REPORT

of the

THIRD HARD RED WINTER WHEAT IMPROVEMENT CONFERENCE

Lincoln, Nebraska

April 11 and 12, 1935

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FOREWARD

This conference marked the first regional meeting of hard red winter wheat research workers since the inauguration of the coordinated program in 1930. Preliminary meetings had been held in 1929 and 1930 to plan and initiate the program. The meeting was sponsored jointly by the cooperating State Experiment Stations and the Division of Cereal Crops and Diseases, United States Department of Agriculture. Its purpose was to exchange information, review what had been accomplished in four years, and make plans for the future.

The conference was organized on a subject-matter basis with Agronomists, Plant Breeders, Cereal Chemists, Entomologists, and Plant Pathologists each having a part in the program. Abstracts of the several papers presented appear herein, together with a brief digest of the ensuing discussions. Free group participation was always solicited, even though the discussions were opened in some instances by members designated by the program chairman.

Those wishing additional copies of this report may secure them from K. S. Quisenberry, Division of Cereal Crops and Diseases, U. S. Dept. of Agriculture, Washington, D. C., or from C. A. Suneson, Agronomy Department, Agr. Exp. Station, Lincoln, Nebraska.

PROGRAM

Dr. F. D. Keim -- Chairman
Mr. C. A. Suneson - Secretary

April 11

9:30 A.M. Research in Quality of Hard Red Winter Wheat
Prof. H. H. Laude, Chairman.

1:30 P.M. Agronomic Research Work on Winter Wheat.
Dr. D. W. Robertson, Chairman.

6:30 P.M. Dinner in Chinese Room, Lincoln Hotel. Talk- "Whence And Whither in Crops Research." Dr. T. A. Kiesselbach.

April 12

8:30 A.M. Phytopathology of Winter Wheats.
Dr. G. L. Peltier, Chairman.

1:30 P.M. Future Plans.
Dr. P. C. Mangelsdorf, Chairman.

HARD RED WINTER WHEAT IMPROVEMENT CONFERENCE

April 11, 1935

The conference was called to order at 9:40 A.M. by Dr. Keim who called on Dr. Salmon for introductory remarks.

SALMON: I feel that a conference such as this is extremely worth while. It costs the states and the federal government a considerable sum of money to send the men, and this money would not be spent if the administrators did not feel that it was thoroughly worth while. The information we get at conferences is important as is the inspiration, new ideas and interchange of ideas. Each of us gets a very much better understanding of the problems of the other fellow and also of his own problems and goes away--I know I do--with not only a great many new ideas but with a different slant on his own problems. I think if I had time to I could bring to mind a number of cases where some of us have been prevented from going off on a tangent, which would have cost a great deal of time and money, because of attending a conference of this kind and getting new ideas and finding out what had been done along the same line. I feel for that reason they are tremendously worth while. This is the first one for five years in this territory. It is high time we did have a conference with respect to winter wheat problems and I am sure the authorities in Washington and those in various states feel that this will be extremely worth while.

Dr. Quisenberry read the following letter from Dr. McCall who was unable to be present:

April 9, 1935

TO THE MEMBERS OF THE
HARD RED WINTER WHEAT CONFERENCE.

Doctor Quisenberry has kindly consented to convey to you my regrets at being unable to attend and to take part in your conference.

I have felt this conference to be a very real, personal responsibility, and have looked forward to attending it with a great deal of interest and pleasure. Unfortunately, however, I cannot be present because of illness in my family. I wish, however, to extend to all of you, individually and collectively, my well-wishes and the sincere hope that the conference will yield in tangible results all that each of us would desire.

In my opinion this conference is tangible evidence of a viewpoint which is going to do a great deal toward the advancement of our crop improvement research. The State Agricultural Experiment Stations and the Department of Agriculture carry a heavy responsibility in assisting to solve the problems of American Agriculture, and to place our farmers again on their feet. Efficiency of production is a factor which must never be lost sight of in any proposed solution, and, likewise, efficiency in research is of paramount importance. The union of forces which this conference typifies is one of the most effective means of insuring efficiency in our efforts, and I want to pledge to all of you in the State Agricultural Experiment Stations our fullest cooperation in working out an effective, joint program.

With kindest personal regards to all of you individually,

Sincerely yours,

(M. A. McCall)
Principal Agronomist in Charge,
and
Assistant Chief of Bureau.

KEIM: Since the days of Mendel, research has been more or less here and there with no one knowing too much about what was going on. Progress is now made because research men are getting together and cooperating throughout the country and over the world and everybody knows pretty largely what the other fellow is doing. For that reason I would like to second the letter and the remarks Dr. Salmon made. The modern system of progress, of which these regional conferences are a part, has had quite an effect on the alfalfa, corn, and spring and winter wheat work. I will now turn the meeting over to Professor Laude who will act as chairman of the morning session.

RESEARCH ON QUALITY OF WINTER WHEATS

Prof. H. H. Laude, Chairman

LAUDE: In this conference we have brought together research workers interested in two major phases: Production of wheat and processing of wheat. Although they have somewhat different viewpoints they are by no means independent because it is of vital interest to the producer to know something about the success with which his wheat can be processed. The processor is also interested in the success with which the producer can grow wheat and particularly with any phases which tend to reduce bushel cost. A conference of this kind should lead to a better understanding of each other's problems. It seems to me it should be of particular value to those interested in research work in production to know something of the problems of the processor and the kind of wheat that will meet his requirements. It will then be easier for the breeder to go forward with research on production and improvement of wheat to meet these requirements. Likewise the processor of wheat will be more familiar with the problems of production and will know the difficulties the grower of wheat encounters in producing the kind of wheat desired by the trade. For these reasons a conference of this kind can be only beneficial. I certainly want to express thanks to Doctors McCall, Salmon, and Quisenberry who had part in making this conference possible.

There are three laboratories represented on the program this morning. These three men might be thought of as the three kingfishes in this field of research. There will be discussion at the close of each talk as you will note on the program. We will start with the man who has done much with the study of quality, -- Dr. Blish

The Baking Test as a Method of Measuring Quality in Winter Wheat

M. J. Blish

Obstacles and difficulties in testing new wheat varieties best suited to serve the interests of the farmer, industrialist and agronomist, have been partly solved by the Cereal Chemist in developing a standard baking test for the estimation of flour quality now used extensively and frequently called the "pup test".

Important features of this test are:

1. Fixed, arbitrary specifications for a basic procedure in which only the simplest ingredients are used, precise control of all environmental factors is demanded, artistry and personal manipulative skill are restricted to the utmost degree by mechanization of operations, all of these features to the end that the flour shall be the only variable.

2. With the basic procedure as the point of reference, various supplementary procedures are provided, each one permitting the variation of a single factor, or for the addition or modification of a single ingredient at a time.

3. The recording and reporting of results in terms of actual flour properties is preferred, rather than in terms denoting excellence, inferiority, or personal preference.

A yard stick for measuring and reporting results for experimentally milled, sound hard winter wheat flours employs the use of a set of photographs showing type models of external loaf characteristics now used in the variety testing work conducted in the Bureau of Plant Industry, United States Department of Agriculture and at the University of Nebraska Experiment Station. The standard basic baking test produces J Type loaves with Turkey types and with Blackhull. Tenmarq and some other varieties give the F Type loaf.

Type F, it may be noted, has those external characteristics generally favored in a commercial loaf. It is a large well-rounded symmetrical loaf with a smooth break or shred. Type J on the other hand, is a small, undeveloped loaf, with little or no break, but with a smooth exterior, well-rounded top and clear, unmottled top crust color. The crumb texture of Type F is usually soft, with fine grain structure and thin cell walls, while that of Type J is comparatively heavy, with frequently a coarse, spherical grain structure and thick cell walls.

Although Type F is a far more attractive loaf than Type J, to the extent that the casual and inexperienced observer would give it the higher rating as to "gluten quality", it must by no means be concluded that the flour that produced the Type J loaf is inferior for commercial bread making. In fact, for certain commercial methods Type J may be the better of the two.

One of the supplementary tests used in addition to the standard basic proceedure employs the use of an oxidizing agent, Potassium Bromate. Oxidizing agents alter the gluten characteristics depending upon the amounts used, the protein content of the flour, and the inherent tolerance or susceptibility of the gluten. The gluten characteristics of experimentally milled flours are altered similar to commercial bleaching where nitrogen trichloride, chlorine, and other chemicals are used.

The variety Blackhull gives a positive response to Potassium Bromate, and Tenmarq a negative response suggesting that oxidizing agebts must be used by the miller and baker sparingly and cautiously.

Some flours not responding to the action of an oxidizing agent require additional treatment such as longer mixing, or the addition of shortening or malt to the dough formula to best develop their adaptability for industrial utility.

With commercially milled flours and low protein experimentally milled samples all sorts of loaf types are encountered in the basic proceedure. A rough and ragged exterior, extremely mottled or "muddy" crust color are signs of inferior commercial bread-making value. A flat mushroon top signifies damaged wheat or low grade flour. The A.A.C.C. test is perhaps more sensitive than is actually necessary for most practical purposes.

Dr. Blish then turned to a discussion of sample loaves which he had prepared.

"Most of these loaves were baked with Cheyenne wheat obtained by Dr. Kiesselbach and Mr. Suneson from Nebraska farmers. The Nebraska station is very much interested in Cheyenne. It is a very unusual wheat as compared to Turkey, Kanred, Tenmarq, and Blackhull in that it is very easy to deceive us as to its baking qualities if confined to tests quite generally used. As I told Dr. Kiesselbach in 1930, "Any new flour will be condemned for awhile." Cheyenne doesn't respond to the bromate differential test. Swanson has reported that it would stand a lot of mechanical mixing, but wasn't stimulated by it. In this work shortening didn't do anything, malt didn't help, 3-minute mix plus shortening didn't do much. With 1 mm. of bromate and three minutes mixing there was some improvement. With bromate and shortening there was much improvement. Bromate, shortening, and malt produced a good loaf even from a 9 percent protein flour. The higher the protein content, the greater the response. Cases were tried to find out if addition of malt were absolutely necessary or if substituting sugar for malt would suffice. Apparently it cannot be done. It was benefited in gluten properties by malt."

Discussion

KIESSELBACH: Would it be objectionable to commercial production to give it the "whole works"?

A. These treatments would be very satisfactory for industrial use. With oxidizing agents, shortening, and probably malt added either in the mill or bake shop or both I would recommend a little more mixing than usual.

Q. Is this wheat you used raised here in Lincoln or elsewhere?

A. It comes from the eastern half of Nebraska, from an area about 100 miles in diameter.

Q. You say, Dr. Blish, that there is malt and shortening in bakes showing maximum development?

A. Yes.

Q. What has been your fermentation period on this?

A. Three hours.

LAUDE: I think there is one thing that might be mentioned in regard to ideas Dr. Blish suggested and that is that it should be very encouraging to men here doing research in improvement of crops that the entire responsibility of making a good food hasn't been thrown on the plant breeder or producer of wheat. This should be decidedly encouraging.

Next we will hear from Dr. Swanson who has spent a lot of time in studying the possibility of developing certain physical tests that will measure differences in characteristics of wheat.

PHYSICAL TESTS TO DETERMINE QUALITY IN WHEAT

C. O. Swanson

In wheat improvement it is necessary to establish certain standards. Flours used for specific purposes like bread baking, cracker, biscuit or cake making, may be selected as standards. The hard red spring wheat, Marquis, and the hard red winter wheat, Turkey have established the standards desired for the bread wheats around which the present discussion will center. The gluten in these wheats has characteristics which are particularly desired in bread baking with yeast as the leavening agent. Two very important physical characteristics in bread doughs are expansibility which allows for the expansion due to the production of carbon dioxide and the retention of this gas. If these two exist in a satisfactory balance, the properly fermented and proofed dough will produce when baked a light bread which meets accepted standards. Other factors must also be satisfactory, but these are presupposed in present discussion.

The recent physical devices for testing desirable characteristics in dough include: The Chopin Extensimeter, the Bühler Comparator, the Brabender Farinograph, and the Swanson-Working Recording Dough Mixer. The first two are designed to test the elasticity or the extensibility of dough. The last two are designed to test mainly the rate of dough development and behavior of dough under the stress of extended mechanical action. By comparing curves or data obtained on dough from flours accepted as standards, with those obtained from new wheats, the characteristics of these wheats are known as far as they may be known from these physical tests.

The description of the Swanson-Working Recording Dough Mixer has been published in Cereal Chemistry. Characteristics of curves made from the flour of the hard spring wheat Marquis, and the hard red winter wheat Turkey, are selected as standards for bread wheats. Standards for cracker, biscuit, cookie, and cake flours may be obtained by using flours found by large bakers to be satisfactory for these purposes.

The curve from a bread dough made from a strong spring wheat flour rises gradually taking three minutes or more to reach the top which is near the upper side of the graph paper. The top or peak of the curve is more or less rounded, and the amplitude decreases gradually, but never entirely disappears. The curve from the cracker flour which is also a good biscuit flour does not rise nearly so high, the top is more rounded, and the amplitude decreases gradually. The curves from the cake and cookie flours are the flattest, and the amplitude disappears entirely showing complete breakdown of the dough.

A number of curves obtained from Marquis as well as some of the newer spring wheats are strikingly similar to the curve obtained from a spring wheat bread flour of known value. The several curves obtained

from the Turkey wheats grown in various places are strikingly similar to those of the spring wheats. The curves obtained on the various Tenmarq samples show that this variety has characteristics strikingly like the spring and the Turkey wheats. The curves from the Blackhull group show very marked differences from those of Marquis, Turkey, or Tenmarq. The steep rise shows that the dough develops more rapidly, the peak makes a quick turn, and the amplitude persists but for a short while. This shows high sensitivity to severe mixing and that under extended mixing the dough breaks down completely. This all means that the physical characteristics of Blackhull wheats are fundamentally different from those of the spring and Turkey types.

Cheyenne, Oro, and Cooperatorka have curves, except for height, more like those of the cracker flour. If these wheats were low in protein as for hard wheats, the curves would be very much like the curves for the medium protein soft wheats.

Quivira is a new early maturing winter wheat. The curves are strikingly similar to those of Kanred, and the baking tests have shown great similarity in baking value. The curves from the soft wheats from states further east in comparison with the curves from the Kansas soft wheats show that the latter are too much like the bread wheats, and are not as well adapted for typical soft flour purposes. If the Kansas soft wheats were low in protein they would better serve the purpose of soft wheats. Kawvale by these tests is shown to have more of the characteristics desired in a bread wheat than in a soft wheat. Baking tests have confirmed this.

The indications of these curves should be supplemented by other tests. The evidence so far is that when the curves of a new wheat are like those of a typical spring wheat or of Turkey, it will prove satisfactory in bread baking. Enough work has not yet been done to relate, except in a general way, the special characteristics of the curves to actual baking performance. The baking results of Oro are usually satisfactory, yet the curve is strikingly different from that of Turkey. It may be that the characteristics found in Oro would make this wheat more of an all purpose wheat, and that the use would be determined more on the basis of protein content than would be the case with Marquis or Turkey. A similar statement might be made with reference to Cooperatorka and Cheyenne.

Discussion

Q. Do you have the protein content of these samples?

A. I did not bring in the effect of protein content because we have not studied it enough yet.

Q. Blackhull starts to break down after how long mixing?

A. It starts to break down almost right away.

Q. What would you say in regard to the mixing tolerance of Kharkof?

A. It seemed that it was not so tolerant. Some have less mixing tolerance than others. The difficulty is that the work hasn't progressed far enough for us to know what we should. I just found out the other day that in certain bakeries they mix the dough rather severely, rest it, and then mix again. They shorten the time of fermentation and

claim they have remarkable results. There is a similarity between mechanical action and the action of yeast.

LAUDE: Now we have a third number, "Baking Quality of the Hard Red Winter Wheat Varieties." Mr. Fifield.

Baking Quality of the Hard Red Winter Wheat Varieties

C. C. Fifield

Comparisons of the loaf volume, protein content of wheat, grain and texture, and crumb color of composite samples with the average of the individuals comprising the composite were made on three groups of samples of wheat grown in the Southern, Central, and Northern districts for the crop year of 1934, arranged in decending order of protein content with respect to the composite. The composite samples were all made up by taking equal portions of the same variety of wheat submitted from the individual stations in the respective district to form the bulk sample for milling and baking studies. There were 9 to 12 different varieties grown in each district. The individual samples were milled and baked in the usual manner, and the individual results were averaged. The results obtained show in the majority of the instances that a very close agreement existed between the composite and the average values of the individuals. Individual stations, making up the composite, may produce in some years samples of inferior baking quality in comparison to the other stations in that same district. Important causes for this, especially in the instances of the 1934 samples from Lincoln, were high yield per acre and low protein content.

Other studies show the relationship between the three districts for the years of 1932-33-34, with respect to yield per acre, protein content, weight per bushel, loaf volume, grain and texture, and color of crumb. All the varieties grown in the one district were averaged and this value was used for making the comparison. Each year's results are different and no conclusion can be drawn as to the superior performances of one district over another.

The various baking methods are outlined and they are as follows: basic, bromate, extended mixing (5½ minutes in the Hobart-Swanson mixer), and a commercial method in which dried skim milk, shortening, malt, and bromate are used. These varieties showing superior baking performance, by one method, show equally well by the other methods, weak varieties consequently having low baking characteristics. Outstanding varieties of current interest are Blackhull, which is depressed in loaf volume in the Southern District, due to extended mixing, but shows increased volume in Central District; Tenmarq, shows negative response to bromate in the Southern District but shows positive response in an increased loaf volume in the Central District; Cheyenne, grown in the Central District shows poor bread making quality; Kawvale, Denton and Fulcaster, soft red winter wheats, show stability in that they produce loaf volumes on the extended mixing equal to the basic bake values.

The uniform yield nursery composite for the 1933 crop is discussed with respect to its milling and baking quality. Many crosses of promise, especially the Turkey selections and Kanred crosses, are equal to the standard varieties in baking performance.

The above studies and conclusions have been determined from the results of 3942 loaves of bread, representing approximately 1100 samples of wheat.

Discussion

Q. Were the samples all the same age, that is, the same degree of time between milling and baking?

A. Yes, it was approximately three weeks. The yeast solution was made up every day. Solutions were measured out with an accurate burette. About 25cc. should be the outside error in loaf volume. We try to eliminate the skill of the baker in making a loaf of bread. Differences shown were due to difference of flour. All of these varieties are baked the same, even weighed out on 15% moisture basis, 60% absorption.

C. O. SWANSON: In the southern district Tenmarq is the poorest wheat.

Q. What did you judge the hard wheats by?

A. Samples from five states were composited according ot the acres of hard wheats grown in those states. That sample has been used as the standard for comparison of variety studies.

Q. How much importance would you attach to crumb color in work of this kind?

A. I wouldn't attach much importance to color because in many instances flour is bleached. Color is not as important, of course, as grain and texture.

Q. Were these bleached?

A. No.

Q. Five states made up the 1934 samples. Did you get about the same variation in replication of bakes between standard and composite?

A. Yes.

Q. Isn't 3 percent shortening a little higher than average?

A. No. The trend in commercial practice has been toward an increase.

FIFIELD: In the southern district Tenmarq apparently does not respond to bromate. Harvest Queen in the basic bake is high in volume. Kharkof is depressed in long mixing. In the southern district Blackhull and Nebraska No. 60 were very good from the commercial standpoint. Nebraska No. 60, Cheyenne, and Blackhull are not so good in the central district, perhaps because as yield per acre increases, protein content decreases.

QUISENBERRY: Yields per acre would show on the average that the high yielding varieties in the central district were Cheyenne and Blackhull for 1934.

Q. In the commercial bake did you mix for 5 minutes?

A. No, I did not; this is only mixed for 1 minute.

Q. Are you ready to interpret this material as differing in quality? Are these dependable measures now of baking quality?

A. We hope so, at least that they are a dependable measure showing the relative standing of these varieties under a set of three conditions.

Q. Minturki is not highly regarded as a bread wheat is it?

A. The color is objectionable although it gives a large loaf volume.

ROBERTSON: Those bread specialists failed to supply us with jam along with the bread.

Adjourned at 12:30 until 1:30 P.M.

AGRONOMIC RESEARCH WORK ON WINTER WHEAT

Dr. D. W. Robertson, Chairman

Breeding For Rust Resistance

P. C. Mangelsdorf

In a program to develop new rust resistant wheat varieties for South Texas, where leaf rust and stem rust are limiting factors in wheat production, crosses were made between Hope, a rust resistant spring wheat, and Mediterranean 3015-63, a strain resistant to leaf rust. The hybrids were grown in large bulk plats, under conditions of severe rust infection. Selection was confined to individual plants free of both rusts. In a test of 122 resistant selections in 1934, all of them were found to be more productive than the nearest checks. Resistance to stem rust is apparently recessive in this cross, and appears to be linked with susceptibility to black chaff and septoria, although there is some crossing over and plants resistant to all these diseases are occasionally isolated. The results of this breeding program suggest the possibility of developing multiple factor foundation breeding stocks which combine resistance to many diseases with other desirable characteristics.

Discussion

LAUDE: Mangelsdorf's paper suggested some important and highly practical ideas. The method used by McFadden for handling a lot of individuals is a simple, efficient way. A program should be developed for securing multiple factor foundation stock. I think Dr. Salmon should tell us of some of their work bearing on this.

SALMON: On the Pacific coast Oro is highly resistant to bunt and very winter-hardy. Federation wheat has the very desirable qualities of short, stiff straw and out there it had a high yielding capacity, but is deficient in winter-hardiness. An F_2 population of Oro x Federation was bulked and produced about 15 pounds of grain. Seed was sent to Laude at Manhattan, to Akron, Colorado, and to Pendleton, Oregon, in 1933. An inspection of Laude's plots showed some marked differences in winter-hardiness. The material this spring seems to be more winter-hardy than when started, since the tender types are killed out.

LAUDE: About half the plants killed in a way that would indicate segregation for hardiness. Seed was taken from the end that had been killed most in 1934. It would seem that marked progress is being made.

CROSS: Until we have arrived at a better understanding of winter-killing is it not a good plan to interchange material between stations that have considerable winter-killing? Thus the varieties will be subjected to different types of winter-killing.

LAUDE: True if hybrid material shows that it might be more resistant to one type of killing than to another.

JOHNSTON: There isn't any question in my mind but what central Texas and northern Oklahoma are hotbeds of stem rust and that stem rust is a hazard to wheat production in all territory north of that area. Whenever conditions are favorable we will have rust in the north. There is a big field for developing more rust resistant types in northern Texas as a barrier between stem rust in southern Texas and the wheat farther north. Winds blow spores and when conditions are favorable we are certain to get the rust. If they would grow more rust resistant wheats it would act as a safeguard to our wheat farther north.

SALMON: We want to encourage them all we can.

Q. McFadden, could we hear of the present status of Hope wheat hybrids with special reference to black chaff disease and failure to stand hot winds, etc.?

McFADDEN: We have not had much black chaff for a number of years. Most of the segregates carry the Hope type of resistance. It may be possible to break that association but I have not been able to do it to-date. I have a number of crosses between Hope and several winter wheats which I carry in bulk. I find that some wheats in the F_2 and F_3 have quite severe winter-killing, about 95%. The winter wheats usually mature before we have much heat. I was interested in mass breeding. Up in South Dakota we lose practically all plants of F_2 ordinarily. They are lost because of lack of winter-hardiness. If material of that kind could be grown farther south and then brought for final testing farther north we could make more rapid progress.

AUSEMUS: Black chaff-resistant Hope and H-44 segregates that we have indicate that the linkage can be broken. We have a number of hybrids which show resistance to both stem rust and black chaff. For the last three years we haven't had an epidemic in which we can feel fully confident. In crosses with Hope and H-44 we have found it rather difficult to get a hybrid as high yielding as the parent put in.

Controlled Hardiness Studies

C. A. Suneson

Of the four recognized forms of winter-killing (i.e., heaving, smothering, winter drought, and freezing), lethal temperatures are most vital to us. This paper will report briefly on our control freezing experiments with winter wheat.

Rather frequent abnormalities in the response of varieties are common in both chemical and direct measurements for cold resistance; and, we dare to believe, in field and nursery experiments also. Explanations for and control of these abnormal variety responses are paramount problems in all cold resistance experiments.

Three types of flat-grown wheat plants are used in our work. These are: (1) greenhouse plants grown continuously at 70° F. until

frozen; (2) similarly grown plants hardened at constant 32 to 37° F. temperatures before freezing; and (3) field grown plants frozen direct from the field. Recovery in all cases is in a 70° F. greenhouse. Experience has taught us to replicate extensively--replication here denoting both number and randomness as to season and type of plant tested. With 30 replications I believe it possible to equal the accuracy of the present uniform winter-hardiness nursery, but such a test fits neither average physiological or breeding experiments.

In striving toward accuracy in fewer replications, we have given considerable attention to temperatures. We now use both field and greenhouse grown plants because normalcy in varietal response has not been found to be dependent on any specific level of cold tolerance. Similarly, the level of cold tolerance is not entirely dependent on temperature for absolute minimum tolerance of field plants during the past 5 years has ranged from -4° to -24° F., with the -24° F. tolerance occurring during the particular winter when mean and minimum temperatures were highest.

Stage of plant development may effect varietal rank, but does not seem consequential if well established plants are compared. As between different growth stages, ignoring varieties, seedlings just emerged and well established plants are both more cold resistant than plants on the verge of tillering. As a result of this discovery, and a companionate one suggesting that bunt infection lowers cold resistance, we have revised our field planting schedules for winter-hardiness and smut nurseries here at Lincoln.

Despite considerable negative agronomic work on source of seed, it seems that we must now question the accuracy of any cold resistance comparison involving seed from different points or of greatly different quality. I make this statement because in 311 paired comparisons of the best and poorest lots of seed involving 6 different varieties in 5 separate experiments, we have found an average difference of 14% supported by highly significant odds.

Seasonal adjustments quite independent of temperature, stage of growth, or seed source must also be recognized, especially when unsimilar varieties or classes of wheat are compared.

We have made considerable use of artificial freezing in our selection work, aiming at retention of about 5% of the original population. We believe this method of selection is very efficient. Our experience also suggests that there is little danger of recovering an excess of late types or a dearth of early types from bulk hybrid populations.

Selection within varieties has also been carried on. Two particularly promising selections, each with a background of 32 paired cold resistance comparisons with its parent variety, might be mentioned. One, a Blackhull selection, cannot be distinguished agronomically from Blackhull but has averaged 16% superior in cold resistance. That should make it about equal to Nebraska No. 60 in cold resistance.

The other was selected from Cheyenne, which it resembles only in part. This selection is nearly 2 days earlier and yet exceeds Cheyenne in cold resistance by 17%.

In planning for the future it would seem efficient and otherwise desirable to link cooperatively a number of stations with control equipment for a concerted attack on the fundamentals of cold resistance--both physiologic and genetic. It is further suggested that the lethal temperatures and survival data, coming from this cooperative experiment, could be translated into valuable regional crop condition reports much more timely than any we now have. The proposed program should feature regional varietal types and provide for testing every 3 weeks during the winter, but even then would not need to tax individual cooperators for more than 5% of their plant capacity.

Supplementary Winter-Hardiness Nurseries

Alvin E. Lowe

The supplementary winter-hardiness nurseries are distinct from and not the same as the uniform winter-hardiness nurseries. The demonstrated value of the uniform winter-hardiness nurseries in obtaining valuable data on winter-hardiness of the more promising varieties, selections and crosses from the winter wheat breeding nurseries led to the establishment of the supplementary winter-hardiness nurseries; the purpose of which is to obtain similar data on a larger number of less advanced strains that it is possible to test in the uniform winter-hardiness nurseries.

The plan of the nursery is simple. It consists of two series of single eight-foot rows, planted at 5 cooperating stations. These short rows are seeded with a nursery drill, one foot apart, at the rate of 6 pecks per acre. Estimates of the percent of plants that survived the winter are made in the spring.

The supplementary winter-hardiness nursery has been grown at Colby, Kansas; Akron, Colorado; Redfield, South Dakota; St. Paul, Minnesota; and Moccasin, Montana. These stations are distributed so that a wide range of winter injury is obtained at one or more of the stations in most years. This is illustrated by the data obtained in 1932-1933; at Colby the survival was 100 percent for all strains tested, at Akron the survival ranged from 20 to 90 percent, and at the other three stations winter-killing was too severe to be of much value.

The presence of a significant relationship between the survival percentages at two stations is shown by the correlation coefficient of 0.4926 ± 0.0474 obtained on data collected at St. Paul and Moccasin in 1930-1931.

Interesting differences have been observed in making comparisons of certain groups of hybrid wheats. In 1931-1932 selections of Kanred x

Marquis made at Hays, Kansas, had an average survival of 49 percent when grown at Redfield, South Dakota, whereas the other groups of hybrid selections tested, ranged from 72 to 79 percent. In 1930-1931, selections of Kanred x Hard Federation grown at Moccasin, Montana and St. Paul, Minnesota, had an average survival of 28 percent, as compared to the other groups tested which ranged from 36 to 57 percent.

This nursery has been very useful in supplying information on winter-hardiness of wheats in process of development, and is a valuable aid to those stations where winter-killing does not occur every year.

Discussion

SALMON: It seems to me that some significance of the latter paper is the fact that this supplementary winter-hardiness nursery is not being used as extensively and generally as might be the case. In making a rough tabulation it appears that in less than half the years have they had differential results of significance despite the favorable location of the stations involved. There has been much less at points farther south, where winter-killing occurs less frequently. Probably the supplementary winter-hardiness nurseries have not been used more extensively by states other than Kansas because the opportunity has not been more generally known. You should consult with Drs. Parker or Quisenberry about it.

Sunoson's paper showed the use of controlled experiments, specifically in this case "controlled freezing experiments" in the plant breeding program. Of course it did not mean that the same thing could not be done under field conditions but does offer an additional opportunity for making selections of that kind under conditions where you can feel reasonable sure what the selections consist of. Second, with respect to the trend in our investigational work, those of us who are a little past the average of age in the group remember that 10 to 15 years ago dependence was placed entirely on field experiments. We used very little of anything else. Only in the past few years have we had any great attention given under controlled conditions. I would not mean to imply that we should abandon field experiments but that we can supplement them in an extremely useful way by controlled experiments of various kinds. It seems we have perhaps two, not antagonistic, but different ways. Very extensive experiments such as field experiments must be the cause of many uncontrolled variations---random or not---and the only way we can take account of them is to conduct experiments in which we segregate the variables under controlled conditions. A significant thing is that in the more exact sciences of Chemistry and Physics progress is made mostly by perfecting methods by which experimental data are secured. Instead of a large number of observations attempts are made to perfect the methods so that the variations are less, and the worker knows more exactly what he is doing. Here we have an example of a similar method of attack in agronomic work. I believe the time will come when we will do a great deal more of our work in that way.

TYSDAL: In studies of the uniform winter-hardiness nursery, did you take up correlation of different stations?

QUISENBERRY: Correlation studies on the uniform winter-hardiness nurseries are now being made and do show distinct difference in the way the data from different stations are correlated. St. Paul and Brookings, for example, are highly correlated indicating that killing at these stations was due to the same cause.

PARKER: In the earlier years this nursery was referred to erroneously as the "Kansas Supplementary Winter-hardiness Nursery." I think that it should be called "United States Department of Agriculture Supplementary Winter-hardiness Nursery."

Breeding Early Winter Wheats

John H. Parker

Kansas farmers want an early variety of hard red winter wheat to grow on part of their acreage, with such varieties as Turkey, Kanred, Blackhull and Tenmarq. Early wheats have (a) certain advantages and (b) some disadvantages. They escape some of the damage caused by wind and hail storms, they allow early marketing and early preparation of seed bed, and spread out the harvest season, thus reducing overhead costs of combine-harvesters. Early wheats are liable to be damaged by late spring freezes, and the varieties now available are much less winter hardy than Turkey, Kharkof and Kanred. It may not be possible for plant breeders to combine extreme earliness with maximum yield, in one variety. The association between earliness and low winter-hardiness, which is probably due to physiological correlation rather than genetic linkage, may also be difficult or impossible to overcome.

Varieties such as Zimmerman, Currell, Nebraska No. 28, and Early Blackhull are early, but lack winter-hardiness. Kanred, Blackhull and Tenmarq are Earlier than Turkey and Kharkof, but do not fill the need of Kansas farmers who want still earlier varieties. Three crosses, made for the specific purpose of combining earliness with winter-hardiness and other desired characters, have been studied rather intensively at Manhattan. These are Kanred x Nebraska No. 28, Kanred x Prelude and Kanred x Hard Federation. The first of these crosses produced no types of sufficient promise to justify extensive testing. Lateness was dominant in this cross, and nearly all segregates resembled one or the other parent, i.e. there were very few intermediates.

A selection of Kanred x Prelude has been named Quivira, and was registered as No. 273, in November, 1932, by the American Society of Agronomy and the U. S. Bureau of Plant Industry. Quivira yields well under favorable conditions, i.e. where it is not injured by winter-killing, or shattering of grain from the heads does not reduce the yield. Quivira is much less cold resistant than Turkey, Kharkof and Kanred, and somewhat less hardy than Blackhull and Tenmarq. It is more winter-hardy than Early Blackhull. Quivira often produces "dark hard" grain, and may need special tempering, to be milled properly. Flour of Quivira con-

tains more carotene yellow pigment than Tenmarq, but not much more than Turkey, Kharkof and Kanred. Quivira flour and bread sometimes show a grayish color, which is objectionable. Quivira needs further testing, as to agronomic characters and quality factors, before it is approved, or disapproved, for increase and distribution to farmers.

Two selections of Kanred x Hard Federation, Kansas No. 2673, C.I. 10092, and Kansas No. 2672, C.I. 10091, appear very promising as early types with short, stiff straw, suitable for combine harvesting. These selections are now being tested in field plots at Manhattan and other stations, and in cooperative wheat variety tests on Kansas farms. Kansas No. 2672 is less cold resistant than Kansas No. 2673, and both selections are much less winter-hardy than Turkey, Kharkof and Kanred. They are less hardy than Blackhull and Tenmarq, but are probably more hardy than Early Blackhull. The grain of these Kanred x Hard Federation selections is not very attractive in appearance, rather light red in color, lacking in lustre and inclined to be low in protein content. However, the milling and baking qualities appear to be satisfactory, and the flour milled from these wheats does not have the objectionable yellow and gray color of Quivira.

Quivira and the better one of the two selections of Kanred x Hard Federation represent definite steps of plant breeding accomplishment, since they ripen about a week earlier than Turkey, and are probably more winter-hardy than any strain of hard red winter wheat of equal earliness, now being tested in this country.

A number of other crosses have been made and are now being tested at Manhattan, in F_2 to F_5 generations. Quivira or Kanred x Hard Federation were used as the early parent in most of these crosses. Some F_5 lines of Early Blackhull x Tenmarq appear rather promising.

It is suggested that plant breeders use early, high quality varieties of hard red spring wheat such as Reward, and early varieties of hard red winter wheat, such as Early Blackhull, Quivira, and Kanred x Hard Federation, as sources of genes for earliness. The methods of back-crossing and of growing hybrids in bulk from F_2 - F_5, may deserve greater use, in the future. The plant breeder needs, and must have the active cooperation of agronomists, plant physiologists, plant pathologists, entomologists, cereal chemists and others, in order to make the most rapid progress in the production, testing and distribution of early, winter-hardy wheats, which will yield well, be resistant to important diseases and insects, and be acceptable to the miller and the baker.

Discussion

CURTIS: At Akron, we want early, winter-hardy wheats. I believe Dr. Robertson can give us some information on yielding ability of winter wheats.

ROBERTSON: We have two early wheats, Turkey sel. 195 and Kanred 0166. In good years when we have lots of rainfall Kanred has out-

yielded these. In recommending a wheat you must take into consideration the small farmer who wants a crop each year and the bonanza farmer who wants the highest yield he can get. We haven't in our spring wheats a cold tolerance to sharp frosts in the spring. It might be possible to get some of these cold tolerant strains.

SUNESON: I might say that the statement made in my paper suggesting that there is no apparent association between time of maturity and hardiness was based on selections from 11 bulk hybrids, only one of which involved parents extremely different in maturity. None of our hybrids were winter x spring.

ATKINS: In connection with earliness and winter-hardiness, I have been growing Minhardi and Minturki at Denton. Minhardi is about two weeks earlier than Minturki and almost as early as Quivira. They apparently lost their winter-hardiness this year for Nebraska No. 60 and Kharkof survived about 15 percent while Minhardi and Minturki killed completely.

LAUDE: We have some artificial refrigeration work which has shown that hardy wheats are the ones which have the capacity of developing great resistance to cold. They tend to lose it quickly when placed under conditions favorable for growth. After a few days of favorable growing conditions they will kill easier than less cold resistant strains.

CROSS: Experience with Early Blackhull has shown that occasionally it will lead the list in yield when we have early summer droughts but when we have late freezes we have almost a complete blast of Early Blackhull. It is possible to get wheat entirely too early, for the late spring freezes will catch it and do injury. For several years now we have been growing a classification nursery, for observation and acquaintance with varieties, in which we have had Minhardi and Minturki. There has always been a very great difference in the top growth of these winter-hardy types and those less hardy. The latter are easily stimulated to succulent growth by periods of warm weather; the hardy types are not stimulated and are more sluggish. When once emerged they are no more hardy than the others but are harder to get into a succulent stage of growth.

PAINTER: Some early wheats are better able to withstand chinch bug, wheat stem maggot, and other insect attack.

A. F. SWANSON: When we have an early drought Early Blackhull is better; when we have a later drought the later wheats are better. There is very little yield difference between an early variety maturing on a given date and a mid-early variety maturing on the same date in a planting date series, when averaged over a five or six-year period.

PARKER: I think the Kansas farmers do not want early wheat for their entire acreage,--just for part of it.

SALMON: If plant breeders make any more crosses for earliness I would like to see Reward used as one parent. It is the highest quality spring wheat in existence.

Pasturing Winter Wheat

A. F. Swanson

Winter wheat in the Southwest is often grazed from November to April when the crop has made a satisfactory vegetative growth. While this vegetative growth is sometimes a protection against winter-killing and always a safeguard against wind erosion, it is also highly nutritive and livestock having access to it make excellent gains.

When a well established growth of wheat is moderately grazed and properly managed, the yield of wheat is usually not reduced and may sometimes be increased. When conditions are unfavorable for the growth of wheat plants, grazing may result in heavy losses in grain yields.

The several factors which make possible the successful grazing of winter wheat without marked reduction in yield are: (1) A well prepared seedbed with a good reserve of subsoil moisture. (2) Moderate and well managed grazing. (3) Continuous grazing from late fall or early winter until plants show a tendency to make erect spring growth, except during periods of inclement weather.

Winter wheat can best be grazed in a region of open winters, limited winter rainfall or snow, and where the temperatures permit the crop to make continuous growth except for the very coldest part of the dormant months. The winter wheat belt of the Southwest has the above advantages over many of the other wheat growing sections of the country, when moisture conditions are favorable for well established stands of wheat.

The firming of the seedbed from livestock grazing over the wheat fields during the winter months is believed to be somewhat beneficial, unless the plants are tramped into the soil beyond recovery. If the surface soil is dry and the plant growth limited injury may occur to the crop. There is some evidence that moderate grazing may conserve the subsoil moisture supply in fields of heavy wheat growth as compared with ungrazed wheat under like conditions. Grazing tends to prevent lodging and to retard maturity somewhat.

Discussion

KEIM: I think without much question those of us who have been answering correspondence and suggesting feed grasses realize the great value of winter wheat for pasture. It has "saved the goats" of a large number of our people. Last Saturday I was out at my farm. My tenant had been pasturing the wheat rather heavily and I wondered whether or not we really had enough data for me to walk over that field and not think it was overgrazed. I personally think he was pasturing it too hard. Somehow I have never felt we will gain much by pasturing winter wheat. I wonder if it would not be a good thing to make more or less

a regional experiment of it. I feel that if we did as good a job as Mr. Swanson has given us it would be worth a trial. I also wondered about evidence to support tramping. I have no data; I can not tell farmers it will increase their yield by packing the soil. I wonder if it would not be possible to work it into a practical temporary pasture experiment? I wondered if it would not be possible to find out the gains under various conditions and the effect on yield.

Q. From the moisture conservation standpoint, what effect will packing have on runoff from a heavy rain in the spring?

A. It may be heavier, I do not know. We do not have enough evidence on the tramping effect. It does firm the ground and may cause larger runoff.

Q. Do you notice more wind erosion if left hard?

A. In the Panhandle of Texas due to the firming of the land by cattle it did not blow as easily.

Q. Do you feel that the pasturing by reducing growth has saved moisture so it increases yield?

A. We were losing no moisture where we grazed a plot. We get less tillers and it thins out the plants a bit.

Q. You report a loss of 3.1 bushels from severe seasonal pasturing. Do you have any idea of the value of that pasturing?

A. You can figure two acres to an animal without loss to the crop and at $2.00 a head per month rental for cattle you will be ahead. The nutrients of the pasture will cause gains in the animals and you will also aid the wheat if not pastured to excess.

Q. I wonder if anybody knows anything about winter wheat sown in the spring for pasture?

LAUDE: We talked this over so my answer represents several professors' ideas. It would be likely that people would get considerable pasture--less than from oats but wheat would stand pasturing better than oats. It probably wouldn't last longer than warm weather in June.

KEIM: That is about the same answer we have been giving farmers.

Differential Response of Wheat Varieties to Time of Application of Fertilizers

C. B. Cross

This paper is a progress report on an experiment which covers only a part of the field of factors affecting yield in wheat. Since only one year's data is available, too much stress should not be placed on differences or trends.

The project was outlined in 1932 under Purnell Funds with the idea of making a field analysis of differences in response of wheat varieties to various times of applying fertilizers. The investigations of W. F. Gericke of California suggested to the author that some varieties, because of greater stooling tendencies in early growth and others at a somewhat later period might warrant a slightly different fertilizer program.

Results of Gericke's investigations in which one of the essential salt elements was absent from the cultural media of wheat for various periods of time following initial exposure of the cultures to complete nutrient solutions, showed that the absence of either calcium or nitrogen rather seriously reduced the protein in the grain. Alkaline or neutral reactions of the media during the later growth phases of the plants caused a slight decrease in protein content. The absence of potassium, phosphorus or sulphur in the cultural media after the plants had grown four weeks in complete culture solutions, had no effect on the protein in the grain. Similar experiments with magnesium showed only slight reductions in protein. Thus it seems that protein content of grain is rather closely related to calcium and nitrogen relations of early growth.

Differences in response suggested that a careful measurement of plant differences under field conditions with fertilizers applied at different stages might be desirable.

The experiment was outlined with dates of application at planting time, thirty days after planting, at the cessation of fall growth, and at the beginning of spring growth. Since the later dates of application were going to be on settled ground, it was felt that, if possible, the "at planting" date should be applied after rain had settled the seed bed, thus avoiding the sifting of the fertilizer in cracks and crevices of the soil. Twenty-one plats, 16 x 48 feet were laid out in three series of seven each, plats side by side and series side by side so that the experiment consisted of a plat of ground 112 feet wide by 144 feet long. Each series received a different fertilizer treatment; one received a complete fertilizer of 4-12-4 composition at the rate of 300 pounds per acre at the four dates above suggested; a second one received the same rate but the potash and phosphate were applied as a base application at planting and the nitrate delayed and applied at dates suggested; the third, the phosphate series receiving a base application of nitrate and potash with the phosphate delayed. To avoid border effect, the twenty-one plats were separated by setting galvanized iron ten inches in the ground and allowed to project five inches above so that no overflow or drainage from one plat would affect the adjacent plat. To prevent water standing and drowning the plants, tiling was laid across between series under the tin partitions.

Four varieties of wheat, two hard and two soft, were used (Turkey, Blackhull, Fulcaster, and Harvest Queen). These were planted in three-row plats in quadruplicate. The kernels were space planted three inches apart in rows twelve inches apart. Only perfect stand plants from center rows were harvested. This was done by pulling. The plants were thrashed separately after the culms had been counted and measured. To determine the date of heading, fifty merchandise tags were put on each variety for each treatment when the tip of the spike had emerged above the sheath. Records were kept from day to day. Chemical analyses for protein and phosphorus were made on composite samples of each variety for each treatment.

The data were calculated on plants arranged in random order, the same number being used for both check and any adjacent treatment. An analysis of these data shows that in nineteen cases out of twenty-four for the first two dates of application, namely at planting and thirty days after planting, the fertilized plats showed an increase over the check while a similar comparison for the last two dates shows only 7 out of 24 treatments exceeding the checks. This may be partially explained on the assumption that part of the fertilizers did not get into solution in time to render any service. If we compare, further, taking the date of heading into account, we find that all varieties in all three series for the fertilizer applied at planting, which is essentially a complete fertilizer at planting, from one to four days earlier on fertilized plats than adjacent checks. For the series with the fertilizer applied thirty days after planting, in three cases out of twelve, the dates were the same; in the remaining nine, the fertilized were from one to two days earlier. The series with fertilizer at the cessation of fall growth, about December 15 to January 1, under Oklahoma conditions, showed from one to two days earlier for the nitrate series, no difference to one day's delay in the phosphate series, and one day's delay in all cases for the complete fertilizer series. The nitrate series, the only one receiving phosphate at planting, was the only one earlier than checks; thus we may account for this difference being due to the influence of the phosphate which was applied at the early date. Phosphorus, being more readily fixed and less soluble than nitrate, must apparently be applied earlier than the nitrate to be effective.

The spring application, delayed heading from one to two days in all but two cases which were not delayed. The yields from these applications were depressed below check in ten out of twelve observations, but were significant only in the cases of Turkey and Harvest Queen. In both these varieties the depressions in yield were significant for the application of the nitrate, whether in the complete fertilizer or alone.

In general, reductions in yield were accompanied by reduction in protein in the wheat. In thirty-one out of forty-eight observations this was true. Culms and height tend to be correlated with yield; positive differences for fertilizer in yield are accompanied by increases in number of culms and height.

A longer period of observation must be made before varietal differences can be statistically calculated with significance.

Discussion

Q. Do you intend to carry this on for a period of years on the same plots? What about residual effect?

A. I anticipate residual effect.

Q. Is the first application of fertilizer made broadcast?

A. We plant and then apply the fertilizer.

THROCKMORTON: The farmer's tendency seems to be to apply the fertilizer at the time of seeding.

Q. Would you find positive correlation between yield and number of culms? There is a trend that way.

A. There was a high correlation between yield and weight of grain per head. It ran 69% in 1932, 83% in 1933, and from 39-59% in 1934. Weight of kernel gives considerable correlation.

Q. Is it a question of weight of seed or seed size?

A. Size of seed on weight basis.

KLAGES: In our work we had no correlation between winter-hardiness and yield. In 1929 correlation dropped down to practically nothing. The later maturing varieties have a greater capacity for yield. Under abnormal conditions the early maturing varieties escape drought.

A Study of The Relationship of Some Morphological Characters To Strength of Straw and Lodging in Winter Wheat

I. M. Atkins

A study has been made of the relationship of strength of straw to lodging of winter wheat in the field. In connection with this study a number of plant characters have been measured to determine their influence or association with strength of straw or lodging. In making determinations of strength of straw, a machine devised by Dr. S. C. Salmon, and described in the Journal of Agricultural Research Vol. 43, No. 1, July 1931, has been used.

The work conducted in 1931 consisted only of strength of straw determinations on 18 varieties of winter wheat. In 1932 a preliminary study of morphological characters in relation to breaking strength and lodging was made on 65 varieties of hard and soft winter wheat. Measurements and notes taken included strength of straw determinations on the lower internode of the plant, length of internode used, diameter of internode or culm, height of plant, date of maturity, and field notes on lodging. Correlation coefficients were calculated for each pair of characters studied. Highly significant correlations were found between strength of straw and diameter of culm, height of plant and diameter of culm, and breaking strength and height of plant. Smaller, although stastically significant correlations were obtained between height of plant and date of maturity, breaking strength of straw and length of lower internode, height and date of maturity, and between lodging and date of maturity. A small negative correlation was obtained between strength of straw and lodging.

Detailed and extensive studies of morphological characters in relation to strength of straw and lodging were made in 1933 and 1934. Forty-four varieties were used in 1933 and 129 varieties in 1934. Notes and measurements taken included strength of straw, diameter of culm, length of internode, weight of culms, weight of a section of culm near the base of the plant, weight of heads, and weight of grain, height of plant, date of maturity, and lodging in the field.

Results obtained in 1933 and 1934 were in close agreement showing breaking strength to be closely correlated with diameter of culm, weight of culm, weight of a section of culm or density of culm, weight of heads, weight of grain, and correlated to a lesser extent with height of plant and length of lower internode. No correlation was found between strength of straw and lodging. A negative correlation was obtained between strength of straw and date of maturity. The extremely high correlation between breaking strength and density of culm as shown by the figures .956 ± .009 in 1933 and .960 ± .005 in 1934 indicate that this character is equally as good a measure of strength of straw as the machine determination.

Lodging was found to be negatively correlated with date of maturity in 1933 and positively correlated in 1934. Neither correlation was very high so it is not known for sure what the effect of date of maturity is. Lodging was found to be correlated with height of plant and weight of grain. Date of maturity was found to be negatively correlated with weight of heads, grain, and weight of straw.

Interannual correlations of breaking strenght were calculated for each pair of years results and showed high agreement in every instance.

The relationship of breaking strength of straw to field lodging was studied not only from results at Denton but from lodging notes taken at other experiment stations. Lodging notes for a single season failed to correlate with breaking strength results. When lodging notes from a number of stations were combined or lodging notes for a period of years averaged, a high correlation was found between lodging and strength of straw in every instance

A study of the influence of stand on breaking strength of straw was made in 1933 and 1934. The importance of stand and tillering in a study of this kind was emphasized by results obtained. The weak strawed Kanred variety was increased from 2.81 pounds reading when planted thick, to 4.65 pounds reading when planted very thin.

A study of the influence of fertilizer on strength of straw and resistance to lodging has failed to show any simple method of improving the standing powor of a variety. Fertilizers high in nitrogen caused excessive plant growth resulting in increased shading, lengthening of the internodes, increased height of plant, increased tillering and severe lodging.

A study is in progress to determine if possible the inheritance of strength of straw between a short weak strawed variety and a tall strong strawed variety. Breeding material is now in the second generation. It is hoped that a strain can be secured having standing power combined with ability to stool and yield well.

Discussion

Q. I am not quite sure of what you mean by "density"?

A. It is a section of the stem of which the air dry weight was taken.

Q. What variety are you using for your stiff strawed parent.

A. Clarkan.

Q. Is there correlation between length of straw and lodging?

A. Yes, there seems to be. In general it is easier to select short strawed wheats which are strong than long strawed ones.

Genetic Studies With Winter Wheat

K. S. Quisenberry

Much of the genetic work with winter wheat has been secondary to improvement work. Crosses have been made for the improvement of a variety and data have been taken on the segregation of various characters. While this work has been useful, more carefully planned work is needed to establish linkage groups of factors for stable characters in wheat and to use these groups as markers in studies of other less stable but important characters. Some of the genetic work being done on winter wheat is as follows:

Rust reaction is being worked on in Texas and Kansas.

Shattering is being studied at Denton, Texas. The preliminary work has established differences between varieties and genetic work is now under way.

Strength of straw in relation to lodging is being studied at Denton, Texas. A survey of the varieties in the classification nursery has established differences between varieties, and the inheritance of these differences is being investigated.

Some work is being done on awn inheritance at various places, although this question is fairly well worked out for many varieties, and most awn types.

Time of maturity is being studied in several crosses at Woodward, Oklahoma.

Winter-hardiness studies are being carried on at St. Paul, Minn., and Moccasin, Montana.

The relation between earliness and hardiness and their reaction under different invironments is the object of studies being conducted at Woodward, Okla., Akron, Colo., and Moccasin, Montana.

Inheritance work with resistance to bunt is under way at Manhattan, Kans., Woodward, Okla., Akron, Colo., Moccasin, Mont., and possibly

other places. Back-crossing, using Martin as the resistant parent is being studied at several stations.

Some varieties cross with rye more easily than do others. The inheritance of this crossability is being worked on, as well as a survey of the crossability of various wheat varieties. The development of good varieties having crossability is highly desirable and should aid in transferring the winter-hardiness of rye of wheat.

Discussion

Since there were no questions on this paper it was suggested that northern men give a brief accounting of their programs.

AUSEMUS: In Minnesota, the breeding program is primarily concerned with hardiness and quality. Minhardi or Minturki have been crossed with Marquis. The progeny yield less than Minturki but quality has been improved. There is considerable interest in Minturki as a feed grain.

Leaf rust is more important than stem rust in our winter wheats. We are back-crossing with Hope.

Our station is concerned over the question of whether a soft wheat might not be better than a hard wheat in southern Minnesota.

KLAGES: In South Dakota the winter wheat acreage rises and falls depending on recent experience with winter-killing. Most hardy parents such as Buffum No. 17, Odessa, and Minhardi are being used in crossing.

SUTHERLAND: From 50 to 100 bulk hybrids are grown each year at Moccasin. About 200 selections are made each year in F_5, F_6 or F_7, on the basis of previous bunt and winter-killing records.

Shattering In Winter Wheat

P. B. Dunkle

A review of literature on shattering in wheat shows that the problem is one of considerable importance to the wheat grower, but one on which very little accurate research work has been done. The selection of a variety resistant to shattering is of first importance to the grower in regions where wind and rain storms are likely to occur during the maturing and ripening period, or where use of the combine necessitates delay in harvesting until the grain is thoroughly ripened. In such regions varieties highly resistant to shattering are a necessity and the breeding of such varieties should become an important project. The whole tendency in wheat breeding programs has been to develop more accurate methods of technique in order to have a better foundation upon which to base conclusions. Exact laboratory methods have been developed for studying such problems as baking quality, reaction to rusts, strength of stem, and many others. In fact, shattering in wheat is a-

bout the only major problem for which a laboratory method of study has not previously been developed.

Varieties of wheat cannot be accurately rated for their resistance or susceptibility to shattering upon field observations alone. The principal reason for this is that shattering does not occur uniformly every year in every variety. In seasons when there is little agitation of the ripened standing grain by wind, only the most susceptible varieties will show any shattering, while in seasons when severe winds occur, or when growth and weather conditions are conducive to shattering, the more susceptible sorts cannot be accurately rated. It becomes necessary, therefore, that some method be devised for producing shattering under controlled conditions in the laboratory.

A mechanical device that will shatter individual heads of wheat in a manner similar to that which occurs normally in the field has been developed by the writer and found to bring to light small differences between varieties. This machine is comparatively simple in construction and can be easily and cheaply made in any ordinary machine shop. It is reasonably accurate as shown by fairly high correlations between different seasons. A picture of the machine and blue prints for construction will be gladly furnished to anyone interested.

Having developed a machine for producing shattering in the laboratory, the writer has been able to proceed in a study of the relation of shattering to certain characters in wheat. Of the thirteen head and grain characters studied in their relation to shattering only three were found to be significantly correlated. Awn length and number of grains per head were found to be negatively correlated and width of grain positively correlated with shattering.

The correlation coefficients for these three characters with shattering were, -.61, -.37, +.27 respectively. Coefficients of determination show that the length of awn is responsible for slightly more than half of the variation accounted for by the variables studied. Next in importance are number of grains per head and width of grain, each accounting for about the same amount of variation, and when added to the effect produced by length of awn, 88.7 percent of the total variation is accounted for. The remaining variables have a very small direct effect and, therefore, are of very minor importance in accounting for variation in shattering in winter wheat.

A separate study of the relation of awn length to shattering has been made in order to emphasize the possible utility of this character in selecting for varieties resistant to shattering. By statistical analysis of the data collected for fifty-two varieties of wheat grown at Denton, Texas in 1932 and 1933, awn length was found to be the most important independent variable in its effect on shattering and was practically independent of the other variables studied.

The fact that the correlation was negative, as the length of awn increased the amount of shattering decreased, is in contradiction

to the results reported by Lewicki, S., in Poland (Abs. Exp. Sta. Record 61:226) and Clark, J. A., Florell, V. H., and Hooker, J. R. at Davis, California, who found that awned varieties shattered more than awnless varieties. This difference in results may be due to the more compact heads of the awnless varieties usually grown in California and failure to differeniate between shattering due to spreading of the glumes and loose insertion of the seed and that due to brittle rachis and weak attachment of the spikelets and glumes. In this study, made at Denton, Texas, It is very obvious that brittle rachis should be considered entirely separate and distinct from loose insertion of the seed in the glumes as a cause of shattering.

Of the several crosses made in 1932 and 1933, the cross Fulcaster x Blackhull has been selected as the one most likely to produce normally at Denton and give the greatest range of differences in F_2. Data for the parents and the F_1 plants grown in 1934 have been collected, but the means of the determinations and other statistical data have not been worked out and no definite report can be made at this time. However, shattering F_1 appears to be intermediate between that of the parents. The only F_2 data collected so far are for a cross between Clark 40 and Fulcaster. In this cross the amount of shattering appears to decrease as the length of awns increase and to be highest in the awnless and tip awned classes.

Plantings made of the parents and crosses in this study in the fall of 1934 were completely killed by a severe freeze on January 21, 1935, and as consequence data on the F_2 and F_3 generations cannot be obtained until after harvest in 1936.

Discussion

Q. I am wondering if you studied the influence of environment on shattering.

A. There was a .6 correlation between 1932 and 1933. Varieties have a considerable tendency to react in the same way in different years.

Q. There are several different kinds of shattering?

A. Yes. There may be brittle rachis or brittle glumes. In the latter the lemma goes first. Shattering may occur before the ripening period.

Q. What type of season as to moisture is responsible for most shattering?

A. That is something that we will have to find out more about. There is apparently normal development one year while in other years there is considerable shattering.

Q. Have you had experience with both kinds of wheat?

A. We find in spring wheats that there is a relation between plumpness and ability to thresh out.

Q. What is your opinion of the value of letting wheats stand some time after harvest to see if they shatter or not?

A. We have tried that and still have not been able to get good records on differential shattering.

The Regional Program

K. S. Quisenberry

The regional program consists of various uniform trials which are conducted throughout the hard red winter wheat region. These trials include uniform plot tests, uniform yield nursery, winter-hardiness nursery, and various disease nurseries. The object of all these tests is to obtain as much information as possible on all available material. The range of adaptation, disease and insect resistance, yielding ability, quality and other information is obtained. In addition, studies are being made to determine the effect of various characters on yield. Annual summaries giving a complete report of this work are presented each year. Some of the more outstanding results in the various agronomic tests will be summarized briefly.

Winter-Hardiness Nursery

This nursery has been conducted since 1919, and each year hardiness data are obtained on 30 varieties of winter wheat from 20 to 30 stations in the northern United States and in Canada. The outstanding variety for hardiness in the nursery at present is Lutescens, a variety which has been in the nursery for two years. Seven winter-hardy hybrids are now available which are as hardy as, or more hardy than Minhardi. Most of the winter x spring hybrid wheats from Kansas are rather tender in comparison to the more hardy material.

Considerable yield data are obtained each year on these nurseries and they show that wheats such as Cheyenne, Kanred, Minturki, and Nebraska No. 60 yield fairly well in both the southern and the northern group of stations. In the south, such wheats as Blackhull, Tenmarq, Quivira, and Kawvale yield well but are low in the north. Also, late, hardy wheats such as Yogo, Turkey C.I. 6152, Minhardi, and Lutescens yield fairly well in the north but are very poor in the south.

Uniform Plot Tests

Uniform plot tests have been conducted at all cooperating stations from Texas to Montana since the fall of 1930. Approximately 20 stations are cooperating in this work. Three varieties, Kharkof, Nebraska No. 60, and Kanred were grown uniformly at all stations for the first 3 years. In 1933, Turkey sel. C.I. 10016 replaced Kanred. In addition to these varieties, other varieties are grown uniformly in each of the three districts; southern, central, and northern. At each station varieties of local interest are also included. Each year data from approximately 100 varieties are assembled and averaged and studied.

In the southern district, based on a 25 station year average, Tenmarq is the most outstanding for yield, being followed by Quivira, Blackhull, and Kharkof. Fulcaster and Harvest Queen are very low in yield. Late spring freezes injured the early wheats in two of the four

years the tests have been under way. In the Texas Panhandle, Quivira is inclined to shatter badly. Nebraska No. 28 was discarded because of low yield, due in part to shattering. Early Blackhull is now included in plot tests as the early wheat. It is the earliest wheat being grown in the plot tests.

In the central district, Cheyenne has the best yield record for the 4-year period. This variety is rather outstanding from the agronomic standpoint but seems to be a bit lacking in quality. Probably the next best yielder in this district, as a whole, is Blackhull. The lowest yielding variety is Minturki. Due to a series of years having mild winter, a number of winter x spring hybrid wheats are making very good yield records at some stations in this district. In the northern part of the district, Quivira does not make good yields.

The data from the northern district are not as complete as is desired, due to the severe climate and the lack of funds which caused the reduction of experimental work. Based on a 4-year average, Yogo has the highest yield with Nebraska No. 60 second. The two lowest yielding varieties are Minturki and Newturk. From these data it would seem that Minturki is adapted to southern Minnesota, but does well in any other area. In this area, the winter-hardiness of a variety is very important.

Uniform Yield Nursery

A uniform yield nursery has been conducted at some stations in the southern and central districts for three years. One object of this nursery is to get preliminary information on new varieties before they are entered in the general plot tests. The nursery is limited to 30 varieties and data have been obtained from 8 to 10 stations each year. Twenty-one varieties have been grown for the three-year period, although 5 of these have since been discarded.

Based on the 3-year averages, several of the newer winter x spring hybrids have the best yield records. Two Kanred x Hard Federation strains, making good records in the nursery, have now been entered in plot tests in the southern district, and in Kansas.

Agronomic data are taken on the nursery each year and much information is available on the influence of various characters on yield, since a rather wide range of material has been included in the nursery.

Correlations have been calculated between the yields of the varieties in the different nurseries for the various years. The most consistant correlations obtained were between Woodward, Okla., and Alliance, Nebraska. Various other station results were correlated for one to two years. Of special interest was a negative correlation found between yields at Woodward, Okla., and Hays, Kansas.

It would seem that this nursery is well worth continuing since the information being obtained is not only interesting but also valuable, and a thorough test in this nursery may present a poor variety.

PHYTOPATHOLOGY AND PESTS OF WINTER WHEATS

Dr. G. L. Peltier, Chairman

PELTIER: This morning we shall cover three groups of wheat diseases,--the rusts, smuts, and foot rots including root rots. We will first hear from Mr. Johnston on "The Rusts of Winter Wheats."

The Rusts of Wheat

C. O. Johnston

Stem rust and leaf rust continue to be the only important rusts of wheat in the hard red winter wheat-growing area. Stripe rust has not advanced into the plains and the high temperatures and low humidities make it seem unlikely that it will ever do so. No major epidemic of stem rust has occurred in this area during the past 12 years, although it continues to be important in central and north-central Texas. Leaf rust has caused severe losses during 6 years of the same period. The average annual loss caused by leaf rust is about 3 times that caused by stem rust.

Both leaf and stem rust overwinter in great abundance in central Texas and leaf rust usually overwinters in abundance in northern Texas. From these foci, inoculum is carried northward and infections gradually advance from south to north as environmental conditions become favorable. Wheats with high resistance to both leaf and stem rust, and adapted to northern Texas not only would give that state a more stable annual yield but would be of definite advantage to states farther north. The amount of overwintering would be reduced and a reduction in the total amount of inoculum would decrease the rust hazards to the northward.

Although many physiologic forms of both rusts have been isolated from collections made in the area, only a few forms of each rust appear to occur in abundance year after year. Forms 18 and 36 of stem rust and forms 9 and 19 of leaf rust seem to be the dominant forms year after year. This increases the probabilities of success in breeding rust resistant wheats for the hard red winter wheat area. The problem is still further simplified by the fact that resistance to several forms frequently is determined by the same genetic factor, and by the fact that many of the physiologic forms are indistinguishable as far as most commercial wheats are concerned.

Many leaf-rust resistant hybrids from crosses between varieties of common bread wheats are now available for study. Interspecific crosses have been avoided because of sterility and possible linkage. Promising resistance to leaf rust has been found in Kawvale, Malakof C.I. 4898, Hussar, Quivira, and selections of Kanred x Hard Federation, Fultz

C.I. 5308, Mediterranean C.I. 3332, Fulcaster Ks. 317, and the type of Mediterranean wheat grown in northern Texas. Certain hard red spring varieties and many soft white springs from Australia also have shown much leaf rust resistance.

Greenhouse experiments have shown that heavy leaf rust infection on a susceptible variety reduces plant height and the yield of grain, straw, and roots, and results in an increase in the water requirement, and the time required to head and to mature. The amount of increase or decrease is proportional to the length of the infection period.

Wheat Disease Garden

C. O. Johnston

A wheat disease garden has been grown at Manhattan, Kansas, for the past 5 years, as a part of the hard red winter wheat improvement program. The nursery consists of 50 varieties and hybrids grown in duplicate 8-foot rows. One series is maintained for studies on seed-borne diseases such as bunt and loose smut, while the other is reserved for diseases parasitic on the leaves, such as the rusts, mildew and leaf blotch.

Owing to a shortage of funds and time no artificial inoculations have been made except with bunt. The seed in the smut series has been inoculated with composite inoculum of all of the bunt collections made in Kansas. In this composite at least 3 sharply contrasted physiologic forms have been present each year. Although no artificial inoculations with loose smut have been attempted, there is an urgent need for such work, owing to the apparent increase in that disease in this area, especially in Texas.

Notes have been taken on the two rusts, mildew, and speckled leaf blotch (Septoria tritici) when they occurred naturally in the nursery. Very satisfactory data have been obtained each year except for 1934 when drought eliminated most plant diseases.

Arrangements for having new wheats included in the disease garden should be made with Dr. K. S. Quisenberry. The data obtained in this nursery are given on the last page of Dr. Quisenberry's annual mimeographed report.

Discussion

PELTIER: Physiological specialization is an artificial classification and not an actual one. Forms which come in from the south go back south for the winter just like robins. The center of overwintering is in the southern district but the spores do not blow all the way up but go in stages northward as the wheat matures. The south Texas situation is a very important one for the winter wheat belt.

Q. At what stage of development is the plant most susceptible?

A. I have not found infection earlier than in the boot stage.

Q. That is true under Nebraska conditions. Does it prevail in the south?

A. Yes.

Q. How do you account for so many different forms and what is the role of barberries?

A. Eradication of barberries is more important in reducing the number of physiological forms than in cutting down stem rust.

Q. Does leaf rust overwinter at Manhattan?

A. Our overwintered leaf rust is not an important factor for spring freezes cut it down.

Q. Point out briefly the significance to the plant breeder and the farmer the difference between seedling reaction and mature plant reaction.

A. In studying resistance we often get a peculiar situation. In the seedling stage you may have resistance recessive. If you grow the same plants to maturity they may have rust. Many varieties are susceptible in the seedling stage but as they grow older they get more resistant. We do have varieties resistant to a number of physiological forms. Kanred is resistant to 11 forms.

Results From Uniform Bunt Nurseries

H. A. Rodenhiser

Two phases of the covered smut of wheat problem are being studied in connection with the general wheat improvement program, namely, a study of the varietal resistance of wheats to bunt and the virulence and distribution of pathogenically distinct strains of the bunt organism.

To determine the varietal resistance of wheats to bunt a series of so-called uniform smut nurseries have been maintained in each of the general wheat regions. Ten of these nurseries are distributed throughout the hard red winter wheat area and one is planted at Kearneysville, W. Va., thus insuring data on the varietal reactions to bunt under a wide range of environmental conditions. In these nurseries are tested the wheats grown in the uniform plot tests, the uniform yield tests, and in addition newer hybrid strains which have shown indication of smut resistance at the station where they were developed. The results obtained in these tests are promising in that a number of lines have developed on the average less than 1 percent of smut as compared with 45.2 percent in the susceptible check, Kharkof, C.I. 1442. The smut resistant wheats include three Beloglina x Hussar lines, two Martin x Blackhull x Blackhull selections, several Nebraska Turkey selections and the new variety Yogo which for the past three years has had an average of 1.3 percent of smut.

The question arises as to whether the inoculum used in these nursery tests is representative of the pathogenic strains present in

the areas for which these wheats are adapted. To answer this question pathogenicity tests with the inoculum from each station were made on the ten physiologic form host testers commonly used for physiologic form identification. The results indicated that only two of the ten known pathogenically distinct strains of Tilletia levis were present in the uniform smut nursery trials. One of these was present in the inoculum at all the stations and is the least virulent of the known forms; the other, a virulent strain and quite widely distributed, was identified in the inoculum from the nursery at Lincoln, Nebraska, and Denton, Texas. Obviously our wheat variety tests are not complete until those lines found resistant in the uniform bunt nursery are further tested to all of the known pathogenically distinct strains. We now have identified 10 of Tilletia levis and 13 of T. tritici. These tests are being started this fall in cooperation with the experiment stations at Bozeman, Mont., and Pullman, Washington. No one pathogenically distinct strain of Tilletia levis or tritici has yet been identified which is virulent on all of the host testers. By combining the factors for resistance it should be possible to breed varieties of wheat which are resistant to bunt as well as having other desirable agronomic characteristics.

Discussion

Q. In connection with the soil origin chart would you think that the biological condition of the soil might be a factor?

A. It is possible that the presence or absence of certain soil organisms may affect the amount of bunt infection obtained. Considerable difference was noted in the amount of mycelial growth in soils from St. Paul and Logan, Utah. This was particularly true in incubation tests at higher temperatures.

Q. What about soil moisture?

A. All soils were held at 20 percent moisture content.

Q. What is the difference in texture of the two soils?

A. The Logan soil is classed as a silty loam as compared with the somewhat heavier loam soil from St. Paul.

Q. Does the percent infection mean a corresponding reduction in yield?

A. No. In one experiment I recall that 1 percent infection amounted to .3 percent reduction in yield.

Q. In your studies of these various numbered forms, can you give us a general statement of your present view of the significant number of forms of the two species?

A. At the present time we have identified 10 pathogenically distinct forms of Tilletia levis and 13 T. tritici. These have been found fairly well distributed in the Palouse area of the West, the western half of the Hard Red Spring wheat region and south in the Hard Red Winter wheat area. I feel quite sure that with an additional number of host testers and smut collections a greater number of distinct strains could be identified.

Q. Do you have any variety of wheat resistant to all of the known bunt forms?

A. Of the varieties so far tested none have proven resistant to

all forms. Some of the varieties are very highly resistant and some immune to certain forms while completely susceptible to others.

Q. How do you account for the presence of new forms in areas where the wheat has previously shown resistance to bunt?

A. It has been definitely proven that new forms of the rust fungi may develop as a result of hybridization and mutation. It seems probably that the same may be true with the bunt organism. In addition new forms may appear in areas as a result of interchanging of smutty seed and as a result of infection from wind-blown spores. Bunt is accumulative - one percent in a field one year may mean several percent the following year. I would emphasize the need for seed treatment even in apparently smut-resistant varieties.

Q. In inoculating winter wheat material in order to get local forms sometimes we have to get the smut from the spring wheats. I wonder if we get the same results?

A. The majority of our spring wheat smut collections although virulent on spring wheat host testers have proven to be among our least virulent strains on the winter wheat host testers.

The Wheat Foot-Rots

Hurley Fellows

Foot-rot is an inclusive name including any disease attacking the cereal from just above the soil line and on down, no matter whether one or all parts are attacked. The name, root-rot, refers to one particular phase of foot-rot.

The major foot-rots and their distribution are as follows:

1. Take-all caused by Ophiobolus graminis. Found in central Kansas and Oklahoma, New York, Oregon, Washington, California, Tennessee, Maryland, Illinois, Indiana, North Carolina, and Arkansas.

2. Dry land foot-rot. Found from the Panhandle of Texas north to the northern border of Montana and other places with similar climate. The cause is not certain but believed to be Helminthosporium and Fusarium.

3. The Fusarium-Helminthosporium group. This is the type of foot-rot in having a seedling blight state. This has no common name.

4. Columbia Basin foot-rot. Found in Eastern Oregon and Washington and northern Idaho. It is caused by Cercosporella herpotrichoides.

5. Browning foot-rot. A foot-rot found in Northern Alberta. It is caused by Lagena radicicola.

6. Several minor foot-rots are caused by species from 12 genera of fungi.

7. Crinkle joint. This symptom may sometimes be caused by more than one foot-rot. It is an indirect symptom.

The symptoms of take-all in its advanced stages are characterized chiefly by distinct, stunted spots in the field and the black discoloration of the lesions. White heads may or may not be present.

The dry land foot-rot is detected at heading time either by the death of individual culms in a stool or by an exaggerated droughty appearance. The crown of diseased plants will be discolored.

The cause of dry land foot-rot is not definitely known, but Fusarium and Helminthosporium have been isolated from diseased plants. It is controlled satisfactorily by a retarded date of planting.

Experimental work with take-all has been along the lines of resistant varieties, soil amendments, the environmental factors effecting its virulence, soil management, its distribution or spread, and the physiology of the organism causing it. No variety of wheat or any near relative of wheat has been found with sufficient resistance. The application of phosphorous has been of some help in control. The barnyard manures have also been helpful in control. However, rotation with non susceptible crops is the best preventive. Drastic treatment to infest soil does not diminish the retention of the disease. The most obvious means of spread is by diseased plant debris. Infection occurs definitely during the fall season.

Ophiobolus graminis, the causal organism of take-all, can utilize but very few nitrogen compounds as food. However, the presence of other organisms help it in utilizing many others.

Discussion

Q. What two organisms in the dryland foot-rot do you consider more frequent, Fusarium or Helminthosporium?

A. Fusarium.

KEZER: We get more Helminthosporium in our isolations.

Q. Have any varieties resistant to take-all been found?

A. I will have to report failure to find varieties resistant to take-all. Since there are 140,000 organisms in the soil you can see that take-all has lots of neighbors. Some of these organisms probably help to make conditions which are favorable to take-all.

Resistance of Wheat to Hessian Fly

Reginald H. Painter

The Hessian fly, a destructive pest of wheat, was apparently introduced into the United States about the time of the American Revolution. As early as 1785 resistant varieties of wheat were mentioned. Since that time there are many casual references and some experimental

data given in publications.

For nearly twenty years the entomologists and agronomists cooperating at Kansas State College have been studying this subject. Much of this work is summarized in Kansas Technical Bulletin 27.

The eggs of the Hessian fly are laid on the leaves of the wheat plant, the young larvae migrate down the leaf and go as far as they can down between the leaf sheaths to a point where it joins the stem. Here the larvae develop, pupate within the "flaxseed" (puparia) and later emerge as adults. From two to five generations occur each year in various parts of its range, and up to nearly 500 eggs for a single female have been recorded. As high as 88 flaxseed have been taken from a single tiller in the field.

Most of the experiments have been conducted at Manhattan and involve fly from the hard wheat belt. These have shown that varieties do differ greatly in their susceptibility to the Hessian fly. Some varieties which have been resistant to the fly from the hard wheat belt have been Dawson, Honor, Fulhard, various Illini Chief selections, Kawvale, Michigan Wonder (Red May), Red Rock, Shepherd, etc. Varieties which have usually had medium infestations have been the Blackhulls, Harvest Queen, Imperial Amber, Poole, Red Winter, etc. Susceptible varieties were Turkey, Kanred, Minturki, Oro, Cheyenne, Kanred x Hard Federation, Quivira, Tenmarq, etc. Some strains of varieties which appear pure in agronomic characters have been found to differ in their susceptibility to Hessian fly.

In the fall the infestation of plants frequently results in a lowered resistance to winter-killing, or sometimes the death of the plants is caused by fly. On several occasions this type of injury has occurred on cooperative wheat variety tests and produced a marked contrast between variety plots. Rows of the different susceptible varieties also differ in their ability to recover from an infestation. This recovery factor is difficult to measure and so far has been very little studied.

In the spring, infestation prevents the culms from heading, reduces the amount and quality of grain, or causes the culms to break over at the point of infestation. On a few occasions this spring infestation has resulted in visable differences between varieties.

Several factors are of importance in the resistance of wheat to Hessian fly. A variation in the ability of varieties to recover after infestation has been mentioned. Stiffness of straw also is of importance in preventing the lodging following the spring infestation. The particular kind of resistance which has been studied most was of the "all or none" character. If a larva reached the base of the culm and was unable to commence feeding it died. If it was able to feed at all, development was normal. This type of resistance is carried by Illini Chief and other varieties.

In the Blackhulls and other varieties there is a type of resistance in which the tiller or culm develops fairly normally in spite of the presence of the fly. In the fall a wrinkling of the leaf is the chief evidence of the presence of the fly. In the spring the implantation of the flaxseed takes place between the nodes rather than at the node. In addition the internodes are not shortened as they are under the usual fly injury. We have spoken of this type of resistance as "tolerance". It appears to be more easily influenced by environmental conditions than is the other type. Some varieties such as Kawvale appear to possess both types of resistance.

Studies on a large number of crosses have given abundant evidence that under comparable conditions, resistance to Hessian fly is inherited. The exact number and character of the genes involved has not been determined. It is known, however, from crude ratios which have been worked out, as well as from circumstantial evidence, that among the resistant wheats there are at least three and probably five or more genetic factors involved. The evidence has come from the fact that hybrids may differ in their spring and fall susceptibility and that a number of different crosses between various resistant varieties have given susceptible, in addition to resistant segregates. The types of resistance discussed above are undoubtedly governed by different genetic factors, some of which are difficult to study.

Hybrids have mainly been studied in relation to the fall infestation by staking the infested plants. It has been shown that hybrids similar to either parent as to fly reaction may be selected from a cross. Hessian fly resistance does not appear to be associated with any of the commonly observed agronomic characters, such as grain quality, winter hardiness, awns, and others.

The results reported so far refer to infestations, by the fly from the hard wheat belt. In the soft wheat belt of eastern Kansas and many of the states further east, varieties listed above as resistant are susceptible, or at least only moderately resistant. This difference in the resistance to the two populations of fly is retained under infestations in cages placed side by side in the greenhouse. On the basis of this and other data it is believed that the population of fly in the two areas is made up of varying proportions of groups of flies able to infest different varieties. In other words there appear to be two or more biological strains of fly which are mixed in different areas in varying proportions. Kawvale and Blackhull appear to have some resistance to both populations of fly.

The interspecific hybrid variety Marquillo is the only common or bread wheat type which has so far been found to exhibit any considerable degree of resistance to populations of fly in both wheat belts of Kansas. In hybrids involving crosses between Marquillo and the winter wheat varieties Tenmarq, Minturki, Oro, Kawvale and (Kanred x Hard Federation) it has been found that resistance is inherited independently of the spring habit of growth. It is hoped to fix this Marquillo type of resistance in winter segregates from these crosses.

In limited studies of species of Triticum it has been found that those with lower chromosome numbers in general are less susceptible to Hessian fly infestations than those with higher numbers. Among the durum wheats and among the emmers some varieties are resistant, others are susceptable and some susceptible varieties contain strains that are resistant.

Breeding for resistance to Hessian fly in wheat is a longtime, complicated problem but considerable progress has already been made. It is our aim to produce varieties that are as good or better than varieties now grown, in other respects, and are at the same time fly resistant.

Discussion of Dr. Painter's paper was deferred until afternoon and the conference was adjourned at 12:05 P.M. until 1:30 P.M.

From 12:40 to 1:20 P.M. the visitors were shown the hardening and freezing equipment in the Plant Pathology greenhouses, and were given an opportunity to observe and discuss freezing experiments with both wheat and alfalfa.

FUTURE PLANS

Dr. P. C. Mangelsdorf, Chairman

MANGELSDORF: This section on "Future Plans" does not lend itself very well to presentation of formal papers. I get just about as much good out of informal discussion which might be called a round table or committee of the whole. There are several questions to discuss:

Question 1: Shall the present general set-up and plan for uniform trials be continued?

KIESSELBACH: I believe we would be in favor of continuing the present set-up of uniform nurseries and field plat tests the same as we have been. I would consider new entries perhaps in the way of varieties. I believe personally I would be in favor of more replication of nursery tests. I notice that importance is attached to the individual line-up of yields of various stations. It seems we are not simply averaging a region to get data but are working out correlations of varieties between stations. I believe no yield test with less than five replications justifies the confidence that should be put into such a test. It is not very expensive as we already have the overhead and I'd say here in Nebraska if we're going to stress the individual station yields as being pretty important, we would like to have five replications. In most cases there are three.

Question 2: Are mimeographed reports worth while, or could they be dropped?

MANGELSDORF: If Dr. Quisonberry is willing to do his part I see no reason why they should not be continued.

QUISENBERRY: The reason that question was asked was to find out whether the reports are worth while. We are willing to summarize the data, and if the reports are used and are not just another piece of mail they will be continued. We are glad of suggestions as to form.

PARKER: As a worker in Kansas we regard them as of great value. They help in annual meetings where we consider branch station work, and the bringing together of previous years' work is a valuable feature of them. I would like to see them continued.

Question 3: Having all agreed that these reports are essential the next question is about what varieties should be considered in uniform trials?

QUISENBERRY: In the southern district Harvest Queen and Fulcaster have a very poor record. If we have material available what would you think of dropping after this year, Harvest Queen and Fulcaster, as uniform varieties? The same question comes up regarding Nebraska No. 60 but this variety is common to all stations. For that reason I would ask to keep Nebraska No. 60.

In the central district if agreeable to others I would be willing to see Minturki and possibly Quivira dropped after this harvest. I have the impression that the Nebraska station is a little north of the Quivira territory.

The northern district is ripe for some changes, possibly the elimination of Newturk, Minturki, and C.I. 8034. I believe the list has been reduced at some stations so that we only had five varieties common to all stations in 1934, I wish it would be possible if we could decide on possibly five for all stations in the region.

MANGELSDORF: The question of whether or not these varieties should be changed and how freely they could be changed is a good topic for discussion.

ATKINS: I would personally agree with Quisenberry. No Harvest Queen is grown in our area. While there is some Fulcaster, at the Denton station we know it is not as good as Denton and several other varieties. It rusts very badly so we would be willing to substitute some better material.

CROSS: We have a pretty good record on them at our station but whatever suits the will of the group suits us. We are very willing to discontinue them as uniform varieties throughout the region.

LAUDE: I would not want to comment now regarding specific variety changes but just in general it would seem to me we should keep in mind the regional viewpoint and if there is a possibility of learning more about wheat just by having a certain variety in, it might be worth while to keep it even though that particular variety doesn't have such importance. Keep it from the standpoint of learning about this particular plant.

MANGLESDORF: Plant breeding resolves itself into the matter of developing varieties more and more highly restricted for various regions. Uniform trials have greater value for finding out the characteristics of wheats rather than yields.

SUNESON: I rather agree with Professor Laude in the desirability of ecologic continuity. Dr. Kiesselbach and I stand for elimination of Minturki on the ground that while it has a fairly good record at Lincoln it has no place farther west. We now know the variety fairly well. In place of Minturki we would like to see substituted some wheat which is winterhardy. The reason for that is that we have stations at North Platte, Alliance, and Valentine where winterhardiness is a definite factor. With reference to Quivira I might say we have no hope for it commercially anywhere in the state of Nebraska. If Quivira is moved out and a Hard Federation hybrid put in we will ultimately have to give an even worse report. Early Blackhull is of more interest to us.

PARKER: I do not believe that Quivira belongs in Nebraska.

CLAPP: I just made the remark to Throckmorton that Blackhull gets along better in northern Kansas. Early Blackhull would be good to keep in.

ROBERTSON: If Kansas decides to drop Quivira we ought to drop it.

PARKER: Keeping it one more year will help us to know what we want to decide.

KIESSELBACH: I am sure in that case Nebraska will be glad to retain it.

A. F. SWANSON: I am perfectly willing to take southern and northern material if it will help their men to interpret results.

SALMON: Is it not true that Quivira was the highest yielder

this past year in the central district?

QUISENBERRY: It was in this year but in a four-year test it has been low.

MANGELSDORF: What about the northern district?

WILSON: We would be glad to cooperate. In dropping Minturki we would be dropping the only commercial variety of winter wheat we have. Until we get something better we are using it as a measuring stick. I think we would prefer, from the viewpoint of our own station, to continue Minturki until we can get something better to put in place of it.

AUSEMUS: I think that is our viewpoint. We would want to keep it in Minnesota. In putting up a new variety the question of seed would have to be considered.

KLAGES: As far as South Dakota is concerned we have great difficulty in recommending something better than Minturki at this time. I have discontinued the variety test plots until we have some of our own material coming on in the nursery. In this northern section I would like to see Minturki left in for the time being.

L. P. REITZ: There is one station where we would be particularly interested from the commercial standpoint and that is the Moccasin station. At the Havre station winter-killing is frequently quite severe and yields are low. From the Bozeman station when we grow winter wheat under favorable conditions the reports show outstanding yields, frequently going over 75 bushels to the acre. That does not resemble the work of nearby agricultural regions. We are very much interested in Yogo. We have no special objection in carrying Minturki a little longer but are not interested in it from the commercial standpoint. I would not recommend it for our own state.

Question 4: Shall we continue the yield nursery about as it is for another five-year period?

PARKER: Referring first to Dr. Kiesselbach's recommendations, I believe we could stand the work and expense of putting in five plots in that particular nursery because it is important not only to us but to the whole outfit. We now have three plots but could take on the extra two. I wish to second the suggestion that we all try doing that. Regarding this nursery, there are quite a few strains that would not do well in Kansas. We are willing to have a reasonable number of what we regard as very ordinary wheats if it renders regional service. I should like also to second the general remarks that we should try in that nursery to be well up with the parade.

REITZ: I would not know where we would get two more replications.

KIESSELBACH: I think the individual stations must be granted liberty in case they do not have enough soil facilities.

Question 5: Should we use Randomization or the Modified Latin Squares?

Robertson remarked that he has randomization in his nursery.

SALMON: Some have had randomization and have gone back to systematic replications. I do not know that I have any settled convictions one way or another. It seems to me that in a program of this kind we are dealing in most cases with pretty large variations and only when dealing with a small number is it necessary to take account of experimental errors. When we get into randomization of plots there is difficulty which is perhaps not serious but worthy of consideration. With systematic replications things go rather smoothly. You can work out

a plan before going to the field and know where everything is. There is less chance of "boneheads". You may correct for small errors but at the same time are taking a chance of making larger errors which may be more important. Just how important that is I do not know. It seems to me that it may in most cases be said by the individual who is doing the work that when he adopts the random method it will take more time and concentration on his part than the systematic arrangement. If he is depending on freshman help he will be more reluctant to turn over his planting list if using random than systematic. I think I would be. Perhaps a good many of those things ought to be considered. We are sometimes inclined to confuse just what we gain by randomization but it seems to me that we are not increasing the reliability of our experiment as much as we are increasing the reliability of our estimate of error. I doubt if we get a more accurate experiment. It is true in many cases that the correction we make in our error is relatively small. If my memory serves me correctly the improvement in estimation of error by randomization is a pretty small item. The whole theory of randomization depends on the assumption that you have enough replications to take care of chance error. With only three I am sure you would not have enough. If you had 30 varieties replicated 30 times I would not object but do question its importance with only three. I am not inclined to insist on it.

TYSDAL: How about application of variance to the systematic arrangement?

SALMON: It depends on the assumption of adequate replications. If you have competition there is a large error any way you do it.

AUSEMUS: If you once get started at randomization it is not bad at all. We make out planting plans and go ahead and plant just as in a systematic arrangement. I am wondering if the increased labor does not come from assembling of data afterwards.

Question 6: There is the question of having a uniform introduction nursery. There never has been any system in the way we get foreign varieties and the way we test them. I realize that 99 percent of the foreign wheats are not adapted to our territory but realize there should be some systematic way of bringing them in and having more or less uniform notes on them so we will know the characteristics of them.

QUISENBERRY: As you know, all foreign wheats that come in must be grown in a detention nursery for one year before they are sent to you. We try to sort them out and send them where we think they will be best adapted.

PARKER: We have to remember there are genes in foreign wheats which may be good. We have had over a 15 or 18 year period quite a few delays and some losses. Taking a que from Maximov, we should think of it in terms of a genetic warehouse. It is important to have some system better than we have had in the past 18 years. I believe it is reasonable that if we ask the head of the Division he will improve the system and speed it up.

FELLOWS: I would like to have everything that comes in.

QUISENBERRY: If you would write to Mr. Bayles you could get much foreign material already grown in detention. Too often the request

goes to a foreign country and the shipment is intercepted. Possibly the wheat desired is on file in Washington.

SALMON: I wonder if this is not a matter of getting together and finding out what these men want. We rather hesitate to send out a lot of material for testing unless the fellows really want it. I think testing for genes is a rather new development, that is, within the last three or four years.

JOHNSTON: I have used plant inventories in selecting the foreign wheats I wanted. They usually give some sort of description of them. There are several things to consider about these foreign wheats. No one paid much attention to them until they read something about them in literature. Then instead of writing to Washington they wrote to the men who wrote the literature. If you keep an eye on the plant inventories you get a pretty good idea of what is available.

PARKER: Would it be in order to make the definite suggestion that Mr. Bayles send out a list every August to the cooperating men of wheat and other small grains received each year?

The request was formally approved.

Question 7: What about multiple factors in foundation stocks?

MANGELSDORF: Everyone is making a large series of crosses of varieties having stiffness of sten, freedom from shattering, earliness, etc. It is very likely that when they get promising material from these crosses that they will have to be crossed again to get other desirable characteristics. Why can't we get something desirable and keep adding other desirable genes? By crossing with varieties known to be productive we stand a chance of getting something good. We would be doing in a systematic way what we are now doing in a haphazard way.

Dr. Mangelsdorf left to take his train and after a brief intermission the discussion was resumed under the leadership of Dr. Quisenberry.

QUISENBERRY: Would you care to discuss the building up of multiple combination stocks? I have a little private project I am playing with in which I am trying to assemble material containing factors for different morphological characters.

L. P. REITZ: It seems desirable. With us we have a combination breeding program for bunt resistance. There is a very strong possibility that in a few years we will have fixed the character bunt resistance in many types. Rust resistance must be tied in with that. At present we are working with spring wheats with Dr. Ausemus at St. Paul. As far as a coordinated program is concerned, we don't have it but it is a more or less chance proposition.

Q. Would not you, Dr. Quisenberry, be in a very good position in traveling over the area this summer to observe combinations and suggest where each might be valuable?

KEIM: Is it not more difficult to do this thing on wheat than on corn? We know so much more about corn genetics than about wheat.

QUISENBERRY: Dr. Mangelsdorf had in mind trying to combine in wheat high resistance to bunt, stem rust, etc., in fact have all the desirable characteristics in one wheat, rather than the development of so-called linkage testers.

KIESSELBACH: There can be no question but what the development of wheat carrying as many of these qualities as possible would be desirable.

ROBERTSON: We have been trying for commercial wheats and not enough attention has been given to breeding stock.

KIESSELBACH: Would it not be desirable to put this in the hands of a committee to develop one wheat like that from a series of wheats which would have certain regional type requirements?

PARKER: I move that we have a committee of one man from each of the cooperating states with Dr. Quisenberry as chairman to work on the idea and make a start toward gathering and combining the superior germ plasm in wheat.

The motion was seconded and carried.

Question 8: Will bulk milling samples bulked by districts be sufficient for established varieties, individual samples being milled and baked only from newer varieties?

SALMON: We have been milling and baking a tremendous lot of wheat. I question if we are not doing a lot of unnecessary work. We are short handed and must find a way to reduce the amount of routine work being done. It is necessary to do something more than merely routine milling and baking tests if we ever get at the matter of quality. By substituting composite samples for individual samples as far as routine testing is concerned you reduce the amount of work tremendously. It gives you an opportunity to do work on things of special interest. Unless there is some real objection to basing our milling and baking data on composite samples we would like very much to do it. I would like to put it into operation this next year.

LAUDE: It seems to me that taking into consideration the labor-saving involved we would be willing to sponsor or endorse a combination of samples. I see no particular reason myself why there is any great advantage in testing individual samples. We are concerned with varietal differences. Regionally they are probably less affected by protein content and plumpness.

BLISH: I think Mr. Fifield's data clearly showed that as much practical information can be obtained from composites as from averages of individual bakes. Comparing on equal protein content is desirable.

C. O. SWANSON: I have used composites for a number of years and have found them very satisfactory. I think I gained by using them.

FIFIELD: In the central district for 1934 samples varied in protein content from 12 to 17 percent. Through compositing that ironed itself out and all varieties fell within 14½ to 15 percent. Eliminating the variable factor there is worth considering.

KIESSELBACH: Suppose an individual station wishes to report on a varietal test for their particular state. Would these data be available for use within our own state? Might we cite the results for the regional sample, of course crediting the department for the analysis?

FIFIELD: There are opportunities to run individuals from stations and give complete reports on material in question. I am quite sure data on any varieties would be available to anyone who would wish for them.

SALMON: Mr. Fifield always bakes at least two loaves so he has a measure of variation between duplicate loaves.

PARKER: Perhaps some system could be arranged whereby a baking test from each state or district could be tabulated and sent out to men interested.

FIFIELD: Would it be of any value to have some of these baking results interpreted? In the near future I will try to interpret some of this year's results. Any suggestions you have to help me out will be appreciated. I will try to rank the varieties for quality.

Question 9: Are the winter-hardiness nurseries being conducted as they should ? How could they be improved?

AUSEMUS: At St. Paul we're glad to render any service we can in furthering winter-hardiness studies farther south of us. It is not of so much value to us. Fulcaster is one of our most hardy varieties this year.

KLAGES: We are glad to grow the winter-hardiness nurseries but they are of no commercial value in our state. Last winter the Minnesota, South Dakota, and Montana stations made an agreement to start a yield nursery on some of the common northern varieties. Because of shortness of seed the plan did not go through. This year we expect to go ahead on that, but if we do not get a good season, I am not in a position to furnish my seed. The whole formulation of plans is depending on availability of seed. We are especially well located for carrying on winter-hardiness studies. I am willing to grow a few rows for some of you southern men but we all realize that there has to be a limit to the amount of such cooperative work. We will be glad to help out.

Question 10: Let us have some discussion of wheat pasturing experiments.

A. F. SWANSON: There should be some work with reference to varietal responses to pasturing. A little more work must be done as to the influence of different degrees of grazing on yields. Farmers have become more interested and I believe livestock investigators are ready to do more work along this line.

Question 11: Regarding the bunt nursery, shall this nursery be continued? What material should go into this nursery?

RODENHEISER: In the uniform bunt nursery tests there is a little too much susceptible material. We plan to run all of the material in the yield nursery and plot test and in addition lines that various breeders want to send in but which show some promise of resistance at their particular station. It does not look to me as though some of this material as now included has much resistance. An adequate test should be run if possible before it is sent to several stations.

There is a possibility of using inoculum from wider area than at present. The inoculum at Manhattan is a composite of numerous collections in the state. It would be much more desirable if the inoculum be built up from a wide territory, even statewide, in which case we might reduce the number of nurseries.

One other point I want to make and that is regarding inheritance studies with wheat. In the past when we started out on inheritance studies we went out into the field and made a collection of smut; that was practically all we knew about it. At the present time we do have a number of these distinct strains segregated out and to my mind it is just as important to know what particular strain we are using in the inheritance study as it is to know about the purity of the strains studied. In the studies to be made in the future the inoculum to be used should be sent to us and we will be glad to run it through our nursery.

ROBERTSON: As far as the bunt nursery is concerned we need it because that is one of the chief problems in Colorado. I would like to see something done toward loose smut resistance for some of these varieties. I think some of the material found to be bunt resistant should be continued and see if it is resistant to loose smut. I would suggest that survivals out of the bunt nursery be tested for loose smut.

DUNKLE: In north Texas loose smut has been a considerable problem in recent years. It started in 1931. It jumped from almost none to 28 or 30 percent loss. Farmers have brought in wheat which by actual count ran from 30 to 50 percent loose smut. We treated seed for two years and thought we had it pretty well under control and did have. However, there was a farmer across the road that had it and it cropped up again about as bad as ever. We are hoping something can be done about this. It has been a general opinion that loose smut would not be a problem in arid sections but apparently it has become a problem even in the Panhandle. Varieties that have been reported to be resistant in other sections apparently are not resistant under our conditions.

SIEGLINGER: I would offer the suggestion as a sorghum man that if you should plant a loose smut garden it should be isolated from the rest of the plots, or trouble will be encountered.

Q. How far will loose smut scatter?

A. I would not know. We were one-fourth mile from the farmer's field and got a pretty serious infection.

SUNESON: There is no doubt but what loose smuts are on the ascendency. In inspecting fields for certification our extension agronomists have observed as much as 10 or 15 percent loose smut in Nebraska No. 60 and Cheyenne. It is a problem worth considering.

Question 12, ROBERTSON: I would raise the question regarding a uniform spring wheat nursery for this region. Komar is the highest yielding of the hard red wheats tested at Akron and Fort Collins.

LAUDE: I wouldn't know if we could undertake the thing on the plot scale because of limitation of fields for spring wheat.

PARKER: It is hopeless this year until we get some rains. We do grow Reward and two or three other varieties. If Komar is still better we would like to know about it.

SALMON: If you are interested in this matter at all you should have uniform wheats of your own regardless of what is grown in the north. If you are going to do anything with this at all you should have a small nursery of about 5 to 10 varieties selected because of probable value to this region.

KIESSELBACH: We would be glad to include any promising recommended material in a spring wheat nursery of the size suggested.

SALMON: It is an interesting thing that Komar was grown in North Dakota and discarded but appears to be making good in the central district. It appears to have some qualities here which it doesn't have farther north.

Decided that Mr. J. A. Clark should confer with the stations concerned with a view of establishing a southern spring wheat nursery in 1936.

Resolutions

PARKER: Mr. Chairman, I move that we give a rising vote of thanks to the Agronomy Department of the University of Nebraska for giving us the invitation to hold this meeting here at this time.

After the standing vote of thanks the meeting was turned over to Doctor Keim.

PARKER: I would like to move that Dr. Quisenberry be delegated as the personal messenger of this conference to carry to Dr. McCall the sincere appreciation of every state and federal man present for allowing us funds and authorizations to attend this conference, and I believe I speak for the whole conference. As far as anything I have seen, report to him it has been 100 percent harmonious and I believe was characterized by a very high percentage of efficiency.

This motion was carried by a standing vote and the conference was adjourned at 5:10 P.M.

A number of the men spent Saturday in Lincoln viewing the winter wheat nursery and field plots..

List of Those in Attendance

COLORADO:

Name	Department or Division	Address
Wayne Austin	Agronomy Dept., Agr. Exp. Sta.	Fort Collins
J. J. Curtis	Cereal Crops & Diseases, U.S.D.A.	Akron
Alvin Kezer	Agronomy Dept., Agr. Exp. Sta.	Fort Collins
D. W. Robertson	Agronomy Dept., Agr. Exp. Sta.	Fort Collins

KANSAS:

A. L. Clapp	Agronomy Dept., Agr. Exp. Sta.	Manhattan
H. Fellows	Cereal Crops & Diseases, U.S.D.A.	Manhattan
C. O. Johnston	Cereal Crops & Diseases, U.S.D.A.	Manhattan
H. H. Laude	Agronomy Dept., Agr. Exp. Sta.	Manhattan
C. L. Lefebvre	Botany & Plant Path. Dept., Agr. Exp. Sta.	Manhattan
Alvin Lowe	Cereal Crops & Diseases, U.S.D.A.	Manhattan
R. H. Painter	Dept. of Entomology, Agr. Exp. Sta.	Manhattan
John H. Parker	Agronomy Dept., Agr. Exp. Sta.	Manhattan
T. M Reitz	Farmer	Belle Plane
A. F. Swanson	Cereal Crops & Diseases, U.S.D.A.	Hays
C. O. Swanson	Milling & Baking, Agr. Exp. Sta.	Manhattan
R. I. Throckmorton	Agronomy Dept., Agr. Exp. Sta.	Manhattan

MINNESOTA:

E. R. Ausemus	Cereal Crops & Diseases, U.S.D.A.	St. Paul
H. K. Wilson	Agronomy Dept., Agr. Exp. Sta.	St. Paul

MONTANA:

L. P. Reitz	Agronomy Dept., Agr. Exp. Sta.	Bozeman
J. L. Sutherland	Cereal Crops & Diseases, U.S.D.A.	Moccasin

NEBRASKA:

M. J. Blish	Agricultural Chemistry, Agr. Exp. Sta.	Lincoln
S. Garver	Forage Crops & Diseases, U.S.D.A.	Lincoln
R. W. Goss	Dept. of Plant Path. Agr. Exp. Sta.	Lincoln
F. D. Keim	Agronomy Dept., Agr. Exp. Sta.	Lincoln
T. A. Kiesselbach	Agronomy Dept., Agr. Exp. Sta.	Lincoln
W. E. Lyness	Agronomy Dept., Agr. Exp. Sta.	Lincoln
H. E. Nelson	Grain Supervision, U.S.D.A.	Omaha
L. C. Newell	Agronomy Dept., Agr. Exp. Sta.	Lincoln
G. L. Peltier	Dept. of Plant Path., Agr. Exp. Sta.	Lincoln
R. M. Sandstedt	Agricultural Chemistry, Agr. Exp. Sta.	Lincoln
P. H. Stewart	Agronomy Dept., Agr. Exp. Sta.	Lincoln
C. A. Suneson	Cereal Crops & Diseases, U.S.D.A.	Lincoln
H. M. Tysdal	Forage Crops & Diseases, U.S.D.A.	Lincoln

Name	Department or Division	Address
NEBRASKA:		
R. Weibel	Cereal Crops & Diseases, U.S.D.A.	Lincoln
R. Weihing	Agronomy Dept., Agr. Exp. Sta.	Lincoln
M. Yount	Barberry Eradication, U.S.D.A.	Lincoln
OKLAHOMA:		
C. B. Cross	Agronomy Dept., Agr. Exp. Sta.	Stillwater
V. C. Hubbard	Cereal Crops & Diseases, U.S.D.A.	Woodward
J. B. Sieglinger	Cereal Crops & Diseases, U.S.D.A.	Woodward
SOUTH DAKOTA:		
H. H. Klages	Agronomy Dept., Agr. Exp. Sta.	Brookings
E. S. McFadden	Cereal Crops & Diseases, U.S.D.A.	Refield
TEXAS:		
I. M. Atkins	Cereal Crops & Diseases, U.S.D.A.	Denton
P. B. Dunkle	Supt., Substation No. 6	Denton
P. C. Mangelsdorf	Agronomy Dept., Agr. Exp. Sta.	College Station
WASHINGTON, D. C.		
C. C. Fifield	Assoc. Baking Technologist, Wheat Investigations, U.S.D.	
O. S. Fisher	Extension Agronomist, U.S.D.A.	
K. S. Quisenberry	Agronomist, Wheat Investigations, U.S.D.A.	
H. A. Rodenheiser	Pathologist, Wheat Investigations, U.S.D.A.	
S. C. Salmon	Principal Agronomist, Wheat Investigations, U.S.D.A.	

KANSAS AGRICULTURAL EXPERIMENT STATION

Manhattan - Kansas

WHEAT CONFERENCE

Aug. 22, 1935

Those attending the conference were:

R. I. Throckmorton
Karl S. Quisenberry, Washington, D.C.
C. A. Suneson, Lincoln, Neb.
A. F. Swanson, Hays
F. E. Davidson, Parsons
C. E. Crews, Kingman
L. E. Melchers
C. O. Johnston
Hurley Fellows
C. H. Fiche
R. H. Painter
E. T. Jones
Rowland J. Clark
R. O. Penee
H. H. Laude
John H. Parker
A. L. Clapp
L. E. Willoughby
E. A. Cleavinger
John Glass
Frank G. Parsons
Alvin E. Lowe

The purpose of the conference, as outlined by R. I. Throckmorton, was to summarize the available data on certain wheat varieties, and to make plans for further testing, distribution or discontinuance of these varieties in such a manner as will best correlate the work of the various Kansas branch agricultural experiment stations, experiment fields and cooperative tests with each other and with out-of-state agencies. In opening the conference, Professor Throckmorton called attention to the necessity of keeping in mind such fundamental factors as yield and quality when determining the value of a wheat variety. He emphasized the need of knowing the insect and disease susceptibility of wheat varieties, but pointed out the danger of letting such factors assume undue importance during certain periods, and thus unbalance the research work.

Wheat Improvement in the Southwest

In discussing wheat improvement in the Southwest, Doctor Quisenberry described briefly the coordinated wheat research program of the area. This program has now been in operation five years and is rapidly reducing needless replication and providing for needed duplication of wheat variety testing at the various cooperating stations in Nebraska, Kansas, Oklahoma, Texas, New Mexico and Colorado. Some fundamental suggestions regarding the wheat breeding program made by Doctor Quisenberry are: (1) Wheat breeding of the future should look toward producing varieties resistant to all hazards in order to prevent complete failures such as that caused by stem rust in many sections this year. (2) Better methods of studying hazards should be developed. (3) More care should be used in the selection of varieties used in breeding in order to select parent stock most likely to produce the results desired. (4) Testing for resistance to such hazards as insect or disease susceptibility should begin with the F_2 generation in order to discard undesirable lines as early as possible.

Kansas Station Project on Hessian Fly Resistance in Wheat

Dr. R. H. Painter outlined the program of study of insect resistance of various varieties and strains of wheat and alfalfa. The Bureaus of Entomology and Plant Industry, U.S.D.A., and the Departments of Entomology and Agronomy, Kansas State College, are cooperating in conducting this program. Uniform Hessian fly wheat variety nurseries will be located at Manhattan, Kansas; Sacramento, California; Lafayette, Indiana, and Carlisle, Pennsylvania. Nurseries of hybrids and varieties will also be located at Parsons, Kansas, and Springfield, Missouri. Promising hybrids between Marquillo spring wheat and such winter wheats as Tenmarq, Minturki and Oro are now being tested. Some F_3 lines of these Marquillo crosses showed only seven per cent plant infestation with fly in the fall, compared to 80 per cent for the susceptible winter wheat parents, and zero per cent fly in the spring compared to 50-60 per cent for the susceptible parents. Some of these F_3 lines were also resistant to stem and leaf rust. Doctor Painter then introduced Mr. E. T. Jones, of the Bureau of Entomology, who is assigned to the project on insect resistance. Mr. Jones exhibited some plants and photographs which showed a wide variation among strains of wheat and even plants in the same row in resistance to chinch bug injury and early spring drouth in 1935.

Plans for Wheat Foot Rot Research

Dr. Hurley Fellows outlined the plan to be followed during the coming year in foot rot studies. Doctor Fellows said, "Since previous work has shown that the best date to plant to escape foot rot is in accord with the best date for securing highest yields as worked out by the agronomists, date-of-planting work at various points will be discontinued." This year the testing of important varieties and strains will be emphasized. This work will be concentrated at Akron, Colorado.

Nebraska Wheat Investigations

Mr. C. A. Suneson, of the Nebraska station, pointed out the fact that the testing of various varieties for such factors as insects and diseases was handicapped at Nebraska by the lack of active co-operation from entomologists and pathologists, and because there is no provision for artificially producing epidemics. Major efforts will be placed on testing winter wheats for winterhardiness. Mr. Suneson described some early generation new hybrids of Hope x Cheyenne and of Hope x C.I. 10016 Neb. Turkey Sel. which are bunt and rust resistant and winterhardy. He also mentioned a promising Cheyenne selection which is outstanding in winterhardiness, is two days earlier than the original Cheyenne, and bunt resistant. This selection of Cheyenne is not so stiff strawed as Cheyenne nor so weak as Kanred.

QUESTIONS FOR DISCUSSION

Kanred x Hard Federation
Kan. 2672, C.I. 10091
and
Kan. 2673, C.I. 10092

The following observations were made in regard to these two strains:

Clapp: A summary of yield data from various stations shows that No. 2673 outyielded No. 2672 on the Agronomy Farm plots, 0.2 bu.; Agronomy Nursery, 2.5 bus.; Garden City, 0.4 bu. and 0.0 bu.; Lawton, Okla., 3.8 bus. and Goodwell, Okla., 7.0 bus. No. 2672 outyielded No. 2673, 3.5 bus. at Kingman; 1.9 bus. at Wichita; 0.9 bu. at Hays; 0.1 bu. at Colby; 0.6 bu. at Tribune; 1.4 bus. in cooperative tests; and 1.1 bus. at Alliance and Lincoln, Nebraska.

Johnston: Both are resistant to leaf rust and susceptible to bunt and stem rust.

Melchers: Both are susceptible to flag smut.

Quisenberry: There is a slight advantage for No. 2673 in the South. At Bozeman, Montana, in 1935, No. 2672 shattered more than No. 2673.

Laude: No. 2672 is slightly earlier in maturity than No. 2673.

Suneson: Prefers No. 2672 on agronomic characters and ability to "come back" after being stunted by unfavorable conditions. No. 2672 is the better in general appearance of plants and one day earlier in heading than No. 2673.

Crews: No. 2672 favored on account of better general appearance than No. 2673. No. 2673 more susceptible to Septoria glume rot than No. 2672.

Parker: Their advantages are earliness and stiff straw, but some samples of the grain of both strains lack luster and dark red color desirable in hard red winter wheats.

Pence: Baking data favor No. 2673 over No. 2672.

Recommendations

Continue both No. 2672 and No. 2673 in plots at Manhattan, Hays and Garden City, on the south-central experiment fields at Wichita and Kingman, and in cooperative tests in south-central Kansas.

Take both out of plot tests at Colby and Tribune because they are not sufficiently winterhardy.

Both strains are to be continued in U.S.D.A. Uniform Yield nurseries, 1935, and in plot tests in Oklahoma, Amarillo and Plainview, Texas.

Harvest Queen Selections Resistant to Flag Smut

Laude: Harvest Queen Selections, C.I. 11611 and C.I. 11612, are resistant to flag smut, while ordinary Harvest Queen is susceptible. The Harvest Queen selections produced consistently lower yields than Harvest Queen. Kawvale and Clarkan are both highly resistant to flag smut. Clarkan and Harvest Queen are similar in plant characters but Clarkan will outyield Harvest Queen.

Melchers: Over a four-year period, Harvest Queen showed 34 per cent flag smut infestation, Sel. C.I. 11611 zero per cent and Sel. C.I. 11612 0.04 per cent.

Recommendations

Discontinue all testing of the two selections with the possible exception of plots on the Agronomy Farm at Manhattan. The selections to be continued in plots on the Agronomy Farm if Dr. S. C. Salmon desires. The selections will be continued in the nursery at Manhattan.

It was decided to allow Mr. W. J. Adams to dispose of the seed of the Harvest Queen selections which he has increased as he sees fit. The Kansas Experiment Station does not recommend the distribution of these selections.

Disposition of Increase Seed of Fulcaster Selection

Parker: Explained that this selection of Fulcaster was made through field selection of heads and nursery testing. He raised two questions: (1) Is it safe to distribute this seed without thorough testing in plots? (2) Is there a need for distributing and certifying Fulcaster?

Throckmorton: Fulcaster is grown extensively in southeastern Kansas. However, most farmers who would want pure, certified Fulcaster seed would probably grow Kawvale.

Davidson: This Fulcaster selection is more susceptible to leaf rust than Kawvale.

Recommendations

Drop all testing and other work with this selection except in the Agronomy Nursery, at Manhattan.

Further Testing of Quivira

Laude: Discussed the quality of Quivira as brought out at the Kansas City meeting of millers last February. The two objectionable features were sharp granulation of the flour, and excessive carotina content, producing a yellow flour.

Pence: Quivira flour had a more creamy color than Tenmarq, but has no higher carotine content than Kanred or Turkey. Quivira flour bleaches easily. The kernels of Quivira are hard and vitreous and do not take water easily in tempering. Mr. Pence thought, however, that the coarser granulation could be overcome by proper tempering.

Crews: Quivira shattered at the south-central fields in 1934 but not in 1935.

Davidson: Quivira shattered at the Columbus field in 1935.

Recommendations

Quivira is to remain in plot tests at Manhattan, Hays, Garden City, south-central and southeast experiment fields, and cooperative tests in the southern half of the state. Quivira is to be taken out of the U.S.D.A. Uniform Winterhardiness nursery.

Kawvale in Eastern Kansas

Parker: Presented the data showing that Kawvale is a consistently high-yielding variety over the eastern section of the state.

Sunseon: Reported that his experience with Kawvale at Lincoln, Nebraska, was favorable and that he thought Kawvale was suitable for distribution in southeastern Nebraska as far north as Lincoln and west to the second county west of Lincoln.

Recommendations

Recommend Kawvale in northeastern, as well as in southeastern Kansas. Decision on a definite western limit is to be made at some later date.

Cheyenne in Nebraska and Northern Kansas

Suneson: Reported that Cheyenne was badly injured by stem rust in Nebraska this year, as previous testing indicated it would be under a severe epidemic. "The acreage of Cheyenne will not increase in sections of the state where stem rust was bad this year," said Mr. Suneson, "but probably will continue to increase in the southeastern section where normal yields and test weights were secured." Mr. Suneson said that the good characters of Cheyenne, stiff straw, large amount of pasture and high yields, still continue to make it a promising variety.

Clapp: In reporting on Cheyenne in cooperative tests in Kansas, pointed out that Cheyenne was more winterhardy than Tenmarq and Blackhull and about the same as Kanred and Turkey. The test weight of Cheyenne averaged higher than Kanred, Turkey or Tenmarq, but not so high as Blackhull. Cheyenne showed slightly less yellow berry than Blackhull and considerably less than Tenmarq, Kanred and Turkey. In a four-year average of 149 tests in Kansas, Cheyenne, Blackhull, Turkey, Kanred and Tenmarq made practically the same yields. In 72 tests in south-central Kansas, Tenmarq outyielded the other varieties approximately one bushel per acre. In 36 tests in the north-central and western sections of the state, Cheyenne approximately equaled Tenmarq, Turkey and Kanred in yield but was outyielded by Blackhull 0.5 of a bushel.

Recommendations

Continue testing Cheyenne in plot tests on all stations and on the south-central experiment fields, and in cooperative tests in north-central and northwestern Kansas.

Distribution of Varieties

Plans for testing wheat varieties on the stations and in cooperative tests were adopted. These plans were based on the plans made at the Branch Station Conference, February 15-16, 1935, with the changes mentioned above, and the following:

Turkey should not be included on the southeast fields, but Kanred should be.

Kanred x Marquis, Kan. 2644, dropped at Manhattan.
Neb. Turkey Sel. C.I. 10094, added at Hays and Colby.
P 1066-1 x Burbank, Kan. 2654, dropped at Hays.
Kanred x Hard Federation, Kan. 2671, dropped at Hays and Colby.
Chiefkan and Kanhull added at Hays, Manhattan and south-central fields.
Rupp wheat added at Hays, Manhattan and south-central fields.
Minturki dropped at Manhattan, Hays and Colby.
Neb. No. 60, Kan. 332, added at Colby.
Clarkan dropped at Garden City.
Kawvale, Kan. 2593, added at south-central fields.

A. L. Clapp - Secretary