

Now, however, the technologists using this particular device are rigidly standardizing both machine and technique. With the probable more uniform interpretation of results that inevitably follows such standardizations, this physical test will surely be a valuable adjunct to the breeder, as well as to the control chemist checking uniform performance.

Because of the weak varieties abounding in the southwest within the last 10 to 15 years, varieties which give very short and very critical dough mixing periods, and with machines like the Farinograph charting short and "Peaked" curves, the pressure has necessarily been in selecting wheats toward those with longer and stable mixing character. Comanche has been a fine advance in this direction. But as the processor of now and tomorrow will not want a return to the very long-mixing tough wheats of years ago, he will want stability rather than excessive length. It could logically be expected that the "curve" of the coming desirable bakers' wheat will reflect the same trends in length of commercial dough-mixing as previously outlined.

Omitted here are many other future properties of wheat and flour from lack of more complete knowledge of either their measurement or significance in terms of commercial usage and quality conceptions. And while the baker-consumer mentioned so often here is an average and dominant figure, there will remain some diverse kinds of bakers and methods and baked goods, using procedures of now and years ago, with flour types to match - from small retailers to larger shops with individualistic ideas. The practice of wheat blending for the mill mixture, to secure from different varieties with certain properties just the right balance in desired characteristics, will continue for long. The fear expressed by a few of a too great expansion of varieties in the Southwest with too much strength for advanced baking procedures need not be realized if we retain the idea that not strength alone is wanted, but the strength of stability and reserve. At present and in the foreseeable period ahead, we have an ample stock of the weaker or very tender varieties, that substitute for extreme mellowing where needful or are available for all-purpose milling.

The varieties Pawnee, Wichita, Triumph, and especially Comanche were answers by the breeders to the real needs of millers and bakers who were rather desperate in their attempts to grind Red Chief, and to mix and ferment properly the flours from Early Blackhull and Chiefkan. With the expected automatic trends in baking, a new quality conception appears. We have seen the rigid high-pressure tire with little real resistance in 1920 give way gradually to the tire of today, stronger but resilient, tougher but tolerant of abuse, smoother and softer in performance. And the miller, able to reduce efficiently friable middlings into a full measure of bright uniform patent flour, the average baking plant, mixing and handling dry pliant doughs that have much leeway for varying conditions, fermenting fairly rapidly to fit the tight schedules, his costs force him to maintain, will value the varietal types which can supply just such properties. That the agronomists who were able to breed Tenmarq and the other hard winter varieties can develop these further qualities needed, along with all the properties required for farm acceptance, and with a realization of the difficulties and complexities involved - members of the milling and baking industries are confident.

Q. Will foreign demand alter the quality level we should seek to produce?

A. Dr. Shellenberger said that we (U. S.) must compete with wheat from Canada and Argentina whose wheat flour strength and tolerance excels ours in the order named. We are only above Australia in this respect.

Foreign countries are more and more milling their own wheat which is generally of poor quality and require strong wheat to add strength to their flours. This may explain why strong flours are required for export business.

Q. What percentage of our wheat should be of the strong type?

A. Iliff: I would say roughly 75% should be of the strong gluten type.

Microbiological Assay of Amino Acids

Byron S. Miller, Kansas

Differences in "microbiologically apparent" cystine and methionine with respect to environment were observed for several varieties of hard red winter wheat grown during one crop year. No differences in lysine or glutamic acid with respect to environment were observed. Likewise, no differences among wheat varieties were found for either cystine, lysine, methionine or glutamic acid. All values are based on total wheat protein.

There was a significant difference in per cent cystine for samples grown in 1946 and 1947. The wheat grown in 1947 contained the most cystine and also required longer mixing for optimum dough development. Thus, there may be a relationship between per cent cystine and dough mixing time as influenced by environment. The longer mixing varieties tended to reflect a greater change in mixing requirement for a small change in cystine content. The nutritional value of wheat protein may be affected by environment due to variation in cystine and methionine content in the protein.

Since the amount of available soil sulfate at Manhattan, Kansas, was not a limiting factor in determining the amount of cystine and methionine synthesized as part of the wheat protein, experiments have been designed to produce a condition of limiting sulfate by means of liquid culture technics. The objective is to grow several samples of wheat containing different percentages of sulfur bearing amino acids in the protein. Complete chemical analyses as well as milling and baking tests are to be performed on each sample.

The Relation of Starch to the Baking Properties of Flour

R. M. Sandstedt, Nebraska

The bread baking properties of wheat flour have long been attributed to the peculiar properties of gluten which enable it to form films which are relatively impermeable to gas. However, the ability of a dough to bake into a loaf of bread is dependent also on some peculiar properties of starch; the starch takes up water by gelatinization in the oven and thus gives the bread cell a rigidity which prevents its collapse. That is, the gelatinization of the starch is responsible for setting the unstable collapsible gas cell of a dough to the more rigid noncollapsible bread cell.

The dough during fermentation and during the first stages of baking must necessarily be flexible and readily extensible, the handling properties required by the baker. These properties are largely dependent on the correct dilution of the gluten by starch, although the character of the starch is also important. The alteration of the starch by the milling process has a profound effect on the handling properties of doughs. A certain minimum amount of damaged starch is necessary for satisfactory water absorption and gassing power, however too much damage causes stickiness and high water absorption with slackening during fermentation. The milling damage is associated with the hardness of the wheat but may be quite largely controlled by the miller.

The dough must be flexible and readily extensible during the early stages of baking but these properties must be lost at a definite stage of the baking to produce good bread. The starch must not only gelatinize at the right temperature but apparently must have certain staling properties to give desirable crumb character to the bread. This may be shown by baking bread from doughs in which the wheat starch has been replaced by other native starches (such as corn or waxy corn) or by altered wheat starches.

Pilot Plant Testing of Wheat

J. A. Shellenberger, Kansas

In many industries pilot plant operations have been standard procedure for a long time. All manipulations designed to guide the future course of operations for any process can be designated as a pilot plant operation. However, the term "pilot plant operation" has become associated more and more in industry with operations which bridge the gap between laboratory and commercial operations. It is in this sense that pilot plant functions are of the utmost importance when used for the evaluation of new wheat varieties in advance of their release for distribution to the farmers.

Until recently equipment has not been available under either Federal or State supervision for testing new wheat varieties under other than laboratory conditions. However, principally through the efforts of the milling industry there is now in the Department of Milling Industry at Kansas State College complete equipment for conducting both pilot plant milling and baking tests. The equipment includes a completely modern 130-sack flour mill and a bakery capable of handling 100 pounds of dough per batch. It will require not less than 10 bushels of wheat for a milling test, and if much fundamental milling data are to be obtained 40 or 50 bushels of wheat will be needed to operate the mill for a period of approximately four hours.

The pilot plant mill under competent supervision and with the equipment available can be expected to give accurate information on at least the following important considerations:

a) Tempering requirements.
b) Power requirements.
c) Breaking, reduction and sifting characteristics.
d) Yield of flour.

It is anticipated that the millers and milling companies will welcome the opportunity to participate to a greater extent in the testing of new varieties. Favorable response has been received already to the suggestion that the milling experiences of many companies be pooled for the purpose of evaluating the milling qaulities of wheat varieties at the pilot mill.

Having used the pilot plant mill to determine milling quality, it should not be too difficult to obtain a final evaluation of the baking quality because a large supply of flour will be available. Thus new varieties, that have for many years received thorough testing by laboratory methods, can be given a complete commercial bakery testing in the pilot plant bakery. When tests of this type are conducted, representatives from the baking industry and the products control departments of the milling industry should be invited to attend for the purpose of participating in the program and helping evaluate the baking results. Also the flour being tested would be available to ship to a number of mill laboratories and bakeries for testing under their own conducted, representatives from the baking industry and the products control departments of the milling industry should be invited to attend for the purpose of participating in the program and helping evaluate the baking results. Also the flour being tested would be available to ship to a number of mill laboratorie and bakeries for testing under their own conditions.

Much of the equipment for the pilot plant mill and bakery at Kansas State College was obtained through the efforts and financial support of the milling industry. The persons who have helped to provide the equipment for pilot plant milling and baking operations have done so with the thought that the facilities would be used in the regional wheat improvement program. It seems that this conference should determine how best to utilize the pilot plant equipment. Perhaps we might discuss profitably the following topics:

a) Does the group favor pilot plant testing of new varieties?
b) What recommendations should be made regarding the production of from 10 to 50 bushels of wheat for milling tests?
c) Where should the costs for growing, harvesting, sacking and shipping of such large samples be placed?
d) Where should the milling and baking costs be placed?
e) What group or committee should control the arrangements with the flour mills and bakeries for participation in pilot plant operations and where should final responsibility for reporting lie?

Summary

Pilot plant milling and baking tests should be used to obtain reliable information concerning the quality of all new wheat varieties before their release to the farmer.

For the first time in the United States modern pilot plant milling and baking equipment are available to help the Federal and State wheat improvement programs. The equipment, installed in the Department of Milling Industry at Kansas State College, has been placed there largely through the efforts and cooperation of the milling industry with the understanding that it would be used to the best interests of regional wheat improvement programs.

Plans for Regional Testing of Quality in Wheat

L. P. Reitz, Nebraska

New strains must be evaluated rather fully for quality characteristics before they are distributed. The Federal Hard Wheat Qaulity Laboratory at Manhattan, Kansas, is doing an effective job for the region through the testing of:

1. All varieties in the uniform district plot experiments.
2. Entries in the uniform yield nursery.
3. Miscellaneous selections sent in by breeders called Special Plant Breeder's samples.
4. Large samples in the pilot plant located at Kansas State College available for state and regional use.

It is recommended that these facilities and kinds of tests be maintained.

Research at the laboratory has made good progress in determining normalcy in the wheat which will enable the greater use of a confidence in results obtained from composites. This seems especially important in connection with Plant Breeder's samples where seed supplies are limited since it will permit compositing grain produced in two or more tests within a state.

Whenever possible it is urged that at least one quality test be conducted on new strains before they are nominated for entry in the uniform yield nursery or uniform plot experiments and that breeders make a concerted effort to get samples for testing from farmer plant breeders who may have new varieties about ready for release. In all cases it is assumed that suitable standard or check varieties will accompany the experimental samples.

Q. Are tests on composites generally satisfactory?

A. K. F. Finney said that the composite samples are very good and that their use permits tests at the Quality Laboratory on a greater total number of selections of wheat.

R. M. Sandstedt emphasized that individual quality samples may be misleading and that composites may mark important quality characteristics.

S. C. Salmon stated that the Beltsville laboratory has been making use of composite samples for about 15 years with good results.

Mr. Reitz thought that composites should be prepared with care to avoid the use of grain produced under abnormal environmental conditions.

TUESDAY AFTERNOON, JANUARY 24

HAZARDS AND FAVORABLE RESPONSE OF WINTER WHEAT TO WEATHER

Leader: A. F. Swanson, Kansas

Introduction and Procedure

A. F. Swanson, Kansas

The chief purpose of this discussion should be a study and an exchange of experiences and observations on the effects of weather on wheat. Out of this part of the conference at least three objectives may be reached:

1. To visualize the normal trend of the climate over a long period of time as made up by the elements of weather, namely rainfall, temperatures, evaporation, wind velocity, frost free days and the wide fluctuations that occur from year to year.
2. To understand how wheat respond on the basis of morphological and physical characteristics, to the departure of the weather from the normal, as well as to the normal. Just what plant breeders can accomplish in developing varieties that will perform best when the weather fluctuates rather widely from year to year cannot be easily determined. Even so the varieties that have become established in their respective regions have certain characteristics that make it possible for them to perform reasonably well in adverse seasons, and exceptionally well in the favorable ones.
3. To get ideas from this conference that would be useful in appraising and evaluating the wheat crop as it unfolds from the time it emerges in the fall and passes out of dormancy in the spring until the grain is ripe. Crop reporters and statisticians are called upon at stated intervals to make crop estimates which the trade and the farmers anxiously await. Yet from April 1 until the end of the ripening period, changes in the weather fom the normal and its influence on the crop is often so great that what was predicted for May 1 or June 1 is often not realized on July 1. For instance, a hazard such as a sharp freeze in Nebraska and Kansas in May when wheat is heading is soon broadcasted over the nation. The long distance calls begin to come in from the terminal markets and the farmers of the region. It is then that the agronomists are hard pressed for a sound appraisal of the damage that has been done. It takes long years of experience, familiarity with crops and weather, and good judgment to render a service to the public that will be accurate and trustworthy.

The Weather Pattern of the Great Plains

A. F. Swanson, Kansas

There are many approaches to a study of the interaction of crops and weather. Graphs have been prepared to show the averages of precipitation and other components of weather for a 28-year period by five-day intervals as obtained from the records of the U. S. Weather Bureau at Hays, Kansas. The advantage of the five-day intervals is that such periods are more easily correlated with measurable or observable changes that take place in plant growth for similar intervals, particularly when the crops are growing vigorously during the seasonal months. (See graphs 1 and 2).

Graph 1 indicates that the rainfall is low in January and February when the wheat is dormant. The precipitation rises in March as the crop goes out of dormancy. Increased rainfall in April and early May stimulates tillering and later booting. Tillers to the extent of 6 to 7 million per acre are often produced during this stage of vegetative growth, but only from 1 to 2 1/2 million will make heads and produce grain. The rest of the tillers will have fallen by the wayside as the crop reaches the heading stage. The maximum amount of rainfall is registered at the end of May and early June when the wheat is pollinating and fruiting. This is the time of the crop's greatest moisture requirement. Western Canadian workers have reported that it requires from 1,000 to 2,600 pounds of water to produce one pound of wheat or from 30 to 80 tons of water to make one bushel of wheat. By far the largest percentage of this moisture is used during the fruiting period.

As the rainfall diminishes the temperature rises in late June and the evaporation is increased. This unique set of conditions, when the weather is normal, ripens the grain for harvesting and for storage. But this period can be also the most critical if high temperatures and evaporation come before the wheat has reached the hard dough stage. The yield may then be reduced and there are indications that the quality of the gluten may be adversely affected.

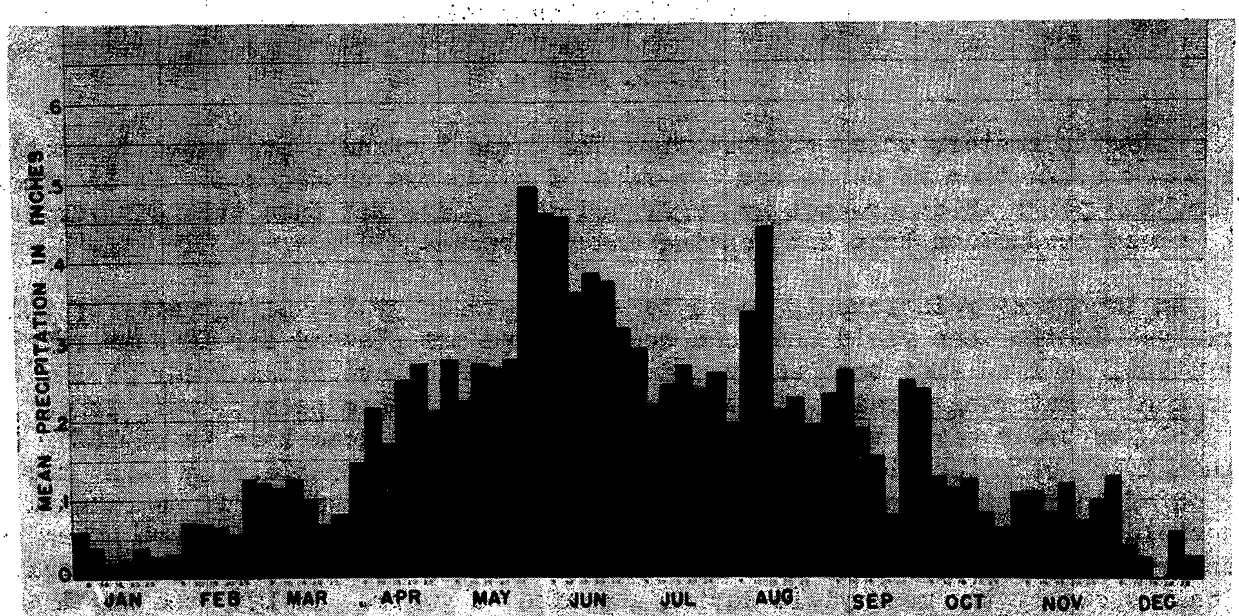
Wheat begins to go out of dormancy when the minimum temperatures begin to stay more or less above freezing followed by rather warm days. Rapid growth takes place when the minimum temperatures reach forty degrees or more and becomes greatly accelerated at fifty degrees or higher.

A wheat crop for best development must follow a rather fixed cycle of growth under favorable environment. The crop should come to a quick and full emergence the last of September or early October in the Hays territory. This will differ for other sections. A cool October is preferred for good root development. A warm October tends to stimulate rapid top growth. A crop initiated under warm October temperatures, when the stored moisture is limited, often exhausts stored moisture to such a degree that maximum yields are not produced.

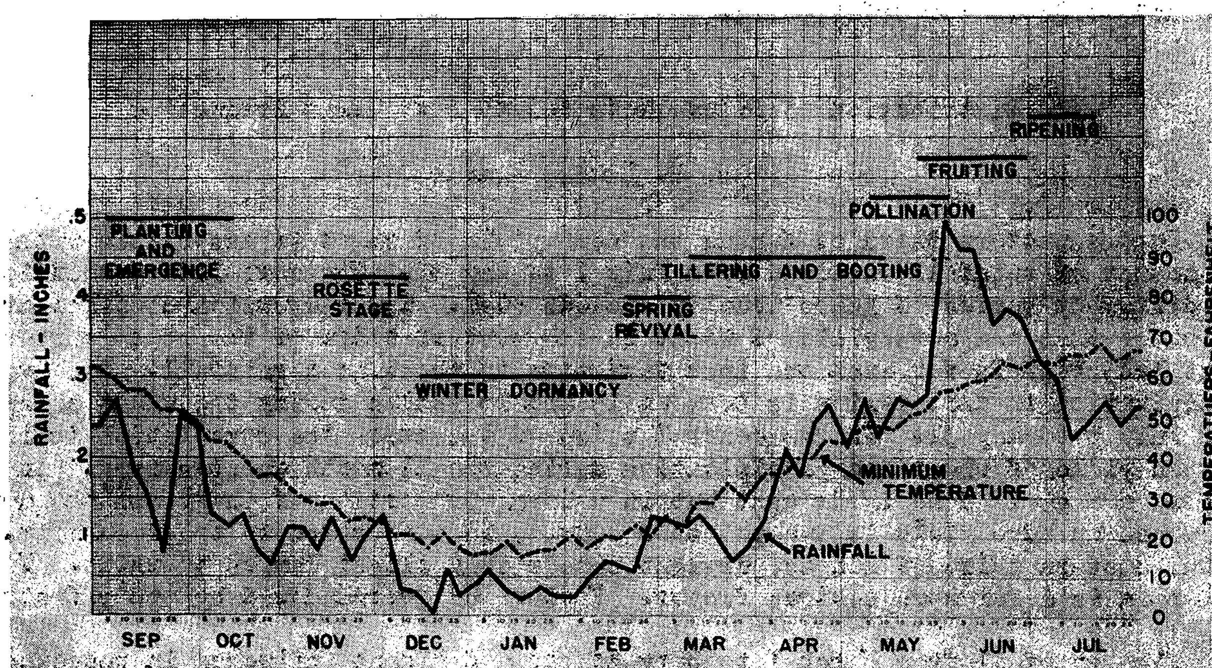
Wheat should reach the rosette stage of four or five strong tillers by December 1. It will then be well established to survive winter dormancy, withstand wind erosion, and be ready to start spring growth about March 1. The growth schedule of the wheat as to tillering, booting and the critical fruiting period has already been mentioned.

It has been observed under Hays conditions that reduced yields or at least maximum yields are generally not obtained when the crop is off-schedule by as much as ten days two weeks in its cycle of growth. The crop grown under these conditions is often subject to epidemics of diseases or insects and most frequently to premature droughty conditions near the end of the fruiting period.

We have found at Hays that some kind of a mental picture of the weather pattern is helpful in planning improvement work. It also helps to explain what may have caused varieties to respond as they did, particularly when precipitation did not come at the expected time.



1. MEAN RAINFALL BY 5-DAY INTERVALS, 28-YEAR PERIOD (1921-1948), HAYS, KANS.



2. RAINFALL AND TEMPERATURE AS RELATED TO NORMAL GROWTH OF WHEAT BY 5-DAY INTERVALS

Rainfall Distribution and Crop Response in the Texas Panhandle

K. B. Porter

Climatic factors which characterize the Texas Panhandle are quite favorable for wheat production if means for a period of years are considered. As in other areas, the years which are not average, and most years fit into this category, make wheat production both interesting and hazardous.

An important relationship seems to exist between yield and maturity of the variety. If the mean yield and mean heading date are plotted for 10 commercial varieties, we find that both early and late varieties have given lower yields than medium maturing strains. The question arises at this point, "will it be possible to breed early varieties for this area without some loss in yield?" Although the relationship holds true to some degree when considering means for a period of years, it does not portray the picture for all years. If we examine the yield in 1939 of several varieties of different maturity which were grown on both dry and irrigated land, we find a decided change in relationship as compared to that shown by the mean yield during a period of years. In 1939 the dry land yields were in proportion to the earliness of the variety while all yielded about the same under irrigation.

Other genetic differences, of course, contribute to year-to-year differences in varieties. I believe there is at least a tendency for Blackhull wheats to have some advantage in our drier years.

The Distribution of Rainfall in Relation to Wheat Production

H. H. Laude, Kansas

In the western third of Kansas the acre yield of wheat is associated with the amount of rainfall received from July 1 to May 31. The correlation coefficient for different series of years usually exceeds +0.8. The regression coefficient indicates that the acre yield of wheat in the western third of the state varies about 1.25 bushels for each one inch variation in the season rainfall. The average precipitation in that region is between 15 and 16 inches during the wheat season from July 1 to May 31. In the central third of the state the correlation is low between yield of wheat and precipitation during the 11 month wheat season. In many seasons damage is done by drought but in a large proportion of the years the dominant influence on acre yield is due to other causes, in some cases to too much rain. In the eastern third of Kansas, drought causes only slight damage to wheat. Too much rain is a far more serious factor. Variations overshadowed by other factors.

High rainfall from March 1 to harvest has a dominant influence in reducing yields of wheat. During the last 39 years (1911-1949) the average yield of Turkey and Kanred in experimental tests at Manhattan has been 29 bushels. In 21 of the years rainfall from March 1 to the time those varieties ripened was less than 13 inches. In 17 of those years the yield was above average and in 4 below average. In the 18 years when rainfall was above 13 inches, since 1911, the yield of wheat was above average only 3 times and below average 15 times. The detrimental influence of too much rain during the spring season was found throughout eastern Kansas by comparing the rainfall record of the U. S. Weather Bureau with the acre yield record reported by the Kansas State Board of Agriculture and the U. S. Bureau of Agriculture Economics. The average rainfall in eastern Kansas during the spring (March 1 to June 30), is 15.47 inches, which apparently explains the frequent damage to wheat from too much wet weather. In central Kansas the average rainfall during the same period is 11.86 inches, indicating that generally the rainfall during that season is below the level that would damage wheat seriously. Average precipitation during the spring in the western third of Kansas is 8.62 inches. Seldom is the wheat crop damaged by too much rain in that section of the state during the spring.

The extensive damage to wheat during late May and in June 1949 apparently can be attributed largely to too much rain during the spring season. Average precipitation from March 1 to June 30, 1949 was 14.74 inches in the western third of Kansas, 14.96 in the central and 17.00 in the eastern third of the state. Thus spring rainfall was high enough to cause serious damage to wheat throughout the entire state.

The relative importance of rainfall at different seasons of the year at three stations in Kansas, namely, Colby, Garden City and Hays, was reported in technical bulletin no 761 U. S. Department of Agriculture, January 1941 under the title Seasonal Distribution of Rainfall in Relation to Yield of Winter Wheat. In that study use was made of a technique developed by Fisher in which the fifth degree polynomial curve was fitted to the sequence of rainfall by 5 day periods for each year. The results are expressed in the influence on yields of wheat of rainfall above or below the average. Precipitation during Sept., Oct. and Nov. and again during March, April and May was found to have the greatest beneficial effect on the yield of wheat.

Winterkilling of Wheat

H. H. Laude, Kansas

It has been shown (Jour. Agr. Res. June 1937) that among the few varieties of wheat studied some lost their resistance to cold more quickly in the period of transition from winter to spring than others. The differential rates were so great that the variety that was most hardy in the winter stage was least resistant to cold in less than two weeks after the plants were exposed to favorable growing conditions. Also the variety that was least winter hardy in the mid-winter condition was most hard after spring growth had started. In the reference cited it is suggested that if this difference in type of hardiness should be found in other varieties, and if the character of retaining hardiness well into the spring season is heritable, then the character of spring hardiness might well be included as an objective in wheat improvement investigations in order to lessen damage by spring freezes. Since that publication was issued, other varieties possessing a high degree of spring hardiness have been found. There is some evidence to show that the character of spring hardiness is heritable and that it segregates in hybrids in which the parents differ in this respect. Kawvale and Pawnee are similar in that they both retain cold hardiness well into the spring. The introduction of Marquillo with Pawnee and Kawvale appears to result in more rapid loss of cold hardiness in the spring. Clarkan is more pronounced in its ability to retain cold resistance than is Harvest Queen. More study of this question would apparently be advisable. Enough has been done, however, to justify consideration of the character of spring hardiness and the use of it in breeding work.

Frost Hardiness in Plants Based on a Study of the Living Bark of Trees

D. Siminovitch and Dr. R. Briggs, Minnesota
(Presented by E. R. Ausemus)

A study of the chemical changes associated with frost hardening in plant tissues has been made in the attempt to elucidate the physiological and chemical mechanism of frost resistance. The living bark of trees was chosen as the material for study because the amplitude of the changes in frost hardiness in these tissues facilitated the detection of the critical chemical changes which are involved. Based on previous research the degree of resistance of bark cells to injury by plasmolysis or desiccation was taken as a test of the degree of frost hardiness of the bark. There was a strong seasonal correlation between the concentration of water soluble protein in the bark and its frost hardiness. Studies on stumps and isolated logs of trees indicated that the seasonal correlation was not just fortuitous because the unseasonal changes in frost hardiness produced in the bark of these stumps and logs did not occur independently of changes in protein concentration. Further indication that a causal relationship between frost hardiness and protein concentration in the bark existed was obtained from observations on ringed trees. In a multiple ringed tree those sections of the tree deprived earliest of organic nutrients supplied by the leaves or roots (through successive ringing of the bark and its phloem in summer and autumn) developed the least hardiness and possessed the least concentration of protein in their tissues. The hindered translocation of carbohydrates to these ringed tissues appears to have decreased the synthesis of proteins.

It is concluded that hardiness in tree barks results from the synthesis or accumulation of a higher concentration of protoplasmic substance within their cells. A similar chemical study of wheat and other herbaceous plants might aid in the elucidation of the factors involved in the hardening process in these plants. It will aid also in assessing the potential hardiness that can be developed by them.

Damage to Wheat by Late Spring Freezes

H. H. Laude, Kansas

Serious damage from spring freezes occured in the main wheat region of Kansas in each of the three years 1945, 1946 and 1947. It appears advisable to conduct research in the attempt to avoid such losses.

Varietal differences in cold hardiness appear to be widest in the fully hardened condition and to gradually narrow through the spring. Probably the narrowest range among varieties prevails in the blooming stage when only 2, 1 or a few cells must be depended upon to develop the grain. Small differences in temperature at or near the lethal level may result in large differences in amount of damage to wheat particularly in causing sterility. Under these circumstances it appears that small differences in hardiness among varieties may be very important. It seems highly probable that a variety which could have withstood even one degree Fahrenheit more cold would have produced millions of bushels more grain in Kansas, in each of the three years 1945, 1946, and 1947. Ability to withstand one-half degree more cold at that critical stage would be of great practical importance. Investigations to develop techniques for measuring small differences in resistance are being carried on by Dr. J. C. Frazier at the Kansas Station. In the regional research program, it would seem advisable to place emphasis on the study of relative resistance of varieties to late spring freezes.

Floral Injury Caused by Late Spring Freezes

J. E. Livingston, Nebraska

The susceptibility of the heads of hard red winter and spring wheats to freezing temperatures is a result of a complex interaction of many factors. Floral sterility may occur with an exposure of 4 hours at -2° C. and increase progressively as the temperature is lowered and the length of exposure is increased. The youngest fully exposed heads appeared to be slightly more susceptible than more mature heads. Heads protected by the boot showed the least floral sterility. A higher percentage of floral sterility resulted on heads that were sprayed with water prior to exposure to freezing temperatures and kept wet during the exposure than on comparable unsprayed heads. High soil fertility greatly increased the susceptibility of florets to low temperatures. Varieties differed in floral-susceptibility to frost with an indication that winter hardiness and resistance to late spring freezes are not the same. For example, Minturki and Thatcher were injured more than Cheyenne and Pawnee. Floral sterility was influenced more by the stage of head development at the time of exposure than by varietal susceptibility.

The Relation of Fruiting Temperature and Stage of Maturity of the Wheat Kernel to Gluten Qaulity and Other Properties of Flour

K. F. Finney, J. F. McCammon, and H. C. Fryer, Kansas

The effect of temperature during the fruiting period on loaf volume was studied for 391 samples of hard red winter wheat grown under a wide range of climatic and soil conditions.

Subnormal loaf volumes were rather consistently associated with high temperature (above 90° F.) during the last 15 days before harvest but high temperature, does not always impair loaf volume potentialities. The association was only partially accounted for in terms of amount of high temperature, percentage of protein in wheat, and the quality of protein as reflected by the mixing time of the dough. The physical condition of the soil appears to modify the extent of injury resulting from a given amount of high temperature. The longer mixing varieties were more tolerant or resistant to the detrimental effects of high temperature. Protein conten accounted for about 95% of the variations in loaf volume, provided temperature during the fruiting period was not a limiting factor.

Gluten synthesis, so far as loaf volume potentialities were concerned began about 21 to 24 days before Pawnee wheat was ripe and reached its optimum volume potentialities of 109% to 118% of those for protein from ripe grain as early as 10 to 14 days before ripe; and excellent crumb grains accompanied these maximum loaf volumes.

The protein in Pawnee wheat that was harvested 29 days after ripe and that stood in the shock after ripe for 29 to about 70 days likewise possessed superior loaf volume potentialities equal to those for the protein that was 10 to 14 days preripe. Thus the optimum volume potentialities for protein that was 10 to 14 days preripe receded to a minimum for ripe grain. Standing in the field or in the shock for about a month after ripe, however, increased loaf volume to the former optimum for samples that were 10 to 14 days preripe.

There may be suitable equipment in the future for drying wheat heads with their straw so that cutting and threshing can be carried out a week to 10 days before the grain normally would be ripe. In this way the farmer, miller, and baker could enjoy wheats with higher test weights (1 to 5 lbs/bushel) and normal milling properties, and flours having superior loaf volume potentialities, higher dough absorptions, better dough handling properties, and more mixing tolerance. If wheat crops could be harvested prematurely, many would escape partial or total damage due to hail, wind, and rain.

Maximum wheat starch content was reached in samples harvested 4 to 10 days before ripe in 1948.

Preliminary data indicate that if there is sufficient soil moisture, the wheat plant can keep itself cool by transpiration and thereby resist and escape material or serious damage from high temperatures during the fruiting period. For example, at Manhattan, Kansas in 1949 the ground was wet all during the fruiting period; and the sample that was heated from June 4 to 11 ($T_E = 50^\circ$ F.) had a loaf volume that indicated the protein was about 90.2% of normal. Similarly, the protein in the sample that was heated from June 17 to 23 ($T_E = 81^\circ$ F.) was 95.6% normal $\left(\frac{819 - 300}{843 - 300}\right)$.

When, however, transpiration was decreased by pulling the plants up by the roots and subjecting them with their limited root systems to nine hours @ 113° F. (9 hours — 1.5 days) in a bath of mud and water, severe damage to protein quality resulted. When transpiration was reduced to practically zero by heating the heads and their attached straw and leaves in an oven for 18 hours @ 120° F., the protein was damaged so severely that its loaf volume potentialities were only 14.3% of normal $\left(\frac{379 - 300}{853 - 300}\right)$

by flour containing 0.0% protein.

Somewhat more elaborate experiments are contemplated on the 1950 crop in an effort to learn more about how and why high temperatures during the fruiting period usually damage baking properties.

Weather and Rust in the Hard Red Winter Wheat Area

C. O. Johnston, Kansas

The proper sequence of favorable weather conditions is vital to the development of rust epidemics. To date, the cereal rusts have overwintered in sufficient abundance in southern Texas to start annual epidemics and the prevailing southerly winds of early spring have started spores northward regularly. Two factors have operated to reduce the hazard of annual epidemics. One of these is the large acreage of more or less resistant wheat varieties in Texas and the other is the absence of weather conditions favorable for early and rapid development of rust infections. Therefore heavy epidemics develop only at fairly long intervals instead of annually in the hard red winter wheat area. For example, the leaf rust epidemic of 1949 was the first heavy general epidemic in the area since 1938. The weather conditions that accompanied that epidemic were the most favorable we have had in year A mild winter in southern Texas resulted in abundant overwintering and early increase in leaf rust. The normal south winds during April and May were carrying the heaviest spore load in many years, as shown by spore traps exposed at several stations. Concurrent with these widespread spore showers there was a long period of comparatively mild weather with frequent rains over a very large area. As a result leaf rust infections were present and fruiting in Kansas as early as April 25, the earliest ever recorded resulting from wind carried spores.

The primary infections were fairly evenly, though sparsely, distibuted all over Kansas by the first of May, but were particularly abundant in the western two thirds of the state. Usually that would not have been serious, for the normally hot, dry weather of May and June would have prevented or delayed heavy secondary infections. However, the rains continued in 1949 at intervals of a few days and the soil was thoroughly wet over a wide area for weeks. That resulted in extremely heavy dews throughout May and most of June. Moisture in the form of dew is the finest medium known for the germination of rust spores. Conditions were favorable for the development of a generation of leaf rust every ten days from May 15 to June 15. That alone would assure four generations, but at least one generation had developed before May 15. It usually has been assumed that rust must pass through the equivalent of three generations to produce an epidemic. In 1949, leaf rust passed through the equivalent of five generations in Kansas.

Stem rust has not been a major factor in the hard red winter wheat area in recent years. That is partly due to the large acreage of resistant Austin and Seabreeze in Texas. The increasing acreage of earlier varieties in Oklahoma and Kansas also has tended to reduce stem rust damage by escape. Stem rust requires higher temperatures than leaf rust for its best development. It therefore has been abundant only on late varieties or near the end of the season in recent years. Hot, humid, muggy weather favors stem rust infection. Moisture requirements are about the same as those for leaf rust.

Effect of Weather on Bunt and Loose Smut

E. D. Hansing, Kansas

Maximum bunt infection is favored by cool soil temperatures of about 45 to 50° F. and by moderately moist soil between planting and emergence of the seedlings. Under these conditions the highly susceptible variety Red Chief may have 95% infection while the moderately resistant variety Pawnee may have 20% infection. Under slightly less favorable environmental conditions, Red Chief and Pawnee may have 90 and 10% infection respectively, and under still less favorable conditions, 70 and 2% infection respectively. Under natural conditions in the field, the supplementary factor of the quantity of inoculum on the seed is important. The moderately resistant variety Pawnee does not have as much inoculum on the seed as Red Chief. Consequently the variety Pawnee has done well under farm conditions in Kansas, and although 35% of the acreage is planted to this variety, 1% has been the maximum infection reported in any field to date.

The goal in a breeding program should be to obtain high resistance to all physiologic races of bunt in the state and preferably in the United States. In a cooperative breeding program in 1949 we had 25 hybrid selections in the F_9 generation which were resistant to all races of bunt in the United States including dwarf bunt.

Maximum loose smut infection is favored by high humidity at blossom time. The percentage of infection is also determined by the quantity of inoculum available. Pawnee is highly resistant and only an average of 2% can be induced by artifical inoculation. Under natural conditions this drops to a trace or zero. In a long-time program it would be well to breed varieties with high resistance to loose smut. Then environmental conditions would not make any difference. In the meantime experiment stations should treat seed of highly susceptible varieties by the modified hot-water method and maintain a supply of foundation seed which is relatively free from loose smut.

The Relation of Weather to Western Wheat Mosaic

R. E. Atkinson, Colorado

The sporadic occurrence of western wheat mosaic in Colorado since 1946 indicates that weather is an important factor in epidemiology of the diesease. The most important effect of weather is on the green bug or grain aphid which transmits the disease. Any factors which favor survival of viruliferous aphids favor the development of the disease. The critical time for the development of epidemics of wheat mosaic is the period from the time the wheat matures until the new crop is up. Direct correlation between early planting and early emergence of wheat with severity of mosaic was first found in Colorado in 1947. So-called "grasshopper strips" around the margins of early planted fields were relatively free of mosaic in mid-May of 1949. This confirms the hypothesis that late planting is one factor in the control of western wheat mosaic.

Weather conditions in Colorado in the fall of 1948 prevented emergence of wheat in most localities until October, while in Kansas ideal conditions for early emergence existed. The spring weather in the two states was almost identical, with severe leaf rust and other wet-weather diseases observed in both states. The yields of wheat in Colorado, where there was little mosaic observed, was 8 million bushels (12%) <u>over</u> the estimate made on May 1, 1949. In Kansas, where severe mosaic was observed in May, the actual yield was 84 million bushels (about 1/3) <u>less</u> than the estimate made at the same time. The average yield per acre was 17.5 bushels in Colorado and only 11.5 bushels in Kansas.

Temperature affects the expression of mosaic symptoms. Under conditions of rapid growth symptoms are most pronounced. When the temperature is low and growth is slowed, symptoms are apt to be masked. Inoculations made at Akron in September resulted in the appearance of symptoms by October 1 but later, when lower temperature prevailed, these symptoms faded. Inoculations made in the greenhouse in September resulted in the appearance of symptoms which disappeared when the plants were placed outside in October. However, when these plants were returned to the greenhouse in November, the symptoms reappeared. Thus the infection in a field at a particular time could be considerably greater than the amount of mosaic observed.

Weather in the spring affects the prevalence of mosaic chiefly due to its effect on the insect vector. Cool, moist weather which occurred in the spring of 1949 was favorable for the growth, reproduction and spread of the aphid. This weather plus an abundance of mosaic-infected plants allowed a high degree of transmission to healthy plants. Observational evidence indicates that plants infected in early fall are so severely affected that they do not head, whereas plants infected in the spring are less severely affected. They head but produce shriveled kernels.

Hail and drought which cause late tillering, and hail at harvest time which causes shattering, allow the profuse development of wheat early in the fall. This growth serves to prolong the feeding of the vector and may cause an increase in the number of viruliferous aphids capable of spreading mosaic to nearby early-planted fields.

An unknown factor at the present time is the relation of mosaic to root rot. It is surmised that, because many factors unfavorable to the growth of wheat favor root rot attack, mosaic may also predispose plants to the attack of root rotting fungi. If this surmise is true, then the weather also would have a tremendous effect on the interaction of the virus and the fungus.

Take-All of Wheat

H. Fellows, Kansas

In the field high moisture and coll temperatures favor the disease. The reaction to these factors is shown in two ways. The amount of disease in a single season depend on whether the moisture is above or below normal. The other reaction is a long time one. Several successive dry years reduce the disease greatly. It doesn't come back immediately upon the resumption of normal moisture but requires several moist seasons before take-all again becomes important.

In Kansas take-all occurs in the humid central and eastern portions of the state. It is seldom found in the western drier portions.

Greenhouse experiments have shown that temperatures from 60 to 75° F. with the soil moisture content of 75% W.H.C. is very favorable for take-all. However temperatures of from 78 to 90° F. with a soil having 40% W.H.C. is unfavorable.

The Effect of Weather on Wheat Insects

Reginald H. Painter, Kansas

Weather is the principal factor influencing the initiation and (in spite of modern insecticides) the ending of insect outbreaks. Its effects differ with different insects. Chinch bugs are highly favored by dry weather and the hessian fly by moist weather about the time of egg laying. In 1933 to 1936 we learned that it could get too dry even for chinch bugs.

High populations of hessian fly have usually coincided with years of high wheat production, the high yield often coming from farms or areas where the fly population was low at the first of the crop year. The actual loss, which amounts to 20% or more for each infested culm, is often concealed by the higher yields of uninfested culms, and the field makes an average yield rather than a bumper crop. The adult hessian fly and the migrating larvae are highly sensitive to weather conditions. We have records of severe infestations being brought to a close by periods of hot, or cold, dry winds near egg laying time.

Aphids are often considered to be favored by moist weather, but the worst pea aphid outbreak and one of the worst green bug infestations occurred in the very dry spring of 1934. The fact that green bugs (<u>Toxoptera graminum</u> (Rond.) are able to breed at a much lower temperature than the parasites and predators on these aphids, results in the early spring buildup of the dangerous pest.

Specific insects and the wheat plant are not always affected in one direction by weather. In certain years it was found that the wheat stem maggot adults emerged from inside the wheat stem at about the same time when there was an interval of 20 days in the heading date of wheat varieties and dates of planting, and when there was only 12 days. This difference in the behavior of the insect and the plant affected the degress of infestation of varieties.

The effect of the weather on weeds and other crops may cause insects to move into wheat. The common pest grasshoppers, <u>Melanoplus mexicanus</u>, <u>differentiales</u>, and <u>bivittatus</u> all prefer, or at least feed as well on forbes as on grasses. When dry weather causes the drying up of the roadside weeds, these grasshoppers often move into adjacent wheat fields with destructive effect.

The slowing up of plant growth by dry weather frequently results in an increase in relative or absolute amount of damage done by insects. The best example of this effect concerns the feeding of false wireworm larvae on the wheat kernel. The slow germination of the seed in moisture-deficient soil gives more time for the feeding of the insects and may make the seed more palatable or increase the substances in the seed that attract the insect. Inclusive statements cannot be made concerning the effect of particular weather conditions on groups of insects. Each species must be considered separately and in respect to separate weather conditions.

Breeding Varieties Suitable for Early Fall Sowing in the Palouse Area

O. A. Vogel, Washington

Dr. Vogel explained that in the Palouse, wheat is grown on land with up to 60% slope. Such steep land erodes badly if not protected by a cover of vegetation. Early sowing of wheat provides a means of getting such cover but has the disadvantage of producing high straw: grain ratios. Breeding work has been directed toward developing a variety having good yield, stiff straw and a straw: grain ration of 3:1 or 1.5:1. He compared several varieties in tillering habit, height, lodging, yield of grain and straw, and response to rate and time of sowing. Uma, a tall variety, tillers less than Kharkof, stands better and yields more when sown at the optimum rate. Orfed x Elgin 1 differs from Kharkof in the same ways enumerated for Uma but is much shorter and has a wiry, dense straw. Norin 10, a new introduction, is even shorter and is a promising parental type for future breeding.

A Century of Progress

K. S. Quisenberry 1/

The workers engaged in a research project such as improvement of hard red winter wheat may become over enthusiastic as to the results being obtained. They are inclined to become convinced that a grand job is being done and that advances of great economic and scientific value are being obtained. But to the unbiased observer the farmer or the administrator the results may not appear so astonishing. This evening I should like to spend some time with you, looking at the record of this project.

In order to get a complete picture of development in winter wheat production a few historical high lights will be in order. It is a matter of record that prior to the coming of white settlers to Kansas, the Shawnee Methodist Mission included winter wheat in its crop program as early as 1839, and by 1847 or 1848 as many as 175 acres were harvested. In these early days there was considerable question as to whether Kansas and the Great Plains area were suitable for the growing of winter wheat, and the crop got off to a very shaky start.

1/ Head Agronomist in Charge, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Dept. of Agriculture. Presented at the Banquet.

It was not until about 1900 that Turkey was fully accepted and became the leading variety. Seventeen years later improved varieties such as Kanred, Blackhull, and others were released to farmers. While the acceptance of new varieties was very slow, the same was true with regard to such matters as seedbed preparation, method of seeding, and time of seeding. In fact the question of time of seeding was unsettled until 1914-1916. Compared to this rather halting progress, from 1839 to 1916 or 1917, let us look at some of the things that have been accomplished since the cooperative effort was organized in 1930. For example there were cooperative experiments at Manhattan, Kans. since 1891, and at Halstead and McPherson, Kans., from 1902 to 1909. Wheat experiments were conducted in the Texas Panhandle from 1902 to 1920. The cooperative experiments at Akron, Colo., and Moccasin, Mont., began about 1908, at Hays, Kans., and Archer, Wyo., about 1912, and at North Platte, Nebr., about 1923.

Practical Results

At 5-year intervals since 1919 the Division of Cereal Crops and Diseases in cooperation with the Bureau of Agricultural Economics has conducted a wheat variety survey. Most of you are familiar with these data. The past year, 1949, was the survey year. The data are partially summarized using preliminary acreage figures, and I will give you a few of the highlights so far as hard red winter varieties are concerned.

In 1949, it was estimated that 83,177,000 acres of wheat were seeded in the United States. Of this area, hard red winter wheat occupied 44,617,698 acres, or 53. percent of the total. This is the highest percentage yet reported for hard red winter varieties.

The 10 leading varieties in the United States in 1949 are shown in Table 1.

Table 1—The Ten Leading Varieties in 1949.

Variety	Percent of Total	Acreage
Pawnee	12.9	10,715,876
Comanche	7.0	5,825,505
Triumph	6.7	5,577,375
Mida	6.5	5,408,457
Thorne	4.1	3,423,689
Thatcher	3.9	3,235,402
Turkey	3.8	3,155,302
Wichita	3.5	2,930,848
Rival	3.4	2,867,022
Tenmarq	3.4	2,846,374

You will note that Pawnee, Comanche, Wichita, and Tenmarq appear in this list, and all were developed in the cooperative program.

In Table 2 is presented the percentage of the total hard red winter wheat acreage occupied by 5 new varieties. Tenmarq was reported since 1934 but the other varieties were reported in 1944 and 1949 only.

Table 2--New Varieties

Variety	Percentage of HRW acreage in			
	1934	1939	1944	1949
Pawnee	----	----	.1	24.0
Comanche	----	----	.1	13.1
Wichita	----	----	----	6.8
Tenmarq	.7	11.7	26.6	6.4
Westar	----	----	----	4.8

I think you will be impressed with the decided and rapid change in the variety picture in the last 10 years. I hope you will be convinced that some of your efforts have been productive in a practical way, and that your varieties are being accepted by the farmers.

Fundamental or Basic Research

It has been stated from time to time that in this program too little effort was being placed on fundamental research. Possibly this is true, but if so it is partly due to the urge to get out new varieties prior to and during the war period; also, there may be some confusion as to just what is basic or fundamental research.

Most research of the U. S. Department of Agriculture and the agricultural experiment stations grows out of a public demand for the solution of some practical problem - not out of a demand for research per se. Congress and the State legislatures constantly demand practical results and are impatient if a research agency seems to spend too much time or effort on pure science. The result is that scientists in these institutions cannot pick posies in every garden nor chase rabbits wherever they may be found. Farmers, for example, want to know how and when to seed wheat, and what varieties to use, and are not especially concerned with genomes, nullisomes, morphological resistance, physiologic races, mixograms, or milling yields. Yet those directly concerned with the research problem know that information on these basic questions is very important, and must be available if an efficient breeding program is to be conducted.

A part of the dilemma can be resolved, I believe, by a better understanding of what we mean by basic or fundamental research. To many it connotes something mysterious and difficult to understand; complicated laboratory apparatus, abstruse mathematic calculations, and difficult-to-understand hypotheses. Often it does involve these things but not necessarily so. To me, basic or fundamental research is nothing more nor less than an attempt to set up experiments or make observations that will provide a better understanding of the phenomena with which we are dealing. It may be no more complicated than finding that a variety is unadapted because it starts growth too early in the spring and is often injured by frost. Another example would be a study of the temperature and moisture conditions related to a disease of cereal crops or life history studies of that disease if it is not already known.

I am sure most of you will agree that we need more information of this kind. We also need more of the kind that can be conducted only in the greenhouse or laboratory under rigid controls, but at the same time we must get the practical answers to satisfy the farmers and others. The crux of the problem, as I see it, is to maintain a proper balance between these various types of research. It is not so much a question of whether a proposed study is basic or practical as it is "Will it give us the information we need most to answer the problem at hand." In other words, we should ask ourselves not whether we should conduct basic or practical research but rather will the research we are doing or contemplate doing answer the questions that need to be answered. Any research that reveals new facts may be properly regarded as basic. Simple problems can often be answered by simple empirical experiments; more complex ones cannot. But we can be easily misled into thinking a problem is simple and easily solved when, as a matter of fact, it may be very complex. Science is replete with examples of man's tendency to overestimate his own ability, and to misunderstand nature's complexity.

Much of the responsibility for proper balance rests upon administrators in the allocation of funds. But much can also be done and is being done by the field personnel in striving to determine "Why?" as well as "How?" Field personnel can also be of much help in pointing up problems that require greenhouse or laboratory study, in determining the limits beyond which field studies can go, and in helping to decide what kind of greenhouse or laboratory studies - basic research if you prefer- are necessary or are likely to be profitable. Because our research is financed entirely or almost entirely by public funds we must be as certain as is possible that whatever studies are undertaken will yield the results we need. Such results usually are not, nor need they be, immediately practicable, but they should contribute to an understanding of a practical problem. If they do this much we can be reasonably sure that a practical use of them will eventually be found.

Basic Results Obtained

At this and previous conferences much fundamental or basic work has been discussed. During the nearly 20 years that this group has been organized many basic problems have been worked out, and today we know infinitely more about the how and why of hard red winter wheat. McFadden's work on species relationships and with wide crosses has been outstanding, and his search for new germ plasm for rust resistance will bear fruit in the future. Work on such characters as stiffness of straw, and shattering, conducted by Atkins and Dunkle at Denton, has contributed to our knowledge of plant characters. The disease work has progressed nicely at several places. Work on loose smut at Kansas and Texas as well as in Illinois has given us much basic information. The bunt picture has been changed by the studies carried on in Oklahoma, Colorado, Montana, and Nebraska. Leaf rust, at first thought to be rather unimportant, has been the basis of much work from Texas to Minnesota, especially at Stillwater and Manhattan. Cold resistance studies have added much to our knowledge of varietal reaction and controlled tests have been perfected at St. Paul, Lincoln, and Manhattan, which allow for greenhouse work on winterhardiness. The entomological side of the picture has been productive, as, for example, the hessian fly work at Manhattan, and earlier at Lincoln, and the aphid resistance studies at Denton and Lawton.

Significant advances have been made on milling and baking studies, and now we know much more about quality, and how to more accurately evaluate the quality characteristics of new strains. This work has been done at St. Paul, Manhattan, and Lincoln.

Many other studies could be mentioned but I wish only to point out a few of the High spots. Mr. Reitz and Dr. Salmon are now working on a 20-year summary of the data that have been accumulated in this program, and when it is completed we should have some good guides on the how and why of varietal behavior, especially so far as the relationship of earliness, hardiness, rust resistance, and other characters to yield. The data accumulated over the years, and published in annual mimeographed summaries is a storehouse of knowledge of the behavior of winter wheats on the Plains. Years could be spent in a critical examination of these data, and the effort would be well worthwhile.

The Job Ahead

From the administrative point of view I wish that the job were done, and that all personnel could be transfered to some other projects needing urgent attention. However it is not done, and many more improvements are needed. It is needless for me to spend much time outlining the unfinished business because you are going to do that.

In spite of the fact that we have made real progress in the program we have made mistakes, but, of course, hindsight is always better than foresight. Since I was partly to blame for the mistakes I do not hesitate to mention a few of them. It was a mistake to pay so little attention to test weight and appearance of the grain for so long. From the start we should have tried to get the characters from Blackhull, but it took the farmer reaction to Tenmarq to teach us that lesson, and under certain growing conditions Pawnee will win few prizes in the grain show.

It was a mistake to put all of our leaf rust resistance eggs in the Kawvale and Hope baskets. At that time it was a case of use those baskets or none. Some feel that we are making a serious mistake in developing varieties that are so lacking in cold resistance. The expansion on Pawnee, Wichita, and Tenmarq into Colorado, and Nebraska may cause loss when that long-predicted hard winter comes.

In the immediate future you must give serious attention to new sources of leaf and stem rust resistance, and work them into commercial varieties. The problem of mosaic must be considered or we will be in for some serious criticism. The question of insect resistance is important in certain areas. I have in mind damage from hessian fly in western Nebraska and from sawfly in Montana.

With the development of Yogo we obtained a combination of just about the extreme in cold resistance in winter wheat, with yield and reasonable quality characteristics. Since that time no progress has been made in getting more hardiness into wheat. With our new techniques of breeding I would like to see someone transfer the cold resistance of rye into wheat. That problem has baffled us for many years, but some day it will be solved.

By a careful analysis of data now at hand we should develop blueprints of the characteristics a variety must have if it is to be successful in any given area. We must find out why these requirements are such as they are. We must use our experience of the past 20 years to chart a better course in the future. From these data, and from more to be obtained, we must get at the bottom of varietal adaptation in relation to soil and climatic factors. The question of time of maturity in relation to cold resistance needs more investigation, especially the importance of the factors in different sections of the area. With the facilities at hand much is being learned each year, and certainly the testing period for a new variety can be shortened. Thirty years ago no one would dream of starting to increase a variety after 3 or 4 years of testing. Now, with data available from many stations each year this is no longer such an unsound practice.

In closing let me say that I hope you are convinced that our program has been productive. But, if you are convinced do not sit back and be fully satisfied because there is stillplenty to do if you are to hold the gains you have made.

WEDNESDAY MORNING, JANUARY 25

SPECIAL PROBLEMS AND FUTURE PLANS

Leader: E. R. Hehn, Montana

Report of the Hard Red Winter Wheat Improvement Advisory Committee

H. H. Laude, Kansas (Chairman)

At the last hard winter wheat conference held at Manhattan in 1945, you asked that the directors of the experiment stations appoint members to a regional committee that would have the responsibility of representing the interests of hard winter wheat throughout the entire growing region. The directors in 9 states responded to the suggestion and appointed members to this committee. Also a member was appointed by the Division of Cereal Crops and Diseases. Possibly other states may now wish to have representation on this committee. The states that now have representation, and the personnel on this committee are: Montana, E. R. Hehn and F. H. McNeal; Minnesota, E. R. Ausemus and W. F. Geddes; South Dakota, J. E. Grafius; Nebraska, T. A. Kiesselbach, and R. M. Sandstedt; L. P. Reitz (Secretary) (representing also the Division of Cereal Crops and Desease); Colorado, D. W. Robertson; Texas, I. M. Atkins and J. Roy Quinby; Oklahoma, H. F. Murphy, and A. M. Schlehuber; Kansas, J. A. Shellenberger, R. H. Painter, and H. H. Laude (Chairman).

In addition to handling general matters the committee undertook a study to determine what questions needed investigation and to develop a research program for the solution of those questions, which, as it would be carried out, should provide scientific knowledge for the most successful production of wheat. The report of that study was published under the title, Research Program for the Improvement of Hard Red Winter Wheat, 1947. It was a unified program made on a plan that provided for part of the work to be done in each of the states.

The program no doubt needs some, possibly major, changes and revision. Some things may have been accomplished. In the light of what has been developed in this conference it may appear that other changes should be made to adapt the program to present conditions and needs. Your suggestions or direction would be appreciated by the committee.

The relation of this committee to the committees set up in the four regions of experiment station directors or the so-called land grant association regions should be mentioned for clarification and so consider the best means of coordinating the two endeavors. This committee is regional in the sense that it involves the entire area in which hard red winter wheat is grown. It extends into three of the four land grant association regions. Each of these three association regions has or probably will have a hard winter wheat committee and will develop some investigations with wheat.

The work of those three regions can be coordinated among themselves and with this committee which represents the entire crop region through a national coordinating committee that is provided for. In this way it should be possible to have one coordinated research program in which the entire area where hard red winter wheat is grown will be properly represented and in which each state or location can participate in meeting its own needs as well as forwarding the regional program.

Source of Seed as a Factor in Variety Testing

J. R. Quinby, Texas

Seed of Wichita and Pawnee was produced for three years at the following eight stations: Chillicothe and Denton, Texas; Stillwater, Oklahoma; Manhattan and Hays, Kansas; Lincoln and North Platte, Nebraska; and Ft. Collins, Colorado. The eight sources of seed were grown in nursery plats in ten replications at Chillicothe, Manhattan, and Lincoln to determine if the environment during the development of the embryo of the seed had an influence on the succeeding crop.

Data for the first year are inconclusive because the seed that was planted had not come from the same source and because it had been stored under different conditions. Obvious differences in time of heading did not occur but there were differences in germination and early growth that did not always show up later in differences in yield of grain. It is thought that there differences are not of the sort that were being looked for. In 1948, there were statistically significant differences in yield at Lincoln and Manhattan between the different sources of seed. There were no significant differences between sources of seed at Chillicothe in 1948 or at any of the three Stations in 1949.

Actually there is much less difference in environment during seed development at the eight stations than one might suppose. There is an extreme difference of a little more than a month in time of heading but less than 5 degrees in temperature during seed development if Ft. Collins is omitted. It apppears that Ft. Collins is several degrees colder than any of the other stations. There is an extreme difference in length of day between the southern and northern Station of one half hour.

The statistically significant differences between sources of seed that occurred at Manhattan and Lincoln in 1948 need explaining. But whatever the explanation of the differences, it appears that source of seed, or the year the seed is produced, could, on occassion, be a source of error in yield trials.

Varietal Performance
on Cropland vs Fallow at Woodward, Oklahoma

A. M. Schlehuber, Oklahoma

Beginning in the fall of 1931 each variety was seeded on summer-fallowed (2 replications) and on spring oat cropped land (2 replications). Eight varieties of hard red winter wheat grown uniformly from 1938-1946 were selected for a statistical analysis (analysis of variance) to determine varietal interactions. Average yields on the two methods of seedbed preparation appear in the table. Statistically significant differences were found for varieties, for years, for methods (fallow or cropped), for varieties X years, but not for varieties X methods. It is hoped that these data can be combined with similar data obtained from other stations in the hard red winter wheat belt to give indications concerning varietal reaction to such treatments.

Average yield and rank of 8 wheat varieties grown on fallowed and on cropped land for 9 years (1938-1946) at the Woodward, Oklahoma, Experiment Station.

Variety	FALLOW Bus. per acre	FALLOW Rank	CROPPED Bus. per acre	CROPPED Rank	Average for fallow and cropped	Rank
Pawnee	41.3	1	35.3	1	38.3	1
Comanche	38.6	2	33.8	2	36.2	2
Cheyenne	37.5	3	30.2	4	33.9	3
Tenmarq	35.3	5	31.4	3	33.4	4
Chiefkan	36.3	4	29.9	5	33.1	5
Blackhull	32.4	7	28.3	6	30.6	6
Kharkof	32.5	6	27.4	8	30.0	7
Early Blackhull	32.3	8	27.6	7	30.0	7

Cropland vs Fallow at Hays

A. J. Casady, Kansas

It appears from the 9-year averages shown in the table that there is little varietal difference in respect to yield on fallowed and cropped land. There seems to be a tendency, however, for the earlier maturing varieties to rise in rank on the cropped land while the intermediate varieties decrease in rank. The varieties considered to be late in maturity appear to maintain the same rank or both fallowed and cropped land. The average yields for the 4-year period indicate the same tendency.

Comparison of average yields of winter wheat varieties grown on 1/50 acre plots on fallowed and cropped land Hays Kansas 1941 to 1949.

Variety 1/	Bushel yield per acre: Fallowed, 4-year average Yield	Rank		9-year average Yield	Rank	Cropped, 4-year average Yield	Rank		9-year average Yield	Rank
E. Blackhull	24.8	11	7	26.9	3	21.7	2	2	23.3	1
Wichita	23.4	13	9	25.6	5	21.0	7	5	22.1	4
Pawnee	25.6	10	6	28.2	1	19.9	9	6	22.8	2
Comanche	26.0	9	5	26.8	4	19.0	12	8	21.9	5
Tenmarq	26.3	8	4	25.6	5	19.3	10	7	20.4	6
Blackhull	24.4	12	8	23.3	7	17.7	13	9	19.0	8
Red Chief	28.3	5	2	27.7	2	21.8	1	1	22.6	3
Kharkof	29.5	4	1	23.2	8	21.7	2	2	19.3	7
Turkey	27.3	6	3	22.7	9	21.1	5	4	18.9	9
Chief x Oro-Tq2/	30.4	3				21.0	7			
Westar	30.6	2				21.2	4			
Triumph	27.0	7				21.1	5			
Kv-Mqu x Kv-Tq3/	30.7	1				19.3	10			

1/ First nine varieties arranged in order of increasing lateness to ripen.
2/ C.I. 12133
3/ C.I. 12128

Almost all of the varieties gave a higher test weight on the cropped land than they did on the fallowed land for both the 4-year period and the 9 and 7-year periods. The 4-year averages agree very well with the 9 and 7-year averages.

It would appear from these data that there is no significant varietal difference in respect to test weight on fallowed and cropped land.

Comparison of average test weights of winter wheat varieties grown on fallowed and cropped land, Hays, Kansas, 1941 to 1949.

Variety	Test weight per bushel and rank							
	Fallowed				Cropped			
	4-year average		9-year average		4-year average		7-year average	
	Test wt.	Rank	Test wt.	Rank	Test wt.	Rank	Test wt.	Rank
E. Blackhull	59.2	5	60.1	4	60.8	4	60.4	3
Wichita	60.1	4	60.5	2	61.7	2	61.0	2
Pawnee	60.4	3	60.4	3	61.0	3	60.3	4
Comanche	59.0	7	59.7	6	60.2	7	59.6	6
Tenmarq	58.1	11	58.4	7	59.5	10	58.8	7
Blackhull	59.2	5	60.1	4	60.3	6	60.1	5
Red Chief	61.8	1	63.1	1	62.1	1	62.8	1
Kharkof	57.6	13	57.8	9	59.5	10	57.9	9
Turkey	57.7	12	58.1	8	59.4	12	58.1	8
Chief x Oro-tq	58.6	9			59.8	8		
Westar	59.0	7			59.3	13		
Triumph	58.5	10			59.8	8		
Ky-Mqo x Ky-Tq	61.1	2			60.8	4		

Results at Akron

T. E. Haus, Colorado

Average yields and test weights of winter wheat varieties grown for 9 years on fallow and cornland at the U. S. dryland field station, Akron, Colorado appear in the following table:

Variety	Fallow		Cornland	
	Ave. Yield	Test Wt.*	Ave. Yield	Test Wt. *
	Bus.	Lbs.	Bus.	Lbs.
Red Chief **	25.3	60.3	17.2	59.5
Comanche	25.1	57.4	15.5	56.7
Wichita	24.7	58.8	15.5	58.3
E. Blackhull	24.5	58.8	15.8	58.2
Tenmarq	24.5	56.6	15.0	55.5
Pawnee	24.4	57.8	15.1	56.5
Cheyenne	24.0	58.3	15.3	56.8
Kharkof	22.5	57.5	14.1	56.4
Alton	17.2	56.9	11.7	55.8

* Test weight taken separately on cornland and fallow for last six years only.
** Eight years.

Fallow *vs.* Crop-land for the Variety Test at the North Platte Substation

L. P. Reitz, Nebraska

Varieties of winter wheat have been planted in duplicate plots both on fallow and after corn in each of the years from 1925 to 1948. During a 16-year period Turkey, Tenmarq, Kanred, Nebraska 60, and Blackhull averaged 24.6, 24.4, 23.8, 23.8, and 23.3 bushels to the acre when both practices are combined. On fallow the average yield would rank these same varieties 2, 1, 4, 5, 3, respectively, and after corn 1, 4, 3, 2, 5. All varieties on fallow averaged 30.1 bushels to the acre and after corn 17.8. The range in yield among the varieties on fallow was 1.8 bushels or 6.0 percent of the fallow mean and after corn 1.7 bushels or 9.6 percent of the crop land mean. The combined averages show a range of 1.3 bushels to the acre. The plots on both practices failed in 1926 and 1937, hence those years have been omitted. Zero yields were recorded after corn in 1932, 1933, 1934, and 1940 generally as a consequence of poor or late emergence due to dry soil. Yield differences between varieties were small in most cases and frequently were non-siginificant as determined by standard errors calculated on the annual data.

Seven varieties were compared in 8 years of the period 1938 to 1948. All plots were destroyed by hail in 1943 and plots after corn failed in 1940 and 1945 so no data are considered for either practice in these years. Combining and averaging the yields, Pawnee with 28.4 bushels to the acre ranked first followed in order by Cheyenne, Turkey, Nebred, Comanche, Kharkof, and Tenmarq, the latter yielding 24.0 bushels. On fallow these varieties ranked 1, 4, 2, 3, 5, 7, 6, respectively, with a range in yield of 6.1 bushels or 19.9 percent of the fallow mean of 30.7 whereas after corn the varieties ranked 2, 1, 2, 5, 4, 6, 7 with a range of 3.7 bushels or 16.9 percent of the crop land mean of 21.9 bushels to the acre. Among the 56 pairs of comparisons (7 varieties x 8 years), varieties ranked the same on fallow as they did after corn plus or minus one place (roughly equal to the standard error of a difference) in 34 cases, within two places in 48 cases, within three places in 54 cases and within four places in 56 cases. Three-fifths or more of the time the productivity of varieties in any year would be judged essentially the same wheather grown on fallow or after corn. Cheyenne was relatively poor on fallow in 1944 when stem rust was severe. In several years differential response to lodging occurred on fallow but not after corn. Early maturity in a variety did not give it any special advantage after corn in contrast to its productivity on fallow.

From the two experiments at North Platte it seems that a variety test on fallow of fairly similar strains of wheat would be preferable to one after corn because better stands are obtained, failure is less frequent, higher yields are made, differences in lodging, certain diseases and some other characters are more evident, field management is simplified, and fallow is an approved practice in this part of Nebraska. On the other hand, farmers might justifiably favor one variety over another for fallow or crop land under certain circumstances. For example, if lodging was so great on fallow that an otherwise highly productive strain was impractical, it might perform satisfactorily on crop land.

The variety test should be designed to characterize varieties at a productivity level consistent with the recommended farming practices where they will be grown.

An Evaluation of the Uniform Experiments of Interest to the Hard Red Winter Wheat Region with Suggestions for their Operation in the Future

E. G. Heyne (and Special Committee)

Brief Description of Tests

Uniform plot experiments.

Tests are planned by districts. Plot size varies. When drilled in they are approximately 1/50 acre. Data from eight of the twenty "plot" tests reported in 1948 were rod row plots. Agronomic, disease and insect data are obtained on these strains. Milling and baking data are obtained on each variety from each location and on a composite sample. Data are reported annually in mimeographed form. The districts are as follows:

Southern - Texas, Oklahoma and New Mexico
Central - Kansas, Colorado and Nebraska
Northeast - Minnesota, Iowa, North and South Dakota
Northwest - Montana, Wyoming, Northwestern Nebraska

Uniform yield nursery.

This test is grown at about 15 stations each year in the following states: Texas, Oklahoma, Kansas, Colorado, Nebraska and Iowa. There are from 25-30 entries in this test each year and the strains are of interest primarily to investigators in the southern and central district. Agronomic, disease and insect data are reported from these nurseries. A single composite of entries is made and milling and baking data obtained from them. Data from these nurseries are reported annually in mimeographed form.

Winterhardiness nurseries.

A uniform nursery is grown similar to the uniform yield nursery and is applicable to the northeastern and northwestern districts. These nurseries are grown in Minnesota, Montana, North Dakota, South Dakota, Wyoming, Alberta, and Northwestern Nebraska. Agronomic, disease and insect data are reported on from this test annually in mimeographed form.

A supplementary winterhardiness nursery is grown every year. About 100 entries are grown at six locations in the northern area of the hard red winter region. These entries are obtained from all investigators throughout the region. Typewritten reports are sent to those who have furnished the strains to be tested. Observations are made generally only on winterhardiness. A very useful nursery for evaluation of strains before they go into other nurseries.

Uniform bunt nursery.

The Great Plains uniform winter wheat bunt nurseries are conducted primarily for the Hard Red Winter Wheat area. Strains are supplied by the various investigators in the region and the nurseries planted in the area using local races of bunt for inoculation purposes. A mimeographed report is published annually.

Uniform rust nursery.

This nursery includes winter wheats, both hard and soft, and is grown throughout the country. The Hard Red Winter Wheat Improvement Area cooperates by supplying strains for the test and growing the nurseries. Data are obtained on leaf and stem rust. The information is summarized by the Cereal office at Beltsville, Maryland, and reported annually in mimeographed form.

Uniform hessian fly nursery.

This nursery is conducted by Dr. W. B. Cartwright of the Bureau of Entomology and Plant Quarantine. This nursery includes both hard and soft wheats submitted by investigators breeding hessian fly resistant wheats. The nursery is grown at locations carrying on hessian fly studies and data are reported in typewritten form to those who have conducted the nurseries.

Suggestions for Operating Uniform Experiments in Future Years

The organization and operation of the uniform tests as now conducted are satisfactory and the tests should be continued. Some suggestions concerning these tests are as follows: A variety (other than checks) should stay in a uniform test only as long as it takes to properly evaluate a strain but preferably not more than three years; There should be no duplication between entries of the plot and nursery trials other than checks; A strain should be well studied by the originating state before it is entered in a uniform nursery; Ask Dr. Cartwright to prepare annually a mimeographed summary of the uniform hessian fly nursery. A continued evaluation should be made of these experiments, such as: keeping routine testing to a minimum to allow sufficient time for research, the actual contribution made by each test, more clearly defined objectives for the use of accumulated data, and the addition or substitution of more efficient methods of conducting the regional work when such information becomes available.

DISCUSSION:

Robertson mentioned the need of a dwarf bunt-nursery.

Vogel volunteered that C. S. Holton might test strains for resistance to dwarf bunt where the disease is prevalent without danger of bringing the disease across the mountains where it is not now prevalent, or to make tests using race T16 which would show whether strains had resistance to dwarf bunt.

Robertson moved that Mr. Reitz and Mr. C. O. Johnston collect strains of promising breeding material with low bunt resistance and make arrangements to have them tested to T16 by Dr. Holton. Seconded. Passed.

The suggestions by Mr. Heyne and his committee met with general approval but no definite action was taken on them.

Permanent Check Varieties in the Uniform Experiments

T. H. Johnston, Stillwater, Oklahoma, led the general discussion.

It was generally agreed that Kharkof should be retained as a permanent check variety.

Suitable checks from the milling standpoint: Finney explained that from the milling standpoint Kharkof would be satisfactory as a permanent check but that Pawnee and Comanche should be kept as check varieties in the central area and Comanche and another commercial variety should be kept in the southern area. Principal need is for a minimum of two commercial varieties grown in an area that have very divergent milling characteristics.

Suitable checks from the maturity standpoint: Schlehuber suggested Comanche instead of Tenmarq.

Heyne agreed with Schlehuber and suggested Early Blackhull be dropped and use Wichita as an early check.

Atkins would like Early Blackhull retained for long-time studies of the relationship of weather and maturity with yield.

Swanson said "I highly favor two checks in the regional nursery of the two most widely, currently grown varieties, changes to be made from time to time. Just now I favor Pawnee and Comanche over Tenmarq.

"Also, I very much favor using Early Blackhull, Blackhull, and Kharkof as long-time continuing checks in the regional nursery for measuring sticks against the time when studies could be made of regional interaction between the weather elements and varietal adaptation as to range of maturity and certain morphological factors."

Shellenberger: Do we spend too much time testing quality of checks?

Swanson: I see little need of routinely testing all of the checks for quality, perhaps Kharkof alone should be routinely tested.

Robertson: Old varieties would be very valuable as checks for comparison with new varieties in case of drouth years.

Heyne: If a drouth comes, Early Blackhull could be put back in tests. We have germ plasm nurseries to keep viable seed available.

Robertson: By the time the seed were increased sufficiently, several years of the prevalent weather conditions would have already passed.

Johnston: Another possibility might be to take the old checks out of the milling tests to release time for quality work on newer material.

Shellenberger: We are not trying to shirk our duty for we are both a service and a research organization. We could use more time for research in the quality laboratory but we are anxious to have it discharge its full responsibility to the region as a whole.

Reitz: It is unlikely that anyone will object to growing Tenmarq or any other single variety in nursery tests since that requires such a small amount of work for the agronomists. However, the question of retaining Tenmarq in the field plot series involves more and should be decided by the conference.

Schlehuber moved that Reitz appoint a committee to decide the question of the continuation of Tenmarq in the uniform plot series. Heyne seconded. Motion carried.

The Heritability of Yield in Barley as Measured By Early Generation Bulked Progenies

J. E. Grafius, W. L. Nelson and V. A. Dirks, So. Dakota

A genetic interpretation of the variance involved in early generation yield testing of bulked progenies of barley crosses was presented. The non-heritable fraction comprised the major proportion of the genetic variance in the F_2. In the F_3, with increased homozygosity, the non-heritable fraction decreased in comparison to the additive (heritable) fraction of the genetic variance.

The importance of the additive genetic variance in selection for yield was pointed out.

It was shown that the parental performance gave a good estimate of the additive genetic variance to be expected in the progeny.

Selection of individual F_2 plants on a yield basis and selection of F_2 progenies (F_3) gave the expected results when the heritability estimates for each generation were taken into consideration.

Wheat Improvement

S. C. Salmon, U.S.D.A.

In the spring wheat area 70 million bushels increase in yield each year has been attributed largely to better varieties. For all wheat 250 million bushels increase in yield annually has been attributed to better varieties. This is remarkable!

The workers at this conference probably have more new ideas or approaches to wheat improvement than can be adequately undertaken so all I shall do is emphasize a few problems. Weather-crop relationships need more study. These might be tied in with varietal response to growing conditions to analyze crop failures, late frost damage on early varieties, etc. The relationship between early varieties and winterhardiness and studies on the high and low temperature relations of varieties are needed as these factors affect survival, dependability, yield, and quality of the crop.

Of course disease resistance is an important objective as has already been mentioned.

Stiffness of straw, shattering, and plant height have been neglected by the breeders of hard winter wheat. I realize that some progress along these lines has been made but concerted effort on these problems seems worthwhile.

The Bulk Hybrid Method of Breeding

I. M. Atkins, Texas

We have used the bulk hybrid method, with some modifications from time to time, almost exclusively in our work in Texas. With the wide range of climatic conditions in the State and limited personnel it seemed the only thing to do. However, as we look back over twenty years' work we are not too well satisfied with the results and have been modifying the method in recent years.

The chief criticism of the bulk method is that we fail to eliminate enough of the undesirable portion of the population in the early generations. When selections are to be made we find too large a mass of material to sample properly and too few really desirable strains among the progeny rows.

If we are to use the bulk method more efficiently then we should eliminate as fast as possible the less desirable portion of the population. If rust resistance or smut resistance is involved an induced epidemic of disease can help eliminate the susceptible portion. Straw strength, shattering, winterhardiness, kernel color or shape, and plant height are other suggested characteristics which might be observed in selecting a superior mass of seed.

We have used the gravity separator as a means of selecting the superior portion of the seed from bulk populations. These separators are used to take rocks out of beans, peanuts, wheat, etc. A bulk lot of seed weighing 56 pounds per bushel can be separated into lots ranging from 50 to 60 or more pounds per bushel. We are testing these separations for yield, test weight, segregation of visible characters such as awns, seed color, disease resistance, etc.

Another feature of selection from bulk populations that some may be over looking is that often good plants are taken out in one year and grown separately while the remainder is harvested in bulk and replanted. It seems to me that this throws you behind the "eight ball" since, theoretically, you have now selected the best out of that material. We grow our bulks up to about the fifth generation and quit. We plant a portion one year, select the best material we can find and discard the rest. The next year we plant from that remnant seed that has not been sampled. From this we have a chance to select more good material.

All of us should exercise more judgment in choosing crosses for our major work. Probably we all make too many crosses. Early elimination of the poorer crosses can be done on the basis of visual characters, thereby providing more time for the better ones.

Some of the better early generation plants may be backcrossed to the desirable commercial parent. We have not done enough of this but plan to do more of it. This again modifies the bulk method but that is all right. We had four Wichita type backcrossed strains that outyielded Wichita by 41 percent at three locations this year.

Lines of Research and New State or Regional Projects Recommended

Chairmen of program sections were called upon by Dr. Hehn for recommendations.

A. I. M. Atkins and A. M. Schlehuber on <u>leaf and stem rust</u> sections.

Suggestions for Future Work on Leaf Rust and Stem Rust

(1) Each state shall provide a list of varieties and strains which show promise as resistant parental material showing where possible the races and number of years to which it has been tested. After this has been brought up to-date, as new resistant material becomes available, it will be reported to L. P. Reitz to be included in a special section of the Regional Report. Such lists are to be made available to other workers on these diseases in other regions.

(2) It was suggested that available, promising germ plasm material be again made available to members.

(3) It was suggested that promising bulk hybrid material of early generations, F_2, or F_3 in the several states and stations again be made available to members of the conference. (See also discussion above, "Future Plans for Rust Control.")

B. R. G. Dahms on insect section

The objectives published in 1947 in the "Research Program for the Improvement of Hard Red Winter Wheat" (pages 15-17) have not been achieved. They are as important at this time as when first recommended.

C. E. D. Hansing on mosaic and root rots

Recommendation of Committee on Wheat Mosaic

The serious losses in winter wheat due to mosaic in the central plains area in 1949 show that this disease has become increasingly important since it was first observed. The disease is known to extend into the spring wheat area. Close estimates indicate that mosaic caused a minimum loss of thirty million dollars in western Kansas in 1949. It also caused losses in Nebraska, South Dakota, Wyoming, Colorado, and Oklahoma.

It is strongly recommended that the present minimum program of study on this disease be expanded along the following lines:

1. Search for sources of resistance to the viruses in winter wheat and spring wheat.

2. Host range of the viruses on wild and cultivated plants.

3. General epidemiology as influenced by vectors, climatic and seasonal factors, especially temperature, soil moisture, and snow cover.

4. Method of natural transmission, and study of insect vectors, their biology, seasonal abundance, alternate hosts, and host resistance to them.

5. Fundamental studies on the properties and identification of the grass viruses

6. Interrelations between mosaic, root rot diseases, and winter hardiness.

Since western wheat mosaic is such a destructive disease, additional funds should be provided for more intensive research. I move that the Regional Hard Red Winter Wheat Conference recommend that such a program be activated and be called to the attention of the directors of the Agricultural Experiment Stations in the Hard Red Winter Wheat Area and to the Chief of the Bureau of Plant Industry, Soils and Agricultural Engineering.

H. H. McKinney
H. Fellows
R. E. Atkinson
E. D. Hansing, Chairman
J. E. Livingston
R. H. Painter
J. T. Slykhuis

D. E. R. Ausemus and J. A. Shellenberger on <u>quality</u>

The recommendations of the Committee on Wheat Quality Evaluation are as follows:

(1) That all wheat samples to be evaluated be sent to the testing laboratory at the earliest possible date after harvest.

(2) That composites rather than individual samples be tested whenever practicable.

(3) That there be no duplication of samples between series except when warranted.

Since a certain amount of fundamental research is necessary for developing a better understanding of quality, the fulfillment of the recommendations will permit a better utilization of time for those associated in the testing program. (See also discussion above on "Evaluation of Uniform Experiments.")

E. A. F. Swanson on <u>weather</u>

It is the recommendation of the committee that a more intensive research effort be devoted to the study of:

(1) The relationship of the elements of weather to the adaptation of varieties varying in range of maturity.

(2) Resistance of wheat to cold during midwinter and spring, and to frost injury at the time of the fruiting period.

(3) Drouth resistance, and development of hardy varieties resistant to drouth and high temperatures.

(4) Factors involved in lodging and shattering of wheat and the development of varieties to reduce such losses.

(5) Test weight as related to the physical properties of the wheat kernel, and as a market factor.

(6) Genetic aspects of wheat breeding.

(7) Cultural practices.

(8) Seed sources as a factor in variety testing which will involve a reorganization of the old work plan on this problem by the regional coordinator.

Heyne moved the acceptance of all recommendations. Shellenberger seconded. Motion carried.

Resolutions Committee Report

Be it resolved that the Hard Red Winter Wheat Improvement Conference extend a vote of thanks and appreciation to the President of Oklahoma A. and M. College for the fine accommodations and facilities put at their disposal during the meetings.

Be it further resolved that the Hard Red Winter Wheat Improvement Conference extend a vote of thanks and appreciation to the management of the Short Course Center for the facilities and accommodations which aided in making the conference a success.

Be it further resolved that the Hard Red Winter Wheat Conference extend a vote of thanks and appreciation to Dr. H. F. Murphy and the Agronomy staff for the splendid arrangements made for the conference.

Be it futher resolved that the Hard Red Winter Wheat Conference extend a vote of thanks and appreciation to the various members and committees who have arranged and presented this excellent program.

We further request the chairman on behalf of the group to make known our appreciation and thanks to the various parties mentioned in these resolutions.

D. W. Robertson, Chairman
M. E. Young
J. A. Shellenberger

On motion by Dr. Robertson, seconded by Dr. Laude, the above resolution was passed.

Dr. Murphy, of Stillwater, introducted Dr. H. G. Bennett, President of Oklahoma A. & M. College, who expressed an interest in the conference work and voiced appreciation from the State of Oklahoma for the highly productive efforts of this group in the development of improved varieties of hard red winter wheat adapted to this state and region.

Conference adjourned.

Registration List

Name	Address
Ashdown, Donald	Oklahoma A. & M. College, Stillwater, Oklahoma
Atkins, I. M.	Texas Agr. Exp. Sta., Denton, Texas
Atkinson, R. E.	Colo. A. & M. College, Fort Collins, Colorado
Ausemus, E. R.	Univ. of Minnesota, St. Paul, Minnesota
Bennett, Henry G.	Oklahoma A. & M. College, Stillwater, Oklahoma
Briggs, H. M.	" " " " "
Brinkerhoff, L. A.	" " " " "
Bruehl, G. W.	South Dakota State College, Brookings, S. Dak.
Burley, Ray H.	Oklahoma A. & M. College, Stillwater, Oklahoma
Caldwell, R. M.	Purdue Univ., Lafayette, Indiana
Carter, John	New Mexico Agr. Exp. Sta. (Plains Substation) Clovis, New Mexico
Casady, A. J.	Fort Hays Agr. Exp. Sta., Hays, Kansas
Chatters, R. M.	Oklahoma A. & M. College, Stillwater, Oklahoma
Coburn, Henry C.	General Mills, Inc., Oklahoma City, Oklahoma
Crumbaker, Don E.	Kansas Agr. Exp. Sta., Colby, Kansas
Dahms, R. G.	Oklahoma A. & M. College, Stillwater, Oklahoma
Daniel, Harley A.	Red Plains Conservation Exp. Sta., Guthrie, Okla.
Derr, L. E.	Oklahoma A. & M. College, Stillwater, Oklahoma
Dines, F. T. *Catching-Dines Co., Crosbyton, Tex.*	~~Tex-O-Kan Flour Mills Co., Amarillo,~~ Texas
Elwell, Harry M.	Red Plains Conservation Exp. Sta., Guthrie, Okla.
Farley, H. C.	General Mills, Inc., Oklahoma City, Oklahoma
Faulkner, H. S.	" " " " " "
Fellows, Hurley	Kansas State College, Manhattan, Kansas
Fenton, F. A.	Oklahoma A. & M. College, Stillwater, Oklahoma
Finney, Karl F.	Kansas State College, Manhattan, Kansas
George, Donald W.	Texas Agr. Exp. Sta., Chillicothe, Texas
Grafius, J. E.	South Dakota State College, Brookings, S. Dak.
Granstaff, Edward L.	Extension Service, Oklahoma A. & M. College, Stillwater, Oklahoma
Hansen, W. W.	Oklahoma A. & M. College, Stillwater, Oklahoma
Hansing, E. D.	Kansas State College, Manhattan, Kansas
Haus, T. E.	Colo. A. & M. College, Fort Collins, Colorado
Hawkins, L. E.	Oklahoma A. & M. College, Stillwater, Oklahoma
Hehn,, E. R.	Montana State College, Bozeman, Montana
Heyne, E. G.	Kansas State College, Manhattan, Kansas
Iliff, Lawrence	General Mills, Inc., Wichita, Kansas
Jackson, Ben R.	Oklahoma A. & M. College, Stillwater, Oklahoma
Johnston, C. O.	Kansas State College, Manhattan, Kansas
Johnston, T. H.	Oklahoma A. & M. College, Stillwater, Oklahoma
Jordan, R. H.	Box 500, Oklahoma City, Oklahoma (Grain Insp.)

Omer Wimberly, O'Keene

D.V. Nelson, Goltry

Registration List (Cont'd.)

Name	Address
Kidd, H. J. *Ent.*	Oklahoma A. & M. College, Stillwater, Oklahoma
Laude, H. H.	Kansas State College, Manhattan, Kansas
Livingston, J. E.	Univ. of Nebraska, Lincoln, Nebraska
Locke, L. F.	Southern Great Plains Field Sta., Woodward, Okla.
Lowe, A. E.	Kansas Agr. Exp. Sta., Garden City, Kansas
MacVicar, R. W.	Oklahoma A. & M. College, Stillwater, Oklahoma
McCammon, J. F.	Kansas State College, Manhattan, Kansas
McKinney, H. H.	Plant Industry Station, Beltsville, Maryland
Miller, Byron S.	Kansas State College, Manhattan, Kansas
Morrison, L. S.	Oklahoma A. & M. College, Stillwater, Oklahoma
Murphy, H. F.	" " " " "
Oswalt, E. S.	" " " " "
Oswalt, R. M.	" " " " "
Painter, R. H.	Kansas State College, Manhattan, Kansas
Peck, R. A.	Panhandle A. & M. College, Goodwell, Oklahoma
Pfeifer, R. P. *agron*	Oklahoma A. & M. College, Stillwater, Oklahoma
Pierson, R. L.	" " " " "
Porter, K. B.	Texas Agr. Exp. Sta., Amarillo, Texas
Quinby, J. R.	Texas Agr. Exp. Sta., Chillicothe, Texas
Quisenberry, K. S.	Plant Industry Station, Beltsville, Maryland
Reitz, L. P.	Univ. of Nebraska, Lincoln, Nebraska
Ridgway, W. O.	(B.E. & P.Q.) Oklahoma A. & M. College, Stillwater, Oklahoma
Rivers, Geo. W.	Texas Agr. Exp. Sta., College Station, Texas
Robertson, D. W.	Colo. A. & M. College, Fort Collins, Colorado
Rodenhiser, H. A.	Plant Industry Station, Beltsville, Maryland
Rohlf, J. A.	(Farm Journal) Overland Park, Kansas
Salmon, S. C.	Plant Industry Station, Beltsville, Maryland
Sandstedt, R. M.	Univ. of Nebraska, Lincoln, Nebraska
Schlehuber, A. M.	Oklahoma A. & M. College, Stillwater, Oklahoma
Shands, H. L.	Univ. of Wisconsin, Madison, Wisconsin
Shellenberger, J. A.	Kansas State College, Manhattan, Kansas
Shultz, O. C. *Pl. Phys.*	Oklahoma A. & M. College, Stillwater, Oklahoma
Skiver, C. E.	Kansas Wheat Improvement Assoc., Manhattan, Kansas
Slykhuis, J. T.	South Dakota State College, Brookings, S. Dak.
Soder, K. E.	Tex.-Okla. Wheat Improvement Associ, Oklahoma City, Oklahoma
Sooter, S. M.	Oklahoma A. & M. College, Stillwater, Oklahoma
Struble, F. B.	" " " " "
Swanson, A. F.	Fort Hays Exp. Sta., Hays, Kansas
Vilm, S. E.	Canadian Mill & Elev. Co., El Reno, Oklahoma
Vogel, O. A.	Washington State College, Pullman, Washington
Wadsworth, D. F.	Oklahoma A. & M. College, Stillwater, Oklahoma
Weibel, D. E.	Kansas State College, Manhattan, Kansas
Whitehead, M. D.	Texas Agr. Exp. Sta., College Station, Texas
Yount, M. E.	Univ. of Nebraska, Lincoln, Nebraska.

Young, Harry C. Assoc. Pl. Path. Stillwater, Okla.

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