U.A. Johnson

PROCEEDINGS . . . .

12th

INTERREGIONAL WHEAT WORKERS CONFERENCE

OKLAHOMA STATE UNIVERSITY
STILLWATER, OKLAHOMA
FEBRUARY 9-11, 1971

UNITED STATES DEPARTMENT OF AGRICULTURE

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Oklahoma State University
Stillwater, Oklahoma
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PSR-38-71

PROGRAM

Feb. 9 - 9:00 A.M. WELCOME - L. Calpouzos

WHEAT AND TRITICALE GENETICS

Discussion Leader - R. E. Heiner

"New Information Needs in Wheat Genetics" - R. E. Allan

"Triticale Development and Future Research Needs" - E. N. Larter

Feb. 9 - 12:00 NOON LUNCHEON - I Predict - L. P. Reitz. Complete text of address is given in 1970 Wheat Newsletter. Vol. 17: 2-5.

Feb. 9 - 1:30 P.M. MAXIMIZING WHEAT PRODUCTION

Discussion Leaders - E. G. Heyne, K. B. Porter.

"Perspectives" - J. R. Welsh

"Cultivars and Hybrids" - E. G. Heyne

"Environmental Management" - K. B. Porter

Feb. 9 - 7:30 P.M. COMBINED SESSION ON INTERREGIONAL AFFAIRS

Discussion Leader - K. L. Lebsock

"International Disease Nurseries" - R. A. Kilpatrick

"Wheat Newsletter" - E. G. Heyne

Feb. 9 - 8:30 P.M. REGIONAL BUSINESS MEETINGS

The Twelfth Hard Red Spring Wheat Workers Conference
The Twelfth Hard Red Winter Wheat Workers Conference
The Twelfth Western Wheat Workers Conference
The Fifteenth Eastern Wheat Workers Conference

Feb. 10 - 9:00 A.M. DISEASES AND PESTS

Discussion Leader - R. M. Caldwell

"Generalized and Specific Resistance" - R. M. Caldwell

"Disease Problems Associated with Intensive Culture" - M. G. Boosalis

"Genes for Resistance to Disease and Insects"
Diseases - J. F. Schafer
Insects - R. L. Gallum

" Economic Implications and Problems in the Use and Application of Chemicals for Disease and Pest Control" - G. Brandes

Feb. 10 - 1:30 P.M. BREEDING OBJECTIVES FOR THE 70'S

Discussion Leader - C. O. Qualset

"International Programs" - J. A. Rupert

"Domestic Programs" - N. F. Jensen

"Yield vs. Quality" - V. A. Johnson

"Quality, Market Classes and Marketing" - Robert Bequette

Feb. 11 - 9:00 A.M. CONTINUATION OF BREEDING OBJECTIVES FOR THE 70'S

Discussion Leader - B. C. Curtis

"Development of Breeders' Rights" - John Sutherland

"Future Relationships Between the Public and Industry Programs" - Iver Johnson

"Future Procedures for Releasing New Varieties" - J. W. Echols

Feb. 11 - Noon SUMMARY OF WORKERS CONFERENCE - J. R. Welsh

ADJOURN

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NEW INFORMATION NEEDS IN WHEAT GENETICS

R. E. Allan

I'm certainly pleased for this opportunity to be on the program. First, it affords me a chance to give you a heavy dose of some of our Pacific Northwest wheat work and secondly, it ultimately got me to the meetings.

New information needs in wheat genetics no doubt are many. It would be impossible to discuss them all. I would specifically like to cover certain aspects of the following: Breeding for disease resistance, aneuploid analyses, alien transfers, hybrid wheat, DNA transformation (higher plants), improved environment (through breeding), mutation research, quality, gene markers and developmental and physiological genetics of wheat.

The importance of diseases and our genetic knowledge concerning the inheritance of resistance has always received major attention in wheat improvement. The last decade has led to our understanding of host-parasite genetics which has been of particular value to breeder and pathologist alike. I'm sure most of us are aware of the importance of this work for its fundamental value, but as yet it has had little practical application in wheat improvement. I'm engaged in a rather long-ranged program of placing stripe rust resistance into susceptible genetic backgrounds. A major objective of this work was to develop single gene differentials that would aid in elucidation of the host-pathogen picture. Many of you have already done or are doing similar work for other wheat diseases. The pitfalls of research of this nature are many. Often the genetic backgrounds we chose carry gene modifiers which negate the usefulness of this type of research.

The 'Chancellor' differentials for powdery mildew incidently are unsatisfactory in field studies at Pullman, Wn. 'Chancellor' carries field resistance under our conditions and the highest infection we've recorded on this cultivar has been 1%; yet 40 to 65% infection occurs on C.I. 13645 and 'Nugaines'. My point is when we are in a period of tight money, definite priorities must be set on the importance of future genetic needs. We must ask ourselves if these are the kind of genes for host resistance we really need to understand? Are they the ones we plan to use?

More emphasis is being placed on the so-called horizontal type of resistance. What actually differentiates the vertical from the horizontal type is hazy. The vertical type is assumed to be relatively vulnerable to pathogenic variation, and is primarily simply inherited. The horizontal type is often believed to be genetically complex. Important exceptions to this occur. 'Gaines' has been under cultivation in the Pacific Northwest since 1961, and its resistance to stripe rust has been stable over that period. In contrast races pathogenic to the 'Chinese 166', 'Heines VII', 'Moro', and 'Suwon 92' forms of resistance have arisen. The pathogen survives on Gaines until certain climatic conditions (presumably temperature) trigger resistance. Yet this so-called "adult resistance" is highly heritable and in fact can be demonstrated to be monogenic. Wheat breeders should not be prejudiced by current host-parasite genetic dogma that simple genetic control of resistance can be easily circumvented. In actuality the organism may have trouble doing this and why it encounters trouble is the kind of information we need to know. Finding these highly heritable, stable resistance forms should receive high priority.

We should not abandon our work on vertical type resistance. Yield losses in excess of 30% due to stripe rust have occurred on 'Gaines' in bad rust years. We need to work with both the vertical and horizontal types to insure best control. Presently, breeders are stimied in this approach since vertical resistance often over-shadows the horizontal type. We need a simple selective technic to tell when we have one or both control systems at work in a plant.

Breeders require improved technics to get uniform infection particularly for various soil borne diseases. This will call for exerted efforts from plant pathologists. Diseases in this category include flag smut, dwarf bunt, the foot and root rots, some viruses, snow mold, Cephalsporium stripe and seedling blights. True progress for resistance to these diseases has remained elusive because of their low heritabilities. My own experience has been that the heritability to several of these diseases is low primarily due to the environmental effects rather than genetic effects.

Flag smut is a good case in point. We've known of it since 1919, yet we are almost totally lacking in the knowledge of its ecology. We have an abundance of resistance to the disease, but we lack a reliable testing method to carry out proper breeding and genetic studies. At present we test in heavily infected fields, yet even at these locations, the CV values among the susceptible check often exceed 40%.

Dwarf smut is similar in that we lack the know-how to make large scale tests and difficulty in repeating results precludes working with low level types of resistance that may represent useful horizontal types. The old land variety 'Requa' may be of this type, but our present methods will not consistently identify this form of resistance.

Snow mold is a disease wherein important gains in screening for resistance have been made. But again the emphasis has been placed on a high level of resistance which could well lead us to a narrow genetic base. We are overlooking useful low-level resistant forms. We must avoid technics that bias results toward any one form of resistance.

We need highly cooperative projects tailored to these problem diseases, wherein pathologists concentrate their efforts in order to thoroughly understand the ecology of an organism. Then they need to come up with technics for detecting and measuring useful resistance. These methods have to lend themselves to employment by the breeders!

Without a doubt aneuploid analyses have supplied a major bulk of the genetic information in wheat as we know it today. This technic has probably done an equally effective job in creating apathy and general disorder in our knowledge of inheritance of certain traits. When used by competent, dedicated scientists the various ramifications of the technic are very useful and should continue to receive high priority.

Use of substitution series is an ideal means of studying complexly inherited quantitative characters in wheat. An excellent example is the work of the Nebraska group; wherein, chromosome substitution lines were effectively employed to gain quality data on the wheat cultivar 'Cheyenne'. Such fundamental information should prove invaluable in future efforts toward quality breeding. Much of the U.S. hard red winter wheat has 'Cheyenne' parentage and we now know chromosomes that cause plus or minus effects.

What is needed in the future? More work of this type. Who will do it is another thing. Unfortunately, the typical U.S. wheat worker tends to avoid such long range, tediuous research. I wish I had the needed substitution series for my 'Burt' isogenics that carry the two semidwarf genes singly, the two genes in combination, plus a set void of both semidwarf genes.

I firmly believe that aneuploid analysis is a powerful tool that wheat workers are fortunate to have at their disposal. Certainly Dr. Colin Law's system of using intervarietal chromosome substitutions is a powerful method of carrying out quantitative genetic analysis. When more aneuploid stocks are developed, this method will add greatly to our fundamental and practical knoweldge of wheat genetics. We need to renew the interest for a number of well-planned monosomic series and substitution lines and find ways to carry the work through to completion.

Keen interest has long centered on alien transfer of desired traits from near-relatives of wheat to wheat genomes. Historically the work is well-established and dates back some 15 years. Workers are more or less in agreement that substitution and addition lines will probably not have much direct value in wheat production. Hence, we are usually talking of specific gene transfer between alien material and common wheat. The most promising procedure for gene transfer appears to be by normal crossingover via the nulli-5B tetra-5D stocks.

But a major point of consideration centers about the value of such strenuous efforts for the benefits received. To date we have no reason to believe that disease resistance of alien germplasm will be any more stable than that we now have in common wheat.

Certainly hybrid wheat should be included in a discussion of new information needs for wheat genetics. I still have high hopes for hybrid wheat. The genetic complexity of the restorer system bothers me, however. We need a simple cytosterile/restorer system, but we seem to be uncovering a geneticist's nightmare. If we must juggle a complex system, I doubt if we'll ever see hybrid wheat. We can't get bogged down in a restrictive drawn-out backcross system in the development of either the A- or the R-lines.

Gametocides are a logical answer and I no longer believe that such a concept is "pie-in-the-sky thinking". Dr. Miller and his students at W.S.U. have extremely exciting data with a certain chemical. They've vividly shown the scheme has potential of working. If further tests hold up with diverse environments and genotypes, then the hybrid wheat stock should rise back to where it was a few years ago.

Equally intriguing is the question of what immediate use can we make of by-products of the numerous studies conducted to measure heterosis in wheat. Most of the gene action has been found to be additive and represents general combining ability. Crosses have been made between parents that no self-respecting breeder would have heretofore contemplated. We are now actively exploiting the best germplasm of 250 hybrid wheat crosses in our conventional program. More specifically we have found valuable yield potential between club and common selections, crosses we avoided in the past. Evidence from isogenic studies suggest unique yield genes may be linked to the club locus that enhance yield once they are placed in a common wheat background.

I am sure most of you are exploiting by-products of your hybrid wheat efforts in similar fashions. At any rate if you have the resources to study such material, I urge you to do so. The concept of "make a few well-planned crosses' may prove to be passé. In fact making several utterly ridiculous crosses may become vogue.

The next few years should bring about significant gains in our genetic knowledge of plant growth and development of wheat. An impressive array of genetic material is available for study. Germplasm includes numerous chlorophyll and plant pigment mutants as well as waxy vs non-waxy lines. Near-isogenic series have been established with diverse height levels in several cultivars. We have nearly completed the development of these lines in 8 cultivars. I'm sure other workers have similar material under development. Dr. Konzak and his group have produced over 12 distinctly different culm length phenotypes through mutation in the 'Burt' background alone.

We have near-isogenic lines of various head types and awn length expressions. The mutation work also has similar lines available. We have established an anthesis range in 'Burt' that spans 10 to 12 days under our conditions. We are now well-equipped to begin appropriate biochemical and physiological tests for the needed information on how the various growth regulating genes act in the wheat plant and what metabolic pathways are involved. Through joint effort from geneticists, biochemists and physiologists we could gain exciting scientific breakthroughs in our understanding of growth and development of wheat. Again this work requires a highly cooperative effort.

We appear to be on the threshold of new exciting ways to bring about genetic modification of plants. Here I refer to the unique work in barley and Arabidopsis; wherein, transforming bacterial DNA has been taken up, retained, transcribed and presumably transferred to succeeding generations of plants. Dr. Kleinhofs of W.S.U. is initiating such a project in barley. Knowledge gained from such an investigation would contribute signficnatly to our present day understanding of gene replication and gene control of high organisms. The implications of being able to ultimately perfect the process for transformation in crops would seemingly have wide practical application. This represents some far-reaching fundamental research that merits consideration.

The public's awakening to their environment should profoundly affect future requirements in genetic know-how. No doubt reshuffling of priorities will occur among many of our breeding programs. I've already discussed the disease picture. I will not be surprised if most, if not all, fungicides go by the board eventually - leaving resistance and biological control as our major weapons.

What about erosion? Rightly or wrongly the farmer has already been singled out for polluting streams with his chemicals and soil. Let us discuss water and wind erosion since my colleagues and I have worked toward their control by improving stand establishment for years. Fortunately, we now see chances of getting on top of the problem. In the Northwest there is no better way to prevent wind or water erosion than by securing a good stand. Dr. Vogel's early argument for semidwarf wheats emphasized that they could be seeded early without danger of lodging and provide erosion control. Early in semidwarf breeding, we ran into the dwarfed coleoptile, slow seedling growth, post-harvest dormancy complex. Thus, poor stands seriously jeopardized semidwarf usefulness in early plantings and delayed effective erosion control.

The seed dormancy problem was easily solved and we've picked away at the problem of dwarfed coleoptile and slow seedling growth for 10 years. Through modified recurrent selection we now have semidwarfs (Oriental type) with near normal seedling growth that emerge adequately from early seedings.

What do we need? We must incorporate more seedling vigor for areas where extremely deep seeding is practiced. We haven't located a wheat that can germinate consistently under limited moisture. Some parental material from Afghanistan looks promising, but we lack reliable tests for screening large numbers for improvement in this trait. We must also find new sources of seedling vigor. We need to locate genetic combinations that can override the poor stand establishment characteristics of Oriental dwarfs. P.I. 178383 appears to be effective in doing this and new lines from the World Collection hold forth even more promise.

Mutation research in wheat appears to finally be coming of age. I can say this since I am within a stone's throw of the largest program in the U.S.A. The role induced mutations will play in the future at this point shows great potential. It became immediately evident that mutation work suffered the same inherent disadvantages of backcross breeding and that selection of power candidates worthy of improvement led to the usual pitfalls.

The W.S.U. program, however, has enjoyed notable success. They've improved their methods of mutagen treatment and have learned how to effectively manage large populations. They've developed short-strawed types in 'Burt' and 'Marfed' that parallel the 'Norin 10' short-strawed types, yet do not reduce seedling vigor. They've isolated a dominant dwarf in 'Marfed' that has exciting promise in the hybrid wheat research. High yielding short-strawed durums are nearing release. Lines with "adult-type" resistance to stripe rust have been isolated. Dr. Konzak reports he has induced fertility restoration of T. timopheevi sterile cytoplasm through EMS treatment. Unique quality types have been produced. Several useful genetic markers unknown to the World Collection have been induced.

With the new "combination breeding" philosophy now adopted by mutation workers wherein they use mutagenesis primarily as a tool to provide parents for conventional crosses, I believe more practical results will start to accumulate rapidly. The enormous scope of mutation work on an international basis almost assures it of certain areas of success.

Genetic needs in the area of quality and nutritional improvement of wheat will undoubtedly be among the important items in the future. I'm sure this subject will be stressed later in the conference. We in the Northwest are mindful of the need for improved quality. Aside from the humanitarian aspects of improved nutrition, our problem in the Pacific Northwest, and I assume in other regions, is to produce highly saleable products for our export markets.

We need continued work on a wide range of market classes of wheat including hard whites. With Australia getting 20% of the total Japanese market in the hard white class and with them moving into soft types, we need to be as aggressive and competitive as we possibly can. Many believe that we should concentrate our energy on improving soft white wheat so we will retain our traditional advantage in this market. Why not do both and sell more wheat?

What do we need? For one thing we must learn how to evaluate noodle quality, and this includes hard wheats which go into 33% of the noodles in Japan. Over 40% of all wheat consumed in Japan is in the form of noodles. At present none of our quality or utilization laboratories can measure noodle quality adequately. I'm sure other areas are in the same boat; that is, they lack the critical tests needed to move their wheats into novel uses for both domestic and export markets.

Physiologists have designed their concept of the ideal wheat plant. Some of these views such as uniculm growth habit, erect-leaf type and large spikes go against some of our thinking. We need to see the proof. But more imporantly how are these traits inherited and interrelated?

Can the U.S. effectively employ the light insensitive types? Results from Washington have been discouraging to date, but certainly irrigated regions could use 100 bushel spring wheat that matures in 70 to 80 days that would fit around their more intensively farmed crops.

We are aware of the need for good genetic markers in wheat. What can be done to enhance this work? Dr. Tsunewaki at one time was willing to spearhead this important phase of research. With the advent of many new markers brought about by induced mutation the time appears ripe to tie this work together. Isn't this information important enough to justify our efforts? We need to establish a workable-highly cooperative program with some realistic goals. Most of all we need warm bodies to do this work. The genetic symbol situation in wheat is improving, but we have a long way to go.

In closing, I'd like to again add that I'm very glad to be here and I am sure our meeting will be a success.

NEW INFORMATION NEEDED IN WHEAT GENETICS

R. C. Thomason

Information is appearing in the literature concerning the activity and inheritance of various plant enzyme systems. Through a better understanding of particular enzyme systems, the plant geneticist is brought one step closer to the DNA molecule. This provides plant breeders with information which should lead to a more accurate evaluation of breeding material.

Presently, research is being initiated at West Texas State University to study the proteins and enzymes related to the development of the fertility restoration system. By studying the proteins and enzymes associated with nonrestorer and restorer lines, it is proposed that better breeding decisions can be made in order to obtain or produce more acceptable fertility restoring lines.

CROSSING MALE STERILE WHEAT WITH AGROTRICUMS[1]

K. B. Porter and N. A. Tuleen

Hybrids of male sterile wheat and 56 chromosome agrotricums have been produced to evaluate the sterile F_1 hybrid for forage. Forage evaluations suggest that the hybrid is no more vigorous than most wheat varieties although they may produce forage over a somewhat longer period.

Studies were initiated in 1970 to determine seed sets that can be obtained on the F_1 hybrid when pollinated by wheat, rye, and 6X triticale in field crossing blocks. Backcrosses of the F_1 to the agrotricum parent and crosses of both 6X and 8X triticale (hand emasculated) to agrotricums were made in the greenhouse.

Seed sets obtained are shown in the following table. The relatively low seed set obtained from rye pollination in the field is believed to be a result of a poor nick of flowering between the parents.

Seed quality of all F_1 seed was quite good except for that involving 6X triticales as the pollinator. F_1 seed of this cross was badly shriveled and germination was very low. Seed of the F_1's, 6X and 8X triticale / agrotricums, crosses of which were made in the greenhouse, were well formed and germination was good.

None of the progeny of the 3-way crosses have been evaluated. It is possible that progeny of the backcrosses to wheat R-lines may have value in both hybrid and pure line breeding. R-lines involved include Nebraska 3547, Primepi, and a selection from *T. timopheevi* / Mq^3 // Bison. Seed of F_1's of backcrosses to the wheat R-lines is available upon request.

Percent Seed Set on Sterile MS Wheat / Agrotricum F_1's From Cross Pollination

Pollinator	% Seed Set on F_1
(Field Crossing Blocks)	
Wheat R-Lines	31
6X Triticales	37
Rye	1.3
(Greenhouse Approach Crosses)	
Wheat R-Lines	37
6X Triticales	47
8X Triticales	11
Rye	25
Agrotricums	27

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[1] Agrotricums provided by Cal/West Seed Co., Woodland, California.

VERNALIZATION, PHOTOPERIOD AND TEMPERATURE EFFECTS IN SPRING WHEAT

Robert E. Heiner

Many successful semidwarf wheat varieties are day-length insensitive. This has extended the range of adaptation of varieties like Red River 68, World Seed 1809, and many of the Mexican derived lines. In other cases, however, insensitive lines like World Seed 1812 exhibit high genotype by environment interactions for grain yield and in some cases, have a narrow range of adaptation.

In 1968 and 1969, the variety WS1812 varied considerably in heading response when compared to a standard check variety. Controlled environment studies revealed that this and a number of other varieties and experimentals possess genes that cause a marked difference in the time of floral initiation when these lines are exposed to vernalizing temperatures in the seedling stage. There may be as much as a 15-day differential in heading due to vernalizing and non-vernalizing conditions. Not only is the heading response altered by temperature, but also dramatic differences may occur in tiller number and head size. If, for example, WS1812 becomes vernalized after sowing in the field, its lower tiller number, smaller head size and earliness cause reduced yields.

Even though the semidwarf variety Era is a long-day (sensitive) line, it is "environmentally stable," that is, low temperatures in the seedling stage do not alter its heading response. Based on the facts presented, it is thought that low temperature responsive genes in spring wheat are undesirable.

GENETIC ANALYSIS OF RYE CHROMOSOMES ADDED TO WHEAT

T. D. Chang, G. Kimber and E. R. Sears

With rye so often used in the improvement of wheat, there is clearly a need for the genetic analysis of rye chromosomes. However, since rye is self-sterile, very few genetic studies have been made. One cytogenetic approach would be to make Triticale monosomic, then develop substitution lines and use these in the same way as C. N. Law did in wheat chromosome analysis. Much work and technical difficulties are anticipated in this approach. We have carried out a project for the last two years on the genetic analysis of rye chromosomes by using wheat-rye addition lines. The technique is similar to Law's and involves the crossing of addition lines with the same rye chromosome from different sources, isolating the crossover chromosomes by backcrossing to wheat, and making these chromosomes disomic. The disomic crossover lines are completely homozygous for a recombinant or non-recombinant chromosome against a uniform background, and thus can be increased on a large scale to compare with the parental addition lines. Such a technique should permit the locating of genes for qualitative characters as well as those for quantitative characters on a specific rye chromosome. If telocentrics are used in the initial crosses, it should also be possible to associate the genes with specific chromosome arms and to map each gene with respect to the centromere. Genes of value to wheat, particularly those related to yield, can then be transfered to wheat or to Triticale by techniques already available.

At present we are adding rye chromosome 5R from 15 rye cultivars to the wheat cultivar Chinese Spring. 5R is the most easily identifiable rye chromosome because it shows at meiosis a stretched-out secondary constriction in the long arm and because it carries the hairy-neck gene. So far, 6 disomic and 9 monosomic addition lines with 5R from 8 rye cultivars have been obtained. Sixteen more monosomic lines with 5R from 8 rye cultivars will be isolated this spring. Intercrosses among 3 disomic lines have been made. It is suspected that in certain rye chromosome combinations, considerable asynapsis will occur. Thus, only suitable addition lines of contrasting characters will be used in mapping experiments.

COMMENTS ON WHEAT STERILITY AND RESTORATION STYSTEMS

C. R. Trupp

The use of Pugsley's gene for male sterility, as isolated by Briggle, in Michigan State University's hybrid wheat program was reported. This gene is being used to construct intercrossing restorer and non-restorer populations. Test crossing sterile phenotypes using B-line pollen differentiates the cause of sterility (genetic or cytoplasmic). Test crossing fertile phenotypes to known genetic male steriles identifies those genotypes heterozygous for the gene for male sterility. The need for such testcrossing is minimal as another morphology associated with the different sterility systems is different.

Benefits from the repeated intercrossing in such a program are expected to be as follows: 1) Enhance the cross-pollination potential of a self-pollinating species by increasing pollen production, pollen dispersal, and female receptivity; 2) development of improved restorer lines by concentrating major and minor restorer genes; 3) create germ plasm pools for immediate or long-range utilization; 4) permit use of selection methods previously limited to open pollinated species for extensive use; and 5) maximize genetic recombination potential.

Pugsley's male sterile gene populations are still available from California and they apparently contain the purple aleurone gene.

Briggle isolated the gene for male sterility from the chromosomal instability. Unfortunately, I have not made a cytological examination of Briggle's stock nor my derivatives from it.

We are incorporating this genic male sterile system into our program and have planted F_2 materials in the field in the fall of 1970. Additional field plantings are anticipated in the spring. A limited sample of the fall material was grown and examined in the greenhouse. It was in this material that I convinced myself that one can identify genetic male steriles on the basis of their morphology in a population with sterile cytoplasm and segregating for fertility restorers.

THE TRANSFER OF GENES TO WHEAT FROM ITS RELATIVES

E. R. Sears

Genes can be transferred to wheat chromosomes from alien, non-pairing chromosomes by use of nullisome 5B to induce homoeologous pairing. A test of this method, using the Agropyron chromosomes of Agrus and TAP67, is now nearly complete. A substantial amount of pairing was induced with the wheat homoeologues, 7D and 3D, respectively, and a number of probable and possible transfers have been recovered. Should none of these prove satisfactory, two other possibilities are available:
1. Derive radiation-induced transfers, which are now known to have a strong tendency to involve homoeologous chromosomes, due to association of homoeologues in somatic cells. 2. Substitute the critical arm of the foreign chromosome for any desired wheat arm, by making the two chromosomes monosomic; following misdivision, the arms will occasionally rejoin in new combinations.

RECENT DEVELOPMENTS IN TRITICALE RESEARCH

E. N. Larter

In a paper presented to the First International Wheat Genetics Symposium, Shebeski (1958) expressed the philosophy that notwithstanding the vast contribution made to man by way of hexaploid wheats, Nature may not, in fact, have employed the most productive species when she chose to use one donating the D genome. Specifically, he stated, "The ABR combination is particularly impressive and as a potential crop has all the appearances of being a far more productive starch producing factory than the best present-day bread wheats". It was based on this philosophy that a full-time "species building" program was initiated at the University of Manitoba in 1954. Rapidly, this program increased in scope with major emphasis being placed on the development of a spring-type, hexaploid triticale. In 1969 (15 years from the commencement of the program) the first variety of this new species was licensed for commercial production in Canada and released under the name, 'Rosner' (Larter et al., Can. J. Pl. Sci., 1970).

Within the past five years, triticale development has received a significant stimulus from the initiation of a large-scale breeding program in Mexico under the auspices of CIMMYT. Using the University of Manitoba material as initial parental stock, the CIMMYT program has made rapid advancement in the development of improved triticale lines. Joint cooperation among personnel of both programs has resulted in the recent derivation of highly fertile, light insensitive strains currently under test in both countries. Similarly, a joint cooperative program between the University of Manitoba and the University of Jabalpur, India is now in its early stages. Moreover, the recent finding by Dr. F.C. Elliott (University of Michigan State) that triticale ranks the highest of the cereals in protein has resulted in the expansion of both the Canadian and Mexican programs to include small-animal feeding trials as a "screen" for nutritional value.

With such cooperative programs either already established, or in the process of development, progress in triticale breeding should continue rapidly. Just as important, such development will proceed at an international level - a most desireable requisite for the improvement of any new crop species.

COMMENTS ON TRITICALES

C. R. Trupp

An interesting side light to Elliott's meadow vole work is that the wide range of PER values obtained in testing 191 CIMMYT Triticale lines was apparently in no way associated with either protein level or constitution as determined by amino acid analysis. There appears to be a very specific interaction determining the ability of an individual vole to utilize a specific protein source.

TRITICALE IMPROVEMENT

B. C. Jenkins

Despite the fact that hexaploid triticale is a relatively newly developed crop plant, considerable improvement has been made since some of the first amphiploids were produced in the early 1950's. Progress has been such that we no longer need to utilize the direct amphiploid production method of getting variation in this new species but rather since crosses can be made with octoploid types and with hexaploid wheat, more rapid progress can be made toward stability. We have had considerable success with our methods which we have been using since 1968 (see Sisodia and McGinnis "New Methods of Utilizing Wheat and Rye Germ Plasm in Triticale Breeding" - Crop Science Vol. 10 March-April, 1970). We feel that it is no longer necessary to use the laborious method of crossing tetraploid wheat and rye which must be accompanied with embryo culture and followed by colchicine treatment in order to produce the amphiploid. The environment at Salinas is ideally suited to the indirect method of triticale improvement and makes it possible for us to obtain almost unlimited variation.

We are also employing chemical mutagens such as EMS (ethyl methane sulphonate) and DS (diethyl sulphate) and have been surprised at the high frequency of usable mutations appearing in the populations. Given sufficient time to exploit the variation that is already available there is no doubt that triticale will, in the fairly near future achieve some of the potential that exists within this new cereal grain crop.

PERFORMANCE OF TRITICALE IN CALIFORNIA

J. P. Gustafson and C. O. Qualset

Triticale performance has been evaluated in California for three years. The mean grain yield of triticale was 50, 68, and 82% of currently used wheat varieties in 1968, 1969, and 1970, respectively. The marked increase in relative performance was due to the inclusion of better triticale varieties in each year. In 1968, only Manitoba lines were treated. These were photoperiod and high temperature sensitive and performed poorly. Materials from CIMMYT and the Jenkins Foundation for Research were included in 1969 and 1970. Higher yields were obtained because of earlier maturity and higher fertility. Davis and Tulelake (northern California locations) were more favorable for triticale production than southern locations. This was evident for both fertility and grain yield. We have found yields of the best triticale comparable and occasionally superior to the best wheat or barley varieties at certain locations.

CROSS-BREEDING MALE STERILE WHEAT WITH RYE

K. B. Porter and N. A. Tuleen

Cross breeding male sterile wheat with rye was initiated in 1963 at the USDA Southwestern Great Plains Research Center. Early studies involved male sterile having Ae. ovata or caudata cytoplasm, but only male sterile wheat having T. timopheevi cytoplasm were used in present studies or as parents of progeny referred to herein. Percent seed set on male sterile wheat in field crossing blocks has been about 1%. Percent seed sets obtained on male sterile wheat-rye F_1's when pollinated in field crossing blocks by rye, wheat R-lines and 6X triticale were .04, .40, and .96, respectively, in 1970, which are similar to those obtained in previous years.

Backcrosses of the F_1 to rye has produced only 1 true backcross plant (35 chromosomes) while two 56 chromosome amphiploids were obtained apparently by apomixis. These are of interest since they were both relatively fertile. Progeny of these two amphiploids are being evaluated.

F_1 progeny of male sterile wheat / rye // 6X triticale are of much interest since many of these are as fertile as could be expected for similar F_1's having wheat cytoplasm. For example, one 49 chromosome F_1 grown in the field at College Station, Texas tillered profusely and set over 1,000 seed from self pollination. Thirty-five F_2 plant progeny from this plant varied in chromosome number (42-50) and seed fertility. The 42 chromosome F_2 plant set seed in 80% of the lateral florets. Eight of 12 additional 49 chromosome F_1 plants of male sterile wheat / rye F_1 // 6X triticale set some seed. The more fertile of these set seed in 15-20% of their lateral florets. The fertility exhibited by the 49 chromosome F_1's male sterile wheat / rye F_1 // 6X triticale, that of their F_2 progeny, and the fertility of the amphiploids of apomictical origin suggest rye or male sterile wheat-rye combinations have restoration capability.

F_1's male sterile wheat / rye // what R-lines in many cases were quite fertile but pollen fertility could have come entirely from the wheat R-lines. Numerous F_3 derivatives of this material are being evaluated.

Value of all of the above material will be determed only by additional evaluations. Examination of microsporocytes is necessary to give a critical cytological evaluation of all material.

TRITICALE

C. J. Peterson, O. A. Vogel and R. E. Allan

Six triticale lines obtained from the Jenkins Foundation equaled or beat the spring wheat Marfed in yield. The lines obtained from Mexico were disappointing in yield and straw strength. As in the past, sterility is a big problem with most of the lines tested. Test weight of all the triticale lines was below 50 lbs. per bushel. Considerable progress has been made in kernel shape and plumpness, however. The main disease problem at the present is ergot. This is probably connected with the sterility problem. If self-fertile lines are developed, the problem with ergot will be greatly reduced.

In April (1970) R. E. Allan and C. J. Peterson went to Obregon, Sonora to obtain parental material to be used in our breeding program. Approximately 350 head selections were brought back and seeded. Thirty-five of these were saved for planting in the fall of 1970 and spring of 1971. Most of the 250 head selections that appeared to be fertile when selected in Mexico were sterile at Pullman. Thirty-five of these were saved for planting in the fall of 1970 and the spring of 1971. These will be used in our breeding program.

The fall planted triticales for the 1971 crop include 50 F_1's, 30 F_2's, 3,000 F_3's and 100 F_4's, plus entries obtained from Mexico, Canada, and Jenkins Foundation. The objectives of our breeding program are to (1) obtain a high yielding, winterhardy semidwarf triticale for use as a fall-sown feed and/or seed crop in Washington and, (2) winterhardy snowmold resistant standard height triticales for early spring pasture.

EVALUATION OF TRITICALE IN THE HIGH PLAINS OF TEXAS, 1968-1970

Kenneth B. Porter

Triticales have been evaluated for grain and/or forage since 1968. Varieties included in some or all trials included those in the uniform regional spring sown trial received from E.N. Larter, University of Manitoba, 1968; 6TA203, 204, 208, 131, 385, 386 from Jenkins Foundation for Research; WS60-2, 60-3 from World Seeds, Inc.; and those in the First International Triticale Yield Nursery from CIMMYT in 1970. Eight separate grain yield trials, including a date of planting trial, have been conducted during the 1968-70 period. Two fall-planted clipping trials and 3 grazing trials have been conducted using 1 or more of the following: A composite of entries in the 1968 Canadian regional trial; Grain Graze 70 from Int. Grains, Inc.; and 6TA208. All trials have been irrigated except for 1 spring-sown dryland trial.

Triticale has produced lower yields than spring wheat and other spring-sown small grain. Triticale, like other small grains, is not well adapted to spring planting in the area.

Triticale appears to have the potential of equaling the yield of winter wheat when seeded in the fall. However, winterhardiness, which has not been a critical factor during 1968-70, is important. The highest yield, 4213 pounds per acre, was produced by 6TA208 from October seeding, but Tascosa wheat produced 4147 and an experimental wheat 4813 pounds per acre in the same test. A more hardy strain, WS60-2, produced only 3138. However, 208, which apparently is day neutral, could be severely damaged by low temperatures.

Triticale included in forage trials planted in early September produced no more forage than barley, rye, or wheat. Stands of Grain Graze 70 and 6TA208, which produced good early growth, were drastically reduced by winter damage when grazed or clipped. This resulted from grazing or clipping these day neutral varieties below the growing point.

Triticales evaluated thus far appear to have limited value on the High Plains of Texas.

PERSPECTIVES ON MAXIMUM YIELD

J. R. Welsh

Any attempt to cover in detail all aspects of yield in the time allotted is futile. I will try to bring out a few points on yield that are probably obvious to most but may help stimulate participation and discussion from the group, which will be most meaningful in the long run.

There are a number of ways of looking at variables that result in some yield figures. It seems to me that because of our own interests, shortsightedness, limitations or other reasons, we tend to have restricted-vision when we look at what we consider to be most important factors in determining yield. It is for the purpose of discussing some of this restricted vision that I would like to speak today.

The amount of grain produced is a function of some combination of variables including spikes per unit area, kernels per spike, and kernel weight. To say that little success has been achieved in manipulating the existing germ plasm to produce plants with a higher yield potential would be in error. One needs only to look at yield patterns and variety development in any given area such as the Central Great Plains, the Pacific Northwest, or the Ohio Valley. We are all familiar with the outstanding success of Dr. Borlaug and his associates in the CIMMYT program in developing genotypes with outstanding yield potential under many environments. In each geographic area, with some exceptions, the improvement in yield through germ plasm manipulation is the result of conscious selection for those characteristics that we can evaluate by visual observation and by serendipity (discoveries by accident). The variety Scout is an example of a combination of these two things. It was selected consciously for such characteristics as stem rust resistance and desirable plant performance under stress. Through extensive testing over a large geographical region, its wide area of adaptation was observed. I submit that the adaptation factor is serendipity, although in terms of total yield it may be more important than those factors consicously selected for. In studying the 1969 Wheat Newsletter, I am impressed with the heavy emphasis on the research of fine details of the systems to which we can apply pressure easily, and the almost total lack of attention to the unexplained systems that may in the long run be most important in determining yield. I would have to include in this latter group the importance and inheritance of: (1) respective components of yield, (2) morphological features such as leaf size, shape, angle and placement and (3) physiological systems to improve water and nutrient energy use efficiency. All three of these and other factors may be interrelated. Indeed, if we were to understand more of these subjects, our efficiency would be greatly increased in making yield progress. Undoubtedly this would improve selection ability in earlier generations and make the intelligent selection of proper parental combinations much easier. Ultimately this knowledge could remove the present yield ceilings that we now experience. I'm afraid at the present time the system is almost entirely a numbers game with a major part of the success going to those with a good breeding eye who are equipped to test large populations. Some of this information could be obtained in the present framework of research. Other research efforts would necessitate additional involvement of expertise from neighbor disciplines. Undoubtedly the physiologist and the biochemist are allies that are a too often neglected but are a vitally important part of the research team.

It could be that obtaining and utilizing this type of information could present the most reasonable combine of efforts by public and private sectors in the wheat improvement industry. The application of this information would be of equal importance to obtaining it.

Estimates vary as to how much of the yield improvement in recent years can be claimed by management (cultural practices) and how much by genetic improvement. Certainly, progress has been made in dryland areas; for example, in yield increases because of moisture conservation and wind damage control. Predictions are becoming more and more accurate relative to expected fertilizer response under a given set of environmental conditions. Differences of genotype by environment interactions have been documented, for example, with the semi-dwarfs under irrigation. It seems to me that we ought to be considering genotype by environment interactions much more than we have in the past. I'm sure many of us have discarded selections that may represent outstanding yield potential under management practices different from those in our nurseries. This is going to become more important as the morphology of our plants continues to change. While there are an infinite number of genotype-management combinations, there are undoubtedly selected combinations that could provide the framework of information on which the decisions to refine or abandon could be based. In addition, the research information discussed in the initial portion of this presentation could be seriously affected by changes in management. For instance, does the leaf angle and effective photosynthetic area of a given genotype vary with plant populations and geometric patterns, and if so, what effect does this have on the total yield of this genotype under various nutrient programs? I leave the answering of this question to the audience.

I have purposely left out any discussions of hybrid wheat in this paper. It seems that answers to those questions I have raised could apply equally well to varieties or hybrids. In fact they may be even more pertinent to hybrids because of the possible additional advantage from heterosis in some systems or management practices.

In summary, we have made good progress in improving yield both through breeding and cultural practices. I feel, however, that we have made no more than a respectable dent on the surface of yield research and development. If we are willing to be far-sighted and even a bit visionary, we can remodel the wheat plant and its culture to surpass what reasonable men now consider impossible.

MAXIMIZING WHEAT PRODUCTION: HYBRID WHEAT

J. W. Schmidt

One of the problems in hybrid wheat production is in seed set in seed production fields. Research in 1969 indicated that seed production would need to be restricted to the areas of more favorable rainfall and humidity. Even under the more favorable conditions of eastern Nebraska, seed production in the center of a 32-row male sterile plot dropped nearly 50% from seed set in the outer rows of the plot. This suggests that it may be profitable to use some means of moving pollen from the pollinator rows to the sterile rows. In 1970 helicopters were used successfully in Nebraska for hybrid seed production in corn. This offers a possibility for improved hybrid seed production in wheat also.

The hope that hybrid wheat would tiller more profusely than their conventional counterparts does not appear to be well founded. Our research over the past few years has failed to show any advantage of the hybrid over their B-line counterparts.

In 1970, the hybrid wheat yield test at Mead, Nebraska, was grown as four-row and as single-row plots in adjacent nurseries. The hybrids failed to show much competitive advantage in single-row plots.

The cytoplasm from a 28-chromosome wheat may produce interactions with a 42-chromosome nucleus other than the production of male sterility. Poor kernel filling is often evident. Baking quality impairment in A lines has been seen. Failure of hybrids to perform as well as anticipated from hand-made cultivar crosses could be partly attributed to adverse cytoplasmic-nuclear interactions. Cytoplasmic change through the use of the new cell fusion methods might offer some promise.

Major genes whose optimal expression is in the heterozygote are needed to produce maximum hybrid vigor. A multiple spikelet strain produced by Dr. Koric from Zagreb, Yugoslavia, shows promise. We are currently investigating this possibility.

PERFORMANCE OF WHEAT HYBRIDS IN THE TEXAS HIGH PLAINS

K. B. Porter

Experimental hybrids developed by commercial companies have been evaluated in 1969 and 1970. In most cases they have not been sufficiently fertile and none have been superior to adapted varieties. In 1970 the hybrids shown in the table below were included in both irrigated and dryland nursery plot trials. They tended to set less seed than the parents and this may account for their relatively low yields. However, some of the hybrids appeared to be about as fertile as their parents but none produced a significantly higher yield than both parents. Similar results were obtained at other locations in Texas.

Hybrid or Parent Pedigree or Variety	Yield bu/A Irrigated	Yield bu/A Dry	% Seed Set Dryland
ms Knox x NB3547[a/]	47.0	25.7	62.3
ms Concho x NB3547	67.9	29.8	84.6
ms Sturdy x NB3547	63.5	25.9	75.4
ms Caddo x NB3547	60.3	27.0	75.7
ms Triumph x BN3547	56.8	27.9	76.4
ms Agent x NB3547	64.3	29.1	84.1
ms Parker x NB3547	62.0	27.8	87.9
Average	60.3	27.6	78.1
ms Knox x BA130[b/]	52.0	23.2	68.1
ms Concho x BA130	66.2		81.6
ms Sturdy x BA130	60.6	23.8	94.7
ms Caddo x BA130	62.2	27.7	90.7
ms Triumph x BA130	60.2	21.6	76.1
ms Parker x BA130	55.2	25.8	90.1
Average	59.9	24.4	83.6
Knox	48.4	25.8	85.3
Concho	68.8	28.0	88.8
Sturdy	70.8	21.4	91.9
Caddo	60.7	29.6	92.2
Improved Triumph	70.8	28.4	83.6
Agent	66.6	26.1	91.5
Parker	60.6	29.9	85.1
NB3547	69.5	28.1	93.1
BA130	59.4	23.3	78.9
Average	64.0	26.7	87.8
LSD 5% Level	8.4	5.1	
1% Level	11.2		

[a/] NB3547 = Nebraska R-Line.

[b/] BA130 = Bushland R-line selection from T. timopheevi / Mq^3 // Bison received from R.W. Livers, Kansas.

HIGH YIELD IN HYBRIDS AND VARIETIES

Ronald W. Livers

From 1965 through 1968 a diallel study of 36 wheat hybrids and their 9 hard red winter parent varieties was grown at Hays, Kansas. Hand-crossed seed was grown in replicated single-row plots. Yield data through 1967 have been publsiehd (3rd Int. Wheat Gen. Symp. 431-436, 1968). All hybrids were superior to their better parent and varaged 132% of the mid-parent yield; and the best hybrid exceeded its better parent by 10.2 bushels or 31%. However, the 36 F_2's compared with their parents in separate experiments have shown no heterosis whatever.

Analysis of parental contributions to hybrid performance is not complete, but a few observations may be made. There were 8 hybrids involving each parent. Mean yields of these groups over 4 years were as follows: Tascosa, 38.1; Scout, 37.3; Cheyenne, 36.9; Bison, 36.6; Pawnee, 36.5; Parker, 35.8; Ottawa, 35.6; Concho, 34.2; and Triumph, 33.6. No matter how we measure performance of these 9 hybrid groups, (compared with midparent, better parent, or best variety in trial), the Tascosa group is always outstanding; and the hybrids of Triumph, Concho and Ottawa are always quite low.

There is a strong relation (r=.63) between midparent yield and hybrid yield. The regression shows that as midparent yield goes up a bushel, the hybrid yield can be expected to go up .8 bushels. When deviations from regression are calculated for the 4 years and grouped by parents, the Tascosa group is again outstanding. All Tascosa hybrids had plus deviations from regression, averaging 2.6 bushels better than would be calculated from their parental performance. Cheyenne, Pawnee and Bison hybrids averaged slightly better than expected. The other five parental groups of hybrids came off nearly a bushel poorer than expected from regression analysis.

Obviously the Tascosa hybrids are a superior yield group. Does this knowledge have any application in breeding of pure lines? To date, in choosing parents of crosses, we have no better criterion than their own performance. It is reasonable that yield of F_1 hybrids might also be used to point out superior parental material. Yields of a number of F_3 and F_4 lines from Tascosa crosses at Hays are quite promising, and there is a suggestion that we may be succeeding in capturing some of the superior yield noted in F_1.

DEVELOPMENTS IN HYBRID WHEAT

J. A. Wilson

Considerable evidence has accumulated for heterosis in space-planted, single-row hybrid yield tests grown in single rows. However, the superiority of hybrids under normal seeding rate is the point in question at this time.

Under conditions of normal seeding rate, in a replicated, single-row yield test, involving 13 hybrids and 4 check varieties, the average yield of the hybrids exceeded the average yield of the varieties by 40%. In this test the hybrids appeared to grow at a faster rate and tended to crowd out the inbreds. The inbreds appeared to be at a disadvantage by the proliferating vegetative vigor of the hybrids in this test, but the superior grain yield of the hybrids might not exist in plots where crowding of genotypes is eliminated.

Several single-cross grain hybrids have been produced on a field scale by our Foundation Seed Department. These hybrids have been tested widely on farm fields and in numerous replicated yield trials involving our own and public tests. Three single-cross grain hybrids, A227, A234, and A235, have been tested in drill strips over the past 2 years at normal seeding rate and appear equal, but not superior to check varieties of their maturity classes. Hybrid superiority has been observed at some locations, but on a general adaptation basis the superiority appears questionable. Generally, the agronomic weaknesses of excessive straw, lodging and improper maturity made the measurements for heterosis uncertain.

Hybrid-environmental interactions were encountered with the above hybrids. It is increasingly clear that hybrid genotype and environmental conditions must be mutally compatible for maximum grain response. Due to certain agronomic or disease weaknesses the first hybrids to be released may have a restricted distribution until greater general adaptation is achieved with more advanced agronomic types.

Utilization of F_2 seed for a commercial crop does not appear to be justified from the data accumulated thus far with restored forms. The F_2 however may be useful in determining the presence of heterotic combinations by comparing yields of the F_1 with the F_2. Other factors such as sterility, maturity and etc. must be considered in the interpretation of the inbreeding depression observed in the F_2 yield. Generally, the F_2's have shown 10% less yield than the F_1's. One location with one hybrid did not show an F_2 yield depression.

The wheats in the southern hard red winter region are utilized extensively for pasture and grain. In this region, a significant part of the economy of wheat is based on its pasture potential. Utilization trends now developing in the High Plains of Texas point to the important role of forage in the dual-purpose wheat areas.

In a 1966 clipping test at Wichita, Kansas, the 49 chromosome forage hybrid, HG 3, and its two parents, a 56 chromosome Agrotricum and a 42 chromosome wheat, were clipped at the same intervals throughout the growing season. The hybrid showed a superiority of 12% over the high parent and exceeded the lower yielding parent by more than 30%.

Two 49 chromosome forage hybrids have been released to farmers and ranchers in the Southwest. They have been distributed for the purpose of filling the late spring grazing gap and of providing the Southwest grower with a streak mosaic, drought tolerant, high yielding cool season forage crop. HG 3 has yielded up to 5.36 tons of air dry forage and has shown an overall protein average for the year of nearly 22%. Fall and early spring protein may exceed 25% in HG 3.

The use of hybrid grain and forage wheats on a broad scale will be determined by their performance and the efficiency or economy of producing the seed. With the commercial production of hybrid forage wheats in some areas at the present time, it appears that hybrid grain types are forthcoming for all reasonably productive wheat environments.

FIELD POLLINATION OF MALE STERILE WHEAT

Dwight E. Glenn

Our experience with cross pollination of winter wheat leads us to conclude that male sterile wheat can be increased and hybrid wheat can be produced using a 3:1 ratio of male sterile to pollinator plants with the width of the male sterile strips being approximately 40 feet and the width of the pollen producing strip being 12-14 feet. Most of the male sterile lines we have been using for the past three or four years and all the experimental hybrids we've produced have given satisfactory results using this system.

We evaluate our results on the basis of yield per acre, though there are many other equally good methods of determining seed sets. We have chosen this method since it will more adequately reflect the cost per bushel of our raw seed. The B-lines we use have all been evaluated in our yield trials with commercial varieties being grown, so that a comparison of the A-line yield to the B-line yield, we think is realistic. By successful, I mean that we expect to obtain between 60% and 75% of a normal yield on a A-line, though we have had some yield less and a few more than this range.

We have experimented with wider ratios, but have noticed that seed sets begin to diminish in the middle of the A-line strip when it's width exceeds 50 feet or so. The other alternative is, of course, to make the pollinator strip more narrow, but this causes difficulty in harvesting with the large commercial combines that are in common use today. This is the system that we are using for increase and maintenance of A-lines, but we have wondered if this is the most efficient system for hybrid seed production. It has certain disadvantages; such as a relatively large percentage of land devoted to growing the pollen parent, and the barrier strip between male and female can in some instances, become infested with weeds. We have wondered if the narrow row culture employed to grow wheat offers some other possibilities which might not be practical under wide rows, such as are used for corn or sorghum hybrid seed production.

Several workers have suggested that blending or mechanically mixing the A-line and R-line might be a reasonable approach to producing hybrids. Our experience with this technique has generally been satisfactory, provided that the A-line and R-lines are selected for nicking ability. Since this is not always possible, we have tried inter-planting individual rows of pollinator within the block of male sterile. This system would seem to offer greater possibilities in that it could be used with a wider range of materials than could be, using a pure mechanical mix. We are using this technique at the present time to produce a forage wheat hybrid. With this particular cross, we're planting two drill rows of male to 18 rows of female in a typical 20 hole commercial grain drill.

We are harvesting a blend of F_1 and pollinator seed. With the crop being used for forage, this low percentage of pollinator plants is not objectionable, though when we begin to consider this system for the production of grain hybrids, it is likely that more serious objections will be raised. We will need to give more consideration to differences in maturity, as well as height, and other physical characteristics. Of course, performance of the R-line itself will be a significant factor, as this could detract from the performance of the end product in the farmer's field.

This may not prove to be a workable system, but if through greater efficiencies and better land use it can reduce the cost of hybrid seed, then perhaps it is worthwhile to consider. At least it offers some interesting alternatives in the area of hybrid wheat seed production.

MAXIMIZING WHEAT PRODUCTION: CULTIVARAL VARIATIONS

E. G. Heyne

The establishment and maintenance of diversity and variability in self fertilized cultivars is a useful concept. Some system that provides for a reasonable appearing phenotype has been shown to be acceptable to farmers even though the mixture is as evident as brown and white chaff colors. Slight variations in height, maturity and grain appearance have also been accepted by farmers as long as the cultivar performs satisfactorily. Increase of F_2 plants provided satisfactory cultivars many years ago (Ceres spring wheat). Selections made in "pure lines" and other sources such as increases of F_2, F_3 or F_4 plants in Kansas has shown that the "mixture" or original has generally performed better than any of the individual lines. However, for certain specific characteristics the reselection may be superior. In present day breeding programs in wheat an economical and effective way in which to sample many crosses is to study the progeny of F_2 plants or F_3 spikes, with the intent of developing cultivars without further reselection.

YIELD COMPONENT EVALUATION

F. H. McNeal

The value of using yield components as selection criteria was evaluated in a 7-year study in Montana. Beginning in 1964 with 1000 F_2 plants of C. I. 13242/Thatcher, plant selection was practiced for 6 years through 1968.

A yield trial was conducted in 1970 at three Montana locations using remnant seed from each of the yield component categories. Average yields from a composite of lines selected for kernels per head and for kernel weight were significantly higher in yield than lines selected for other characteristics. Selecting for heads per plant and for grain yield per plant was a losing battle, as we obtained the lowest yields from the groups selected in this way. Average yields from the three locations for various selection criteria were:

	bu/A
Heads/plant	41.9c
Kernels/head	50.9a
Kernel weight	52.5a
Spilelets/head	46.3b
Grain yield	43.7c

On reflection, tillering may not be as important as other components since we can exert some influence on number of heads produced on a given area by adjusting seeding rate.

COMMENTS ON "MAXIMIZING WHEAT PRODUCTION"

R. E. Allan

By use of near-isogenic wheat lines in the cultivar "Burt" background, we have attempted to measure the various agronomic virtues of the Sd_1 and Sd_2 gene that in combination control height of Nrn 10/Bvr 14 (C.I. 13253). Results collected over a three-year period show the Sd_1 genotype may have certain advantages over the Sd_2 genotype in grain yield (+8.1%), test weight (1.4 lbs.), tiller number (+2.3%) and emergence rate index (+11%). A slight advantage for the Sd_1 genotype in 1000 kernel weight occurred some years. The Sd_1 gene produces a longer coleoptile (+5%) and first-leaf (+7%) than the Sd_2 gene. The Sd_1 genotype also averages about 3 cm. taller than the Sd_2 in the Burt background. Some evidence suggests that lines with the Sd1 genotype may be better adapted to unfavorable yield conditions than lines of Sd_2 genotype. Yield differences between the two genotypes are less apparent under high N conditions.

THOUGHTS CONCERNING PURE SEED PRODUCTION

Howard Wilkins

What is a variety?

The term variety (cultivar) denotes an assemblage of cultivated individuals which are distinguished by any characters (morphological, physiological, cytological, chemical or others) significant for the purposes of agriculture, forestry or horticulture, and which, when reproduced (sexually or asexually) retain their distinguishing features.

The standards of the Association of Official Seed Certifying Agencies contains the statement: "Other varieties shall be considered to include plants or seeds that can be differentiated from the variety that is being inspected, but shall not include variations which are characteristic of the variety as defined by the breeder."

Variety descriptions supplied by the breeder very seldom if ever include the complete listings of the variability that the variety contains. Seed producers must have a complete description in order to maintain and purify the material. The AOSCA standards define the off-types and/or varieties in the foundation class to be 1 per 3,000; registered class 1 per 2,000 and the certified class 1 per 1,000. Would any field actually pass inspection?

The seed certifying agencies now are to operate under the limited generation system with the certified class being the end of the line for certification. The definition of the classes of seed allows foundation seed to be the progeny of foundation seed, but does not allow the certified class to be used for further certification. If a class of certified seed of a self fertilized crop were inspected and found to pass with less than 1 per 3000 off-type plants then why isn't this pure enough for recertification? Why do we limit the generations on one end and not the other? Can this be justified genetically? Is it economic?

We have the National Variety Review Boards established for variety approval. Why aren't these boards used for each variety released?

I feel that it is time for everyone to think and act along the practical lines.

SOME CONSIDERATIONS IN BREEDING FOR HIGH YIELDS IN SOUTHERN GREAT PLAINS

E. L. Smith

The advent of the 'Green Revolution' and reports of yields in excess of 200 bushels per acre in certain wheat growing areas of the world have placed additional sources of pressure on wheat research teams in the Southern Great Plains. Our growers are asking for varieties or hybrids that will put them in this 'high yield' bracket.

As wheat workers in the Southern Great Plains what can we do about it? Our first reaction might be to try to explain why it is not possible to match the 'Green Revolution' production levels because of severe limitations imposed by our climate. We can point out such problems as drought, unproductive soils, untimely high and low temperatures, high winds, hail, and a wide spectrum of pests. On the other hand, we can accept the challenge and shoot for the 200 bushel yield level. I believe it can be done. We have come part of the way already. Wheat yields of 100 bushels per acre were obtained in the Southern Great Plains in 1970.

High production levels won't, I believe, be made by genetic improvement alone, although this will be a vital part of it. The environment must be considered also. Major limiting factors imposed by the environment must be identified and methods developed for alleviating or circumventing these factors. The development and use of genetically superior varieties will have to be coupled with better soil and water management, improved cultural practices, and effective pest control.

Traditionally, we have developed and grown 'Turkey Type' varieties in the Southern Great Plains. In our breeding programs for the past 20 years we have been concerned with bread making quality, rust resistance and yield, and for the most part, I would judge, in that order of priority. During this period, substantial genetic improvement has been made in these three characteristics as well as in the improvement of straw strength.

What comes next? In order to get 200 bushel per acre yields will we have to abandon our 'Turkey Type' model and substitute a completely different architecture as far as the wheat plant is concerned? I don't believe so, unless we can make substantial changes in the environment of the Southern Great Plains. There is good reason for the fact that 'Turkey Type' varieties have been so successful in this area and I believe we will have to stick with this basic type. But genetic improvement must be made in certain parts of the plant.

Let's consider the following systems of the plant and see what kinds of changes can be made and where we want to make them.

a) Straw strength. We will need stronger straw and moreover we will need a certain quality of straw. Resiliency with strength, I believe, is to be preferred to stiffness per se. We will not want to go to a complete semi-dwarf type unless it is for irrigated areas.

b) Root system. I believe the success of the 'Turkey Type' variety is due, in large part, to a vigorous and extensive root system that is remarkably efficient in extraction of water and nutrients from the soil. I believe it is essential that we keep this type of root system.

c) Tillering capacity. Under optimum growing conditions, according to Donald (Euphytica 17:385-403. 1968), the ideal wheat plant should have but a single culm. This may be true for optimum growing conditions, but in the Southern Great Plains conditions are seldom optimum. Consequently, I believe we need a genotype with a high tillering potential that allows some flexibility to the plant depending on environmental conditions.

d) Size of spike and kernel. Traditionally, our varieties have had rather small slender spikes which under certain conditions will set 3 seeds per mesh. The size of kernel has not been too bad but types with larger ones are grown in other areas. Germplasm is available for increasing these two components and herein, I believe, lies the way toward maximum genetic improvement for yield. Admittedly, there is a complex interrelationship among the three yield components (tiller number, kernel weight, and kernels/spike) and an increase in one component may well result in a decrease in one or both of the others. However, there is, no doubt, an optimum point of balance involving these components. We need to find it.

The breeder must also consider quality, pest resistance, maturity and other characteristics such as winter grazing potential in the development of high-yielding varieties. In any event, we must be in a hurry. We can no longer afford the luxury of the conservative approach to breeding and the extensive testing of potential varieties. We should take as many short cuts as feasible in variety development in order to maximize yields.

STUDIES OF THE PHYSIOLOGY AND EARLY DEVELOPMENT OF THE WHEAT PLANT

Donald W. George

Early-seeded, prostrate-growing wheat is effective in reducing both wind and water erosion, which are occasionally very severe in the Pacific Northwest. Winter wheat is the crop best adapted to the region. But none of the presently grown wheat varieties is designed for very early seeding. Hazards to early seeded wheat include: increased losses from *Cercosporella* foot rot and several foliage diseases, especially stripe rust; winter injury; and the likelihood of too early growth in spring resulting in frost injury. Early seeded wheat will provide an overwintering place for stripe rust unless the variety has good seedling resistance, and greenbug infestation is a likelihood.

Post harvest dormancy, commonly a characteristic of freshly harvested seed of most wheat varieties, necessitates holding planting seed from the previous year in order to insure good emergence from early seeding.

We are following several lines of investigation toward the goal of a wheat variety capable of surviving the winter and producing well when seeded as early as July. It must germinate and emerge well in a hot seedbed and make good late summer growth. Its vernalization and photoperiod requirements must insure that it will remain vegetative, or at least, that the stems will not elongate, until April. It must have the characteristic of tillering vigorously whenever frost damages the primary tiller heads. And it must have superior resistance to diseases both of the foliage and the root system.

Our winterhardiness testing program utilizes a modification of the Marshall crown freezing technique. With it we are able to screen the advanced yield nurseries and eliminate lines with inadequate winterhardiness. Growing point development and elongation is being watched in all varieties of the advanced yield nursery in an attempt to identify and eliminate those lines susceptible to spring frost because of rapid early culm elongation. This same group of varieties and potential varieties are tested and classified after harvest for post harvest dormancy. Work is planned in cooperation with the Western Wheat Quality Laboratory to study whether or not a relationship exists between postharvest dormancy and alpha amylase content of the grain. Low alpha amylase is necessary in flour used for the manufacture of Japanese noodles.

PHOTOSYNTHETIC AREA AND STOMATE DISTRIBUTION AND FREQUENCY ON THE INFLORESCENCE OF WHEAT

I. D. Teare

We measured the photosynthetic area of various components of the wheat inflorescence--glume, lemma, palea, and awn--in an attempt to determine reasons for variability in yield of Triticum aestivum.

Photosynthetic area was determined by measuring the area of the glume, lemma, palea, and awn and estimating the proportion that contained chlorophyll. The area of the glume and awn were considered 100% effective for photosynthesis, but the lemma was considered only 63% effective and the palea 9% effective in photosynthesis.

The cultivars were divided into three groups according to awn area index; long awned cultivars with an awn area index over 1.0, medium awned cultivars with an awn area index between 0.1 and 1.0 and short awned cultivars with an awn area index less than 0.1.

Makeup of the inflorescence area index for the long awned cultivars was 25% lemma, 18% glume, 2% palea, and 55% awn; of medium awned cultivars, 30% lemma, 23% glume, 2% palea, and 45% awn; of short awned cultivars, 53% lemma, 41% glume, 3% palea, and 3% awn. When inflorescence area index was compared with leaf area index, the inflorescence area index represented 124%, 95%, 42% of the flag leaf area index (adaxial surface) of the long, medium, and short awned cultivars, respectively.

The inflorescence area index was used in a simple regression analysis to predict grain yield with a resulting correlation coefficient of 0.942. The correlation coefficient with awn area index as the independent variable was 0.841, which supports previous reports of the importance of the awn in filling the ear.

To measure the diffusive capacity of the various components of the wheat spikelet, we counted the stomates per unit area of lemma, palea, glume and awn to determine stomatal distribution and frequency for each component. Field data--such as spikes/Ha; spikelets/spike; lemma, glumes and paleas/spikelet--were used to estimate the potential diffusive capacity of the inflorescence on a hectare bases.

Stomates occurred in rows on the abaxial surface of the lemmas and glumes. The portion of the lemma covered by a glume or adjacent lemma did not have stomata. A single row of stomata extended down each side of the crease of the palea. Each awn had 2 parallel rows of stomata at the base, which spiraled up the awn and were reduced to one row at the tip.

We found that awn stomata/Ha could range from fewer than a billion to 79 billion/Ha depending on the expression for awns. The palea stomata ranged from 10 billion to 56 billion /Ha, lemma stomata from 113 to 169 billion/Ha, and glume stomata from 96 to 138 billion/Ha. Inflorescence stomata/Ha represented 15 to 19% of the flag-leaf stomata/Ha.

IRRIGATING AND FERTILIZING WINTER WHEAT ON THE HIGH PLAINS OF NEW MEXICO

R. E. Finkner

Irrigation and nitrogen tests were conducted using the variety Scout in one experiment and Sturdy in the other. The Scout test had nitrogen applied in the fall of 1967 and three crops were harvested from these plots. The Sturdy test had the nitrogen applied in the fall of 1968 and two crops were harvested from these plots.

The plots were arranged in a split plot design with irrigation being the main plots and nitrogen levels as the sub plots.

Table 1 gives the main effect of yield for irrigation regimes and nitrogen levels.

Nitrogen carry-over was evident in the Scout test in 1969 but not in 1970. Yields in the 1970 Sturdy test were low indicating no nitrogen carry-over in this test. Because Sturdy does not lodge as easily as Scout, it can utilize more of the nitrogen and produce higher yields with increased water applications.

Table 1. Main effects of yield (bu/A.) from irrigation regimes and nitrogen tests using varieties Scout and Sturdy.

		Varieties				
		Scout			Sturdy	
	Inches	1968	1969*	1970**	1969	1970*
Irrigation Regimes	12	51.3 c	58.8 abc	39.2 b	53.9 d	34.5 a
	18	60.3 a	55.0 c	40.6 ab	58.2 c	37.4 a
	24	55.8 b	57.7 abc	39.0 b	66.0 b	31.9 a
	30	60.8 a	60.2 ab	36.8 b	66.9 b	33.9 a
	36	54.9 b	61.1 a	37.5 b	70.2 a	35.8 a
	42	55.0 b	57.0 bc	43.7 a	72.0 a	35.2 a
Nitrogen Application	100	58.3 a	49.5 c	38.9 a	62.0 b	33.4 a
	200	56.5 ab	60.4 b	38.6 a	65.8 a	35.3 a
	300	54.2 b	65.1 a	40.8 a	65.8 a	35.6 a

* One year residual effects
** Two year residual effects

Any two means followed by the same letter are not significantly different (Duncan's Multiple Range at 5% level).

THE EFFECT OF RATE AND DATE OF SEEDING OF IRRIGATED WINTER WHEAT UNDER TWO NITROGEN LEVELS

R. E. Finkner

Field tests using seven different seeding rates and four planting dates, with each at two different levels of nitrogen were planted in 1967 and 1968. The field plot design was a 7 x 4 x 2 factorial within a randomized complete block design, with three replications.

Table 1 shows a two-year average of the main effects of yield and other agronomical characteristics for date of planting, rate of seeding, and nitrogen applications with the variety, Scout wheat.

A significant interaction was detected between rate of seeding and date of planting as shown in Table 2.

Results of this study indicates the optimum planting dates on irrigated land of the High Plains of New Mexico would be in October. Early planting without grazing can cause the wheat to lodge, which limits production. Late sown wheat tillers less, especially at low seeding rates, and yields are likewise limited. However, the possibility of utilization of fall growth by grazing might justify earlier planting at heavier seeding rates.

The most economical seeding rates at the October plantings varied from 30 pounds per acre to 45 pounds per acre. Even the 15 pound seeding rate produced good yields. If very expensive hybrid wheat seed is being sown, the 20 to 30 pound seeding rate could well be the most economical if planted early. A late planting date can be compensated for by increasing the rate of seeding.

Nitrogen application of 100 pounds per acre produced as high yield in these tests as the 200 pound rate. In soils which are low in nitrates and where moisture is not a limiting factor, the 200 pound rate should be considered. However, there has always been the danger of lodging with too much nitrogen.

Table 1. Main effects of yield and agronomic characteristics studied, for years, nitrogen rates, seeding rates, and seeding dates at the Plains Branch Station, Clovis, New Mexico.

Years	Date Headed	Date Ripe	Plant Height	Weight per 1000 Kernels	Test Weight per bushel	Yield per Acre	% Lodging	No. Seedling per 20 feet	No. Heads per 20 feet
	May	June	in.	grms.	lb/bu.	bushels			
1967-68	17.1 b	25.5 a	40.3 a	31.5 a	63.1 b	58.2 a	25.4	174 a	802 a
1968-69	10.9 a	26.3 a	44.6 b	34.8 b	60.1 a	58.8 a	5.3	187 a	892 a
Nitrogen rates per acre in pounds									
100	13.5 a	27.7 a	42.4 a	33.5 a	61.9 a	59.0 a	13.2	181 a	843 a
200	14.4 b	26.1 b	42.5 a	32.9 b	61.3 a	58.1 a	17.6	180 a	852 a
Seeding rate per acre in pounds									
15	16.0 e	27.1 d	41.3 a	33.4 a	61.4 a	53.3 a	9.4	62 a	801 a
30	15.1 d	26.4 c	41.3 a	32.7 a	61.6 a	57.3 b	10.7	100 b	799 a
45	14.2 c	25.8 b	42.1 ab	33.2 a	61.7 a	57.8 bc	13.6	139 c	814 ab
60	13.7 b	25.7 ab	42.6 ab	33.3 a	61.7 a	59.9 cd	11.4	183 d	840 ab
75	13.1 a	25.6 ab	43.1 b	33.2 a	61.8 a	59.3 bcd	18.4	221 e	859 bc
90	12.9 a	25.5 ab	43.4 b	33.3 a	61.3 a	61.1 d	19.5	253 f	902 cd
105	12.7 a	25.2 a	43.3 b	33.0 a	61.6 a	61.0 d	17.5	306 g	916 d
Dates of Seeding									
9/15	8.9 a	23.8 a	45.5 d	32.8 a	61.3 a	57.6 b	31.9	179 b	933 c
10/1	11.2 b	25.0 b	43.3 c	33.2 a	61.7 bc	61.1 c	20.8	168 a	945 c
10/15	15.4 c	26.5 c	41.7 b	33.7 b	61.9 c	61.1 c	6.8	192 c	821 b
11/1	20.3 d	28.3 d	39.3 a	33.0 a	61.4 ab	54.3 a	1.3	183 b	890 a

Any two means followed by the same letter are not significantly different. (Duncan's Multiple Range at 5% level).

Table 2. Interaction of seeding rates x planting dates for yield. Plains Branch Station.

	Dates of Seeding				
Lbs/Acre	9/15	10/1	10/15	11/1	Mean
	-------Yield in Bushels per Acre----------				
15	BC 57.8 ab	C 59.8 a	B 54.9 a	A 40.7 a	53.3 a
30	B 58.0 ab	C 63.2 a	B 58.1 a	A 49.8 bc	57.3 b
45	A 54.6 a	B 59.6 a	C 64.6 c	A 52.3 c	57.8 bc
60	AB 60.5 b	B 62.7 a	AB 59.0 ab	A 57.4 d	59.9 cd
75	A 55.9 ab	BC 60.8 a	C 63.4 bc	AB 57.3 d	54.3 bc
90	A 58.8 ab	AB 61.4 a	B 64.0 c	AB 60.2 de	61.1 d
105	A 57.7 ab	AB 60.5 a	B 63.7 bc	AB 62.2 e	61.0 d
Means	57.6 B	61.1 C	61.1 C	54.3 A	58.5

Any two means followed by the same letter are not significantly different. (Duncan's Multiple Range at 5% level).

IRRIGATION OF WINTER WHEAT, 1970

Galen M. McMaster

A field experiment was conducted on the Twin Falls Branch Station to test the effect of soil-moisture levels over two periods of the growing season on yield and quality of soft white winter wheat. The periods of the growing season were from spring emergence to heading and from heading to maturity. Three soil-moisture levels were maintained by using different irrigation frequencies over both periods of the growing season. Moisture contents of the soil were allowed to vary from field capacity to 60%, 40% and 20% available soil moisture for three irrigation treatments, respectively, over both periods of the growing season. Nitrogen rates of 0, 80 and 160 pounds N/A were applied early in the spring to split plots of the irrigation treatments.

The effect of soil-moisture levels and nitrogen were measured on lodging, plant height, yield, test weight, protein, sedimentation, seed weight, head fullness and head density. Soil moisture samples were taken before and after each irrigation and at various periods between irrigations to gravimetrically determine water consumptive use and determine when the next irrigation should be applied. The soil-moisture level early in the season and nitrogen level affected lodging, yield, test weight, seed weight, head fullness, protein, sedimentation and head density. Soil moisture level late in the season affected only sedimentation.

Table 1. Effect of soil moisture from emergence to heading on lodging, test weight, seed weight, protein, sedimentation and head density.

	Available Soil Moisture		
	60%	40%	20%
Lodging index	0.2	1.0	1.4
Test weight (lbs/bu)	61.9	60.7	59.7
Seed weight (gr/100 seeds)	3.45	3.31	3.14
Protein (%)	9.4	10.4	11.5
Sedimentation	13.5	18.8	22.7
Density (heads/ft^2)	43.6	46.9	48.9

Table 2. Effect of nitrogen on plant height, lodging, test weight, seed weight, head fullness, protein, sedimentation and head density.

	Nitrogen (lbs/A)		
	0	80	160
Plant height (in)	30.7	32.3	32.6
Lodging index	0.0	0.4	2.1
Test weight (lbs/bu)	62.4	61.0	58.8
Seed weight (g/100 seeds)	3.51	3.38	2.94
Head fullness (seeds/head)	34.6	35.3	38.5
Protein (%)	9.1	10.4	11.7
Sedimentation	13.3	17.9	23.8
Density (heads/ft^2)	44.1	48.8	46.6

Table 3. Effect of soil moisture from emergence to heading and nitrogen on yield of grain (bu/A).

	Available Soil Moisture			
Nitrogen	60%	40%	20%	Average
0 lbs/A	73.0	87.7	94.8	85.2
80 lbs/A	91.2	91.8	91.8	91.6
160 lbs/A	86.8	81.0	77.3	81.7
Average	83.7	86.8	88.0	

EFFECTS OF CLIPPING AND APPLICATION OF N, ZN AND CCC ON SCOUT WHEAT

H. D. Fuehring

Clipping Scout wheat on March 26 shortened stems by five inches and increased yield from 3522 to 3999 lb/A. Scout sprayed with CCC on April 13 at 2 lb/A. was three inches shorter and yielded 3823. Lodging was about 20% in both sprayed and unsprayed plots but the clipped plots did not lodge. Nitrogen was applied at 300 lb/A. In a factorial experiment with N and Zn, applied N decreased yields considerably at 22 lb Zn/A but had little effect at 7 lb. Zn. Applied Zn decreased yield much more at 210 lb. N/A than at 70 lb.

Yield of Grain, Scout Wheat, lb/A.

N, lb/A	70	210
Zn, lb/A.		
7 1/2	4462	4534
22 1/2	4304	3728

Effects of clipping and spraying with CCC on wheat. Plains Branch Station.

Entry	Yield of Grain, lb/Acre	Test Weight	6/23 Lodged	6/2 Height
		lb/bu.	%	in.
Scout	3522	58.9	19	41
Scout (clipped 3/26)	3999	59.2	0	36
Scout, CCC (sprayed 4/13)	3823	58.5	18	38
Caprock	4214	59.4	0	34
Sturdy	4027	58.1	0	35
NM 62124	4323	58.4	0	33
NM 63147	3890	58.3	0	37
Tex 62A2607	3657	57.8	0	34
Tex 65A1682	4139	59.5	0	31
Palo Duro	3209	59.8	19	35
Average	3880	58.8		
L.S.D. .05	312	.8		

MOISTURE DEPLETION BY SHOSHONI WINTER WHEAT PLANTED FOUR DIFFERENT DATES AND FOUR SEEDING RATES

R. G. Sackett and B. J. Kolp

Shoshoni winter wheat was planted at the rates of 15, 30, 45, and 60 pounds per acre at four different seeding dates over a two year period at two locations in southeastern Wyoming. Seeding dates were spaced one week apart. The first seeding was August 19 in 1966 and August 20 in 1967. Moisture depletion was measured by using a neutron-probe.

The early planting depleted the soil moisture 1.42 inches from the seeding date until the middle of November, whereas, the last seeding depleted moisture only 0.06 inches. The two higher seeding rates depleted moisture significantly more than the two lower rates.

There was no significant difference in moisture depletion among dates or rates from the middle of November to the middle of March.

The early planting dates produced less straw and depleted the moisture the least from mid-March to harvest. The higher planting rates depleted moisture less than the lower rates during the same period. The rank in moisture depletion as affected by planting dates and rates during the spring and summer was the reverse of that during the fall months. The result was that there was no significant difference among dates or rates in amount of moisture depletion when the entire growing season was considered.

There were no significant yield differences among dates or rates during the test period. The average grain yield in 1965-66 was 38 bushels per acre and in 1966-67 it was 34 bushels per acre. The precipitation during the 1965-66 growing season was 15.11 inches and 1966-67 it was 22.84 inches.

MAXIMIZING SURVIVAL OF PLANTS UNDER SEVERE DROUGHT CONDITIONS

Glenn W. Todd

Vegetative wheat plants growing in the Southern Great Plains region are subjected to winter drought to some degree of severity nearly every year. We have identified a number of plant characteristics that improve survival in plants subjected to drought. In developing new plant materials, plants could be selected which exhibit these characteristics.

These factors are:

1) Water retention of intact seedlings at a given vapor pressure gradient is correlated with overall drought resistance, especially within a species (e.g. barley retains water better than wheat).

2) Ability to "harden" with respect to water retention by subjecting plants to drought before the test (e.g. wheat can be hardened, oats cannot).

3) Transpiration control is greater in more drought-hardy species and this often is correlated with more but smaller stomates (e.g. barley is better than wheat in transpiration control).

4) Improved root development especially with respect to development of shoot was evident in the more drought-hardy barley than in wheat or oats.

5) Avoidance of desiccation appears to be a more important selection feature among the cereal grasses than drought tolerance (e. g. wheat leaves are slightly superior to barley leaves in desiccation tolerance).

6) Photosynthetic rates during water deficits were not significantly different within a number of wheat varieties. When plants were injected to a given water deficit, photosynthesis in leaves was greater in wheat than in oats.

INTERACTION RESPONSES OF WHEAT VARIETIES TO RATES OF CCC AND NITROGEN

Milton D. Miller, John Prato,
R. C. Huffaker, and James T. Feather[1/]

The growth regulating effects of CCC, (2-chloroethyl)-trimethyl-ammonium chloride, in shortening plant stems and some of its effects on wheat were first reported by N. E. Tolbert (J. Biol. Chem. 235:475-479 and Plant Physio. 35:380-385). Since 1963 a total of 14 field experiments have been conducted in California testing this compound on a wide range of wheat and barley varieties under varying rates of CCC and soil fertility levels. Wheat generally has proven more responsive than barley. There has been a striking difference in yield and plant height in response to CCC foliar application among wheat varieties. Presumably this differential response is related to genetic differences between varieties, although the influence of environment cannot be overlooked in interpreting results.

Foliar sprays at the rate of 2 pounds of active CCC/acre including a 1/10 percent surfactant (Tween 20 and X77), applied after tillering and during early jointing generally were the most effective. The best treatments increased yield about 17 percent, reduced plant height about 17 percent, reduced lodging and shatter losses, and increased protein content about 1.7 percent. Where soil fertility was marginal, some slight reduction in grain yield and protein resulted from CCC treatment in some tests, depending on variety.

A foliage spray at the rate of 4 lbs/acre increased yield of Sentry durum wheat by 17 percent, increased the number of spikes per square foot, increased 1000 kernel weight from 48.0 gms to 49.6, reduced height from 51 inches to 37 and reduced straw weight by 22 percent. In a 1967 test 4 lbs/acre of CCC increased the yield of Onas 53 wheat by 28.0 percent, 1000 kernel weight from 31 gms to 32, increased the protein content from 7.0 to 7.4 percent, and reduced plant height by 50 percent.

Treating seed with CCC dusts or solutions preplant did not reduce matured height or influence yield.

In cooperation with USDA Western Wheat Quality Laboratory, Pullman, Washington, milling and baking tests were conducted on wheat produced from CCC-treated Siete Cerros 66, INIA 66, and Sonora 64. The resulting

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[1/] Burton J. Hoyle, WSFS-UC Specialist, participated in one of the experiments conducted at Tulelake, and Sutter County Farm Advisor L. L. Buschmann participated in the Sutter regional experiments.

data, including mixograms reflected no effect from CCC treatment although milling quality did appear to improve with increasing fertilizer and protein levels in both the treated and non-treated samples.

The table below is illustrative of the differential response in 1970 of three of the "Mexican" wheat varieties to 3 levels of foliarly applied CCC and 2 nitrogen fertilizer levels.

WHEAT VARIETY AND CCC X NITROGEN RESPONSE
SUTTER REGIONAL EXPERIMENT
1970

	N_{80} lbs/A			N_{120} lbs/A*		
Variety	CCC_0	CCC_2	CCC_4	CCC_0	CCC_2	CCC_4
			YIELD - LBS/ACRE			
Siete Cerros 66	5752	6665	6575	6217	6577	6192
INIA 66	4120	4562	4515	5485	5820	5750
Sonora 64	4270	4325	5100	5522	6230	6290

Highly significant spray effect: F = 9.30** CV = 8.2%
Respraying 30 days after to provide 4 lbs/acre CCC effect NS
*N_{80} preplant + N_{40} topdressed prior to CCC spray

			EFFECT ON HEIGHT - CMS			
Siete Cerros 66	45.2	39.0	34.7	45.2	40.5	35.5
INIA 66	40.0	36.5	36.0	41.0	36.7	37.2
Sonora 64	36.7	33.5	33.7	38.2	34.0	35.2

Siete Cerros 66 - no spray vs spray**
1 spray vs 2 sprays**

INIA 66 - no spray vs spray**
1 spray vs 2 sprays, NS

Sonora 64 - no spray vs spray**
1 spray vs 2 sprays, NS

			CCC EFFECT ON GRAIN PROTEIN PERCENT			
Siete Cerros 66	9.9	10.2	10.4	10.8	11.1	11.2
INIA 66	13.9	13.7	13.3	14.8	14.1	14.3
Sonora 64	14.4	13.2	13.1	14.7	14.6	14.4

THE EFFECT OF SOIL MOISTURE, RAINFALL AND SOIL CHEMICAL ANALYSIS ON CHECK YIELD LEVEL AND FERTILIZER RESPONSE IN THE HAYS, KANSAS AREA

Carlyle A. Thompson

During the past seven years (1964-1970), fertilizer experiments on winter wheat have been conducted on a total of 69 different sites (about 10 sites per year) within a 60-mile radius of the Fort Hays Branch Experiment Station. In this 24-inch rainfall area the following conclusions have been drawn.

Depth of moist soil and inches of available water (6-foot profile) at planting time have not been good indicators of the check yield level or of response to applied nitrogen or phosphate fertilizers. Each inch of available soil moisture (between 0.8 to 11.2 inches) in the early spring has increased the check yield level by 1.7 bushel (r = .36**), but has had little influence on response to fertilizer additions. For every inch of rainfall (between 0.1 to 7.0 inches) from April 1 to June 1, the check yield level has increased by 1.9 bushel (r = .39**) but the effect on fertilizer response has remained unchanged. A 0.7 bushel decrease (r = -.34**) on nitrogen treated plots has been realized for each additional inch of rainfall in June (between 0.3 to 11 inches).

An increase of one ppm N in the nitrate-nitrogen level (between 1.3 to 14.4 ppm NO_3-N) in the top 24 inches of the soil profile has given a 1.5 bushel increase in the check yield level (r = .39**) and a 0.8 bushel decrease to applied nitrogen (r = -.45). Although organic matter content (between 0.8 to 2.9%) in the top 6 inches of soil does not correlate with check yield level, an increase of one percent has decreased the response to applied N by 4.6 bushel (r = -.39**). Total inorganic nitrogen content (NO_3-N + NH_4-N) in the top 24 inches of the soil profile has not correlated with nitrogen response. Although the nitrate-nitrogen content has a greater influence on the response to applied nitrogen than does organic matter, the combined effect gives a multiple correlation value of R = .54**.

An increase of one pH value (between pH 6.0 to 8.0) has resulted in a decrease of 16 pounds per acre of available phosphorus (r = -.40**) and a decrease in the check level of 5 bushel (r = -.27). For every 20 pounds per acre increase of available soil phosphorus (between 5 to 110 lbs P), yield response to applied phosphorus has decreased one bushel (r = -.42**).

The combined affect of increasing nitrate-nitrogen, available moisture in the soil in early spring and April 1 to June 1 rainfall have a positive influence on the check yield level while increasing pH lowers the check yield level. The combined affect of these 4 variables on check yield level gives a multiple correlation value of R = .67**.

THE EFFECT OF CCC ON SEVERAL WHEAT CULTIVARS AT VARIOUS LEVELS OF NITROGEN

Howard Lafever

The effect of CCC (2-chloroethyl-trimethylammonium chloride) on six different traits of several soft wheat cultivars grown at five different levels of nitrogen was determined in field studies at Wooster, Ohio, in 1969 and 1970. Cultivars used in 1969 were Arthur, Benhur, Logan, Redcoat, Monon, and Reed. In 1970 Monon and Reed were dropped and Blueboy added to the experiment. Topdressed nitrogen levels used were 0, 50, 100, 150, and 200 lbs/acre. CCC levels used were 0 and 4 lbs/acre applied approximately one week after spring growth began (4 to 5 leaf stage). A split-split plot design with 4 replications was used with cultivars as the main plot, rates of N as the subplot, and CCC rates as a split of the subplot.

No significant interactions of CCC with rates of nitrogen were found for any traits in 1969 and the only significant interaction involving CCC and rates of nitrogen in 1970 was for plant height.

Application of CCC in these tests as shown by the data in Tables 1 and 2 significantly changed the mean yield of several cultivars of wheat in 1969 and 1970. In 1969 a significant interaction existed between cultivars and CCC application for yield and % lodging. Although plant height was significantly reduced both years by application of CCC, the % lodging was not significantly reduced. Thus the change in yield which occurred both years does not appear to be due to changes in lodging. An examination of yield components in 1970 indicated CCC application resulted in reduced seed size.

Test weight was reduced by application of CCC both years, however, the effect was significant only in 1970. Percent protein was increased by application of CCC both years, however, the effect was significant only in 1970.

Table 1. Effect of CCC and Cultivar on Wheat Yield (Bu/A) and % Lodging (in parentheses)*

Wooster, Ohio

CCC Level	Arthur	Benhur	Logan	Redcoat	Monon	Reed	Blueboy
				1969			
Check	67.2(55)	52.2(38)	53.3(40)	53.3(36)	47.3(88)	48.1(44)	
4 lbs/A	73.9(72)	56.6(51)	56.4(45)	52.9(38)	47.1(93)	47.1(27)	
Means	70.6(64)	54.4(44)	54.8(42)	53.1(37)	47.2(90)	47.6(36)	
5% LSD-cultivars-6.0 Bu/A and (40%), 5% LSD-CCC level within cultivars-2.9 Bu/A and (12%)							
				1970			
Check	60.8(2)	37.6(0)	44.3(2)	45.2(0)			35.5(6)
4 lbs/A	62.4(2)	37.0(0)	42.1(0)	43.1(0)			34.6(5)
Means	61.6(2)	37.3(0)	43.2(1)	44.2(0)			35.0(6)
5% LSD-cultivars-3.8 Bu/A and (3%), 5% LSD-CCC level within cultivars-N.S.							

* Data averaged over all levels of nitrogen

Table 2. Effect of CCC on Six Wheat Characteristics+

Wooster, Ohio

CCC Level	Heading Date	Plant Ht. (in)	% Lodging	Test Wt. (lbs/bu)	% Protein	Yield (bu/A)
			1969			
Check	5-30	47	50	57.7	13.78	53.6
4 lbs/A	5-30	41**	54	57.4	13.86	55.7**
			1970			
Check	5-27	40	2	56.8	13.52	44.7
4 lbs/A	5-27	36**	1	55.1**	13.70*	43.7*

* Significantly different from check at the 5% level.
** Significantly different from check at the 1% level.
+ Data averaged over all varieties and levels of nitrogen.

AIR POLLUTION DAMAGE TO GREENHOUSE-GROWN WHEAT PLANTS

A. L. Scharen and H. A. Menser

Air pollution damage to wheat plants grown in a greenhouse with a forced-air, evaporative cooling system was indicated by symptoms that could not be explained otherwise. Leaves showing bleached spots and stripes, tip burn, and premature senescence were seen on 'Little Club', CI 4066; 'Gaines', CI 13448; 'Wisc. Sel.', CI 12632; 'Hadden', CI 13488 and 'Asosan', CI 12665.

Attempts were made to duplicate the symptoms seen in the greenhouse by fumigating wheat seedlings with ozone or sulfur dioxide. Little Club, Hadden, and Gaines seedlings in the 3-leaf stage were not damaged by 4 hours exposure to O_3 at 0.08 ppm and SO_2 at 0.25 ppm, but seedling of the same 3 cultivars sustained severe leaf-tip burn and scald when exposed to O_3 for 3 hours at 0.42 ppm. At 0.20 ppm O_3, seedlings were damaged after 3 hours exposure, and damage increased with exposure extended to 6 hours. No varietal differences were evident.

In subsequent fumigations of seedlings of the same cultivars for 5 hours at 0.12 ppm and 0.08 ppm of O_3, all plants were injured but Hadden was less damaged than Gaines and Little Club.

Wisc. Sel., Hadden and Asosan were selected for study in four different environments. Little Club and Gaines were not used because of interference by powdery mildew.

For each cultivar, three 5-inch pots containing 6-day old seedlings in soil were placed in each of the following environments:

(1) Ordinary greenhouse
(2) Floral-breeze greenhouse
(3) Activated charcoal filtered air
(4) Balanced unfiltered air, flow of air same as (3).

After 3 weeks in the above environments, all plants were harvested and dry weights of shoots and roots recorded. Symptoms, as already described, developed on plants in all environments except the charcoal filtered air. However, there was no difference between the weights of plants grown in the charcoal filtered air and the ambient air being pumped at the same flow rate. Plants grown inthe same flow rate. Plants grown in the floral breeze greenhouse weighed slightly more than those grown in an ordinary greenhouse, but less than those in the high air flow charcoal filter and balanced air flow houses. The measured effect on growth of roots and shoots was due much less to the noted damage than to increased or decreased air flow over the plants.

EFFECTS OF ETHREL CHEMICAL GROWTH REGULATOR ON THE AGRONOMIC CHARACTERISTICS OF SPRING WHEAT AND BARLEY

Vern R. Stewart

The effects of the growth regulator Ethrel (2-chlorethane phosphonic acid) have been studied at the Northwestern Branch of the Agricultural Experiment Station, Montana State University. The effects of this material on spring wheat yields, test weight, lodging and kernel size were evaluated during 1967 and 1968.

At the Northwestern Branch Station, Ethrel was applied to Sheridan spring wheat at rates of 1 and 2 pounds per acre during the tillering, early boot and late boot stages of growth. Plant height was reduced significantly and maturity of the crop was delayed, but effects of treatments on yield, tiller number and test weight were not significant statistically. Lodging severity was reduced as the rate of Ethrel was increased at the late boot stage of development.

INTERNATIONAL DISEASE NURSERIES AND THE WHEAT NEWSLETTER

K. L. Lebsock

Scientists with the Agricultural Research Service, U. S. Department of Agriculture have coordinated regional, national and international wheat testing programs for many years. A uniform Rust Nursery was initiated in the early 1900's by Stakman, Humphrey and Clark, and by 1919, the U. S. and Canadian scientists began to exchange information from this nursery. In the 1940's, Dr. Bayles, USDA, started a rust testing program between the U.S. and the Mexico-Rockefeller group. The emergency caused by the rapid spread of race 15-B of stem rust prompted Dr. Rodenhiser, USDA, to arrange for a test of almost 1,000 lines from the U.S. World Collection of Wheats in Mexico and six South American countries in 1950. The program was so successful that this International Spring Wheat Rust Nursery (ISWRN) was grown at additional locations in Mexico and South America in succeeding years. In 1952, Dr. Bayles arranged to have the ISWRN grown in Asia and Africa. Funds appropriated by the U.S. Congress in 1955 permitted expanded testing and seed increase of small grain cereals. Barley and oats have been included in international tests since that time.

The international nurseries have been the source of valuable germ plasm, not only for rust resistance, but for other characteristics as well. Some entries have been increased as commercial varieties. Exchange of information related to the international nurseries has helped to establish excellent working relationships among cooperating scientists.

The Wheat Newsletter has been an excellent means for exchanging current information among wheat workers. We are indebted to Dr. Heyne, Kansas State University, and Drs. Knott and Campbell, Canada, for their efforts in processing the Newsletter. If the Newsletter is to be continued, financial help from individuals and organizations is needed.

Please give your attention to summaries on the international disease nurseries by Drs. Kilpatrick and Scharen and on the Wheat Newsletter by Dr. Heyne. The success of all of these ventures depends upon full cooperation of all concerned.

INTERNATIONAL RUST NURSERIES

R. A. Kilpatrick

The International Rust Nursery Program involves six nurseries of wheat, oats, and barley. The nurseries are composed of the most diversified rust resistant germ plasm known to exist. Nurseries are prepared in September and January of each year. Two-hundred and twenty-six sets of these nurseries are sent to 45 cooperating countries.

Entries for the four wheat nurseries are received from plant breeders and pathologists in approximately 50 different countries. The percentage of entries submitted from the United States varies with the nursery, as well as each year (Table 1). The winter wheat nurseries contain the largest percentage of entries from U.S. breeders, while the spring wheat entries are received from the largest number of locations. In 1970, sources of entries for the winter wheat nurseries were from 16 states and 23 countries; spring wheat entries were from 13 states and 42 countries.

Table 1. Percentage of entries in the four Internation wheat rust nurseries submitted from the U.S., 1966-70

	Nursery			
Year	Spring	Spring-Stripe	Winter	Winter-Stripe
1966	35	26	68	10
1967	44	21	68	72
1968	41	37	74	55
1969	41	43	90	58
1970	23	35	90	60

The total number of entries submitted for the four wheat nurseries varies greatly from year to year. Total submitted were: 1967 - 450; 1968 - 1297; 1969 - 535; and 1970 - 1547. The large increase is due to a misunderstanding among breeders; greater access to world wide materials (FAO, Mexican Yield Nurseries; and increased number of available Plant Introductions); and increased screening program being carried out at Beltsville. The present policy of the International Rust Nursery Program is to accept advanced breeding materials which have rust resistance. Level of resistance if left to the judgment of individuals submitting entries. A ceiling on number of entries submitted by one individual has been left to the discretion of the breeder, but may, in the future, have to be limited. The World Collection of Small Grains provides the bulk of material for screening at Beltsville. Thousands of wheat Plant Introductions are yet to be catalogued and screened. The screening procedure involves four common cultures of *Puccinia graminis tritici*.

Encouraging materials are further inoculated with six additional cultures. Generally, less than five percent of the Plant Introductions contain the level of resistance we require for submission to the International Rust Nursery program. Material submitted by the breeders and pathologists are entered in the IRN without screening. Unfortunately, the lack of personnel prevents general screening of all materials.

Size of the four nurseries varies with the nursery and from year to year (Table 2). The spring wheat nursery has always been the largest. This is due to greater activity among spring wheat breeders in the development of stem rust resistant varieties around the world. The winter wheat nursery, has, in general, been the smallest of the four nurseries. Prior to 1969, there were questions on usefulness of this nursery. However, in 1969 and subsequent years, a greater number of entries have been submitted.

Table 2. Number of entries in the four International wheat rust nurseries, 1965-1971.

	Nursery			
Year	Spring	Spring-Stripe	Winter	Winter-Stripe
1965	663	421	180	512
1966	598	523	156	645
1967	455	414	194	432
1968	527	226	159	578
1969	577	391	288	569
1970	720	410	320	205
1971	810	614	450	330

The policy of the USDA is to assign C.I. (Cereal Investigation) numbers to named varieties and selections with desirable characteristics on request and by the permission of the originator. The breeder and institution where the selection was developed must give their consent on unreleased germ plasm. Once a variety or selection receives a C.I. number, seed becomes open stock and remains available for future use. Without a C.I. number, we are prohibited from filling requests. One large International group has given blanket permission to assign C.I. numbers to any of their selections we deem worthy of a number. This splendid cooperation has resulted in world-wide impetus to wheat breeding programs. The resulting progenies have been incorporated in many breeding programs. Are you willing to share your materials with others? If so, you can help by giving Dr. J. C. Craddock, World Collection of Small Grains, permission to assign a C.I. number when submitting entries for the IRN. You may rest assured that we will encourage breeders to acknowledge origin (developer) of seed.

THE UNIFORM WHEAT MILDEW NURSERY

A. L. Scharen

The first wheat mildew nursery for which records are available was put together in 1949 and grown in 1950. Coordinated by the late Conley V. Lowther, it has 21 entries and was grown in 16 localities within seven states. All of the original locations were in the Middle Atlantic and Southeastern regions of the U.S.A. The nursery added international character in 1956 when, under the guidance of Harry R. Powers Jr., the Swedish Seed Association at Svalov became the first foreign cooperative grower. L. W. Briggle coordinated the nursery in 1959, and helped me learn about it when I came to Beltsville in 1960. During the past decade, the nursery has grown slowly in number of entries, but is being grown in many more locations than previously. The 1970 nursery had 37 experimental entries, and was grown at 37 locations in the U.S.A. and 15 foreign countires.

The purpose of the nursery is to test new sources of resistance to *Erysiphe graminis tritici* in the field where they will be exposed to as wide a range of pathogenic cultures as possible. To this end, I invite plant breeders and pathologists to enter their promising lines in the nursery for evaluation in most parts of the world where powdery mildew is a problem.

WHEAT NEWSLETTER

E. G. Heyne

A group of individuals interested in wheat discussed the possibilities of a newsletter at the American Society of Agronomy meetings held at Minneapolis, Minnesota in the fall of 1954. It was agreed that such a venture should be tried and since that time a newsletter has been issued annually (Vol. 1 - 1954; Vol. XVI - 1969). The response has been good. The largest one and the greatest number of copies were issued for the last volume (1969, Vol.XVI). The additional pages and extra copies gave financial problems.

The first issues, Vol. 1 - Vol. VIII were prepared largely on faith. Since 1962, Vol. IX, the National Wheat Improvement Committee has sponsored the newsletter with much appreciated help in securing finances.

Twenty-five to 50 copies have been printed in excess of requests and these generally have been exhausted before the next issue has been put out.

Items receiving the most consistent appreciation from year to year have been the list of cytogenetic references and list of aneuploidy-located genes and listing of CI numbers.

Volume XVII for 1970 is under preparation. Contributors have been faithful, requests have been numerous, but to keep it going we need financial help as printing appears to be more inflated than other costs as shown in the summary data on the Wheat Newsletter.

WHEAT NEWSLETTER

Vol. No.	Year	Date of issue	Editors	No. printed approx.	No. pages	No. contributors approx.	Support	Est.Cost[1/]
I	1954	1 April 1955	E. G. Heyne	300	66	80	Agron. Dept., KSU	$250
II	1955	1 March 1956	E.G. Heyne, D.R. Knott	300	76	120	do	250
III	1956	1 March 1957	do	300	90	135	do	250
IV	1957	1 April 1958	do	300	74	125	do	250
V	1958	15 March 1959	do	300	86	130	Okla.Wheat Res. Found.	300
VI	1959	15 March 1960	do	350	104	135	Nebr. Wheat Commission	300
VII	1960	15 March 1961	do	350	94	130	Agron. Dept., KSU	300
VIII	1961	1 April 1962	do	350	106	145	Ogden Grain Exchange Kansas Crop Imp. Assoc.	300
IX	1962	1 May 1963	do	350	97	145	Saskatchewan Wheat Pool	300
X	1963	15 April 1964	do	350	91	140	Wash. Wheat Commission	350
XI	1964	15 April 1965	do	375	116	155	Ore. Wheat Commission	480
XII	1965	15 April 1966	do	400	126	150	N.D. Agr. Exp. Sta.	500
XIII	1966	15 April 1967	do	400	128	150	DeKalb Agr. Assoc.	600
XIV	1967	1 May 1968	do	400	123	160	Agron. Dept., KSU	600
XV	1968	15 April 1969	E.G.Heyne,A.B. Campbell	500	151	165	Natl. Coun. of Plt.Brdrs. Can. Coop. Wheat Producers	700
XVI	1969	1 May 1970	do	600	176	160	Seed Co. & individuals	1070

[1/] Includes printing and postage - not secretarial help.

Vol. IX, 1962 - first issue to include contributions from industry.
Vol. XI, 1964 - first issue with contributions outside Canada and the United States.

GENERAL AND SPECIFIC DISEASE RESISTANCE

R. M. Caldwell

The idea that general resistance to plant disease exists in an important degree and may be a reasonable objective of plant improvement has gained considerable support from both breeders and pathologists during the past decade. It also seems to have generated considerable and important opposition within the same groups. Since the two approaches of general and specific resistances are not mutually exclusive and do not offer an either-or choice it would appear that both must be considered in the breeding effort to control important diseases.

Knowledge on general resistance is in a primitive stage compared to that on specific resistance. We have had little research in the area as compared with the intensive study of the specific resistance to diseases and of the specialized pathogens that cause them, covering most of the present century. Nevertheless it is necessary to risk defining general resistance in the light of the little solid knowledge we have and to distinguish it from specific resistance if we are to discuss them.

A confusing complex of names has been applied to the concept of general resistance, as presented here, by many competent people. This complexity has confused the thinking in the area and may be an important factor in the neglect or dismissal of the possibilities of general resistance. These names include field, non-specific, partial, generalized, horizontal, minor-gene, polygenic, epistatic, and uniform resistance, and erroneously, tolerance. It is proposed that general resistance supplies a simple descriptive name for the important concept involved in the distinction between the idea of a uniform, broad-spectrum resistance to all pathogenic variants and the narrow-spectrum resistance commonly referred to as specific.

The understanding of general resistance requires first an understanding of what it is not, i.e. specific resistance. The following definitions are proposed as a basis for this discussion.

Specific resistance is resistance that is effective against only certain clones or populations of a pathogen and ineffective against others. Specific resistance to the rust, smut, and powdery and downy mildew pathogens is often accompanied by a hypersensitivity or "fleck" host reaction and by monogenic inheritance. However such associations are not universal. There are both hypersensitivity and single-gene resistances that, quite certainly, are general and permanent. The names monogenic, major-gene, seedling and physiologic resistance also have been applied to specific resistance.

General resistance is resistance that confers an enduring and stable protection against a pathogen. Many have erroneously equated general resistance with polygenic and "minor gene" inheritance, with delay in expression to the mature plant stage or with expression in the "field".

Actually no one nor all of these attributes *per se* can assure general resistance.

Van der Plank (11) offers a meaningful comparison of the two types of resistance as follows: "Vertical resistance implies a differential interaction between varieties of the host and races of the pathogen. In horizontal resistance there is no differential interaction".

The closed-flowering character in barley affords an illustration of an excellent and obvious mechanism of general resistance to loose smut (*Ustilago nuda*). Since the glumes remain tightly closed at anthesis, the floral infecting spores are mechanically excluded from penetrable floral tissues (5). No fungal variant could conceivably break this barrier and it therefore provides a permanent solution to the loose smut problem as was shown by the near elimination of the disease by the widespread use of the variety Proctor in England. The closed flowering character is simply inherited (5). Small lodicule size also is simply inherited and is associated with closed flowering, but large lodicule cultivars may be closed flowering and highly resistant to infection.

An association between the level of wheat scab infection and the time and length of the period of glume opening in Trumbull and Thorne wheats has been demonstrated (10). This also correlates with the writer's observations of the natural infectability of the two varieties by, the floral infecting, loose smut. These observations deserve much more study.

However, the genetically simple, and presumably specific, resistance to loose smut found first in Kawvale has been effective under extensive use in the widely grown variety Pawnee and its derivatives for over 40 years. This should satisfy the criteria for judging general resistance.

The long enduring resistance to flag smut in the Australian variety Nabawa is an outstanding example of a general resistance to a seedling infecting smut that is known to have functioned for nearly 50 years.

Another known exclusion mechanism for general resistance is operative in the sheaths and stems of wheat toward leaf rust (*Puccinia recondita*). Despite the association of this host and parasite since both evolved, no parasitic strains have appeared that can enter the stomata of these organs on an important scale (9). Although normal appressoria form on the stomata of sheaths and peduncles little or no penetration occurs when the plants are in full vigor. As ripening and senescence progress, penetration occurs on both structures, and many small subepidermal uredia and telia are produced. This is a perfect example of an adequately tested, incontestable case of a highly effective, general resistance to a cereal rust.

A "slow rusting" general type of resistance to leaf rust has been studied in a number of winter wheats at Lafayette, Indiana (1). It has been effective in the varieties Vigo and LaPorte. Vigo has not been observed to be attacked early, or severely, when exposed to pathogenic leaf rust populations under field conditions. In some fast and slow-rusting varieties differences in exclusion by stomata of flag leaves have been demonstrated, similar to that shown by stomata of the sheaths and peduncles (9).

A "pattern type" of delayed development of leaf rust has been observed in experimental plots at Purdue (1). The rust first appears in the blade area adjacent to the sheath and later on the more distal area. This type of delayed infection has been observed since it was first distinguished on Ble Tendre by the writer in 1959. It is apparent on Mentana and its derivatives, Lerma 50 and 52, Lerma Rojo 64, and Inia 66. In Sonora Mexico in 1970 under a severe epidemic of virulent races the foliage of Inia 66, grown on vast contiguous areas, was observed by the writer to suffer only limited rust infection for over three weeks after that of susceptible varieties, such as Thatcher, had maximum infection. High yields of excellent quality grain followed. The spring cultivars, Ble dur Tendre, Menkemem, Veadeiro and others also showed the pattern types infection in the Purdue studies and were protected from early severe infection.

The pattern infection also has been recognized in varieties having hypersensitivity resistance as well as in susceptible varieties under severe inoculation. It has been possible to combine both types of resistance in one genotype from hybrid populations.

The general resistance of corn to its leaf rust, P. sorghi is well known, and serves as the major protection of the crop to destructive disease (2). Despite the apparent susceptibility of commercial varieties to this rust, infection in nature is always limited but does not involve the hypersensitivity reaction. Inbreeding of open pollinated varieties has resulted in the production of segregates (inbred lines) that possess little general resistance and suffer severe natural infection.

The importance of the "small-uredia reaction" to Puccinia graminea f. sp. avenae has been shown in careful yield comparisons of spring oat varieties (3). This is a resistance that appears not to be associated with hypersensitivity. It therefore deserves attention as a possible type of general resistance that results in limited multiplication of the pathogen.

Many field observations provide circumstantial evidence of the operation of effective general resistance. Highly effective monogenic resistance to Septoria tritici, associated with hypersensitivity has been observed (7). In addition, various levels of field resistance have been observed by the writer that are not associated with hypersensitivity and give promise of a general type of resistance to be exploited if the monogenic types should prove to be specific and ephemeral.

Similar observations have been made by the writer in Indiana of an effective field resistance in barley to Rhynochosporium scald.

A long-lasting resistance in barley to Septoria passerinii in Minnesota (4) has been reported that is highly indicative of general resistance. Varieties grown previous to 1955 were little affected by this fungus. However the introduction of the Kindred variety in 1955 resulted in severe epidemics.

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DISEASE PROBLEMS ASSOCIATED WITH INTENSIVE CULTURE

M. G. Boosalis

In preparing this talk, I decided to solicit the assistance of some of the leading plant pathologists working on wheat diseases. I selected researchers representative of the different wheat producing areas of the United States and one researcher from Canada. All of the researchers contacted were extremely cooperative in giving their professional views and ideas as well as providing their current research papers and slides on the subject. I must confess that I did not expect to receive such enthusiastic response and generous assistance from these busy researchers, for I feared my request might be considered an imposition and a little excessive in asking them to help me with my assignment. I would, therefore, be remiss not to acknowledge the help I received from Dr. George Semeniuk, South Dakota State University; Dr. Thor Kommedahl, University of Minnesota, Dr. Robert Hosford, North Dakota State University; Dr. R.J. Cook, ARS, Pullman, Washington; Dr. Albert Scharen, ARS, Beltsville, Maryland; Dr. Robert Powelson, Oregon State University; Dr. Tom Atkinson, Research Station, Lethbridge, Alberta, Canada; Dr. Su Chan Hsu, Michigan State University and Drs. Weihing, Staples and Anderson, University of Nebraska.

Intensive cultural practices incorporating agricultural technological improvements are continually being adopted by the growers in reducing the cost of production and/or in increasing the yield of the crop. Some of the technology incorporated into intensive cultural practices relate to planting date, irrigation, fertility, tillage, monoculture, and new varieties. That these and other cultural practices generally lead to more efficient crop production is well documented. The plant pathologists, as well as other scientists in related disciplines, have good evidence to indicate that some of the intensive cultural practices have already markedly affected or probably will affect the development of specific diseases. In many cases, the evidence points to an intensification of diseases, and in other instances the evidence points to a reduction of disease development or to no appreciable change in disease development in relation to intensive cultural practices. In many cases, however, the evidence for disease increase or decrease in relation to intensive culture is predicated on field surveys or on the results of empirical research. Although the results from such investigations clearly relate to outbreaks of or the abatement of diseases with specific cultural practices, they fail to specify what factor(s) associated with intensive culture affect disease development. We know very little about how intensive cultural practices operate to influence the physiology of plant, the physical, the biological and the nutritional environment which in turn may affect the incidence of disease. And until this huge gap in our knowledge on the basic aspects of intensive culture in relation to plant diseases is narrowed, diseases will continue to be a very important limiting factor of wheat production. My presentation will emphasize some of the better known soil-borne diseases associated with intensive culture.

Common root rot of wheat caused principally by *Helminthosporium sativum* (Perfect stage known as *Cochliobolus sativus*) is a disease of great importance in the United States and Canada. Estimates of average annual yield reductions in wheat range from 5 to 12%. This is the most economically important disease in western Nebraska. Although this disease is generally associated with high soil temperatures and low soil moisture during the early stages of plant development, this disease is also associated with intensive culture. A monoculture system of wheat production is one of the most frequently cited examples of intensive culture contributing to severe outbreaks of common root rot. One reason why continuous cropping to wheat results in a high incidence of the disease may relate to the mode of survival and to the mode of spore germination of the pathogen in soil. The pathogen survives in the soil apart from the host and plant residue as conidiospores. We've shown that a small percentage of the conidiospores retain their viability and virulence in the sandy-type soils of western Nebraska for over 4 years. In contrast to this, nearly all of the spores of the pathogen lose their viability after 1 year in the heavier organic soils of southeastern Nebraska. It is noteworthy that the formation of chlamydospores within the conidiospores apparently contributes to the longevity of the pathogen in soil. There is good evidence to indicate then that continuous cropping to wheat may increase the amount of common root rot by substantially increasing the inoculum of the pathogen in the soil. This is particularly the case in western Nebraska where the sandier soils favor the survival of the conidiospores for several years. A high level of inoculum in the soil, however, does not always result in a high incidence of the disease as there are many other complex and interrleated factors that affect disease development. Unfortunately, we know very little about how the multitude of factors of the environment operate to influence soil-borne diseases. Researchers have shown that the conidiospores of *Helminthosporium sativum* germinate in soil amended with various nutrients such as the straw residues from different crops. There is great diversity in the fate of the germinated spores in soil in the absence of the host. The germ tube and the young mycelium developing from germinated spores may quickly lyse in soil before sporulation occurs on these structures. This destruction of the germ tube and the mycelium may be accompanied by death of the parent spore. Researchers at Michigan State University, however, recently showed that lysing of the germ tubes and/or the mycelium is not always accompanied by death of the germinated conidiospore. In thise case the original or parent conidiospores were able to germinate at least 5 times on a synthetic medium following complete lysis of hyphae on soil. Circumstantial evidence indicates this regermination phenomenon of the parent conidiospores may occur also in soil. In some instances the germinated conidiospores sporulate before the germ tubes and the young mycelia lyse. With this type of precocious sporulation, the new conidia develop on the tips of germ tubes or on conidiophores from the myelia. Incidentially, the conidiospores produced in this manner are just as viable and virulent as the parent spores. In fact they may show greater viability than the parent spores depending on the age of the parent spores and the lengths of time they are in the soil. We have noted also that a small percentage of the conidia placed adjacent to wheat roots may germinate and sporulate precociously. We have also recovered a few conidia showing this type of germination and sporulation from the rhizosphere of commercial wheat fields. This tremendous diversity of spore germination and subsequent sporulation in the soil presents an insuperable obstacle to attempts of controlling the disease with soil amendments aimed at stimulating germination of soil-borne conidiospores followed by lysis of the germ tubes and mycelia prior to sporulation.

More recently, Dr. Atkinson and his associates at Alberta have reported that the rhizosphere of a spring wheat line resistant to common root rot contained microorganisms antagonistic to Helminthosporium sativum whereas the rhizosphere of the parental wheat variety susceptible to the disease was free of microorganisms antagonistic to this pathogen. It may be possible, with further research, to show that resistance to common root rot is associated with the occurrence of antagonistic microbes in the rhizosphere. Such a phenomenon might make it possible to control the disease by developing varieties whose roots support high populations of microbes antagonistic to the pathogen. It may also be that the resistance of such varieties to common root rot would not be affected appreciably by intensive culture such as continuous planting to wheat. The fact that roots of wheat resistant to common root rot support relatively high populations of antagonistic microorganisms may help to explain why wheat varieties resistant or susceptible to the disease do much better in fields previously planted to a resistant wheat variety as shown by Dr. Kommedahl.

Continuous cropping to wheat can also lead to insect problems which in turn may be associated with root and crown rot of wheat. A case in point is the relationship of Hessian fly injury to wheat and root and crown rot incited primarily by species of Helminthosporium and Fusarium. In this case, high populations of the insect attacking winter wheat early in the fall are related in western Nebraska to a monoculture of wheat and to an early planting of the crop. Results from our research indicated that the larval feeding of Hessian fly predispose the plant to infection by soil-borne fungi. The insect and the root and crown rot resulting from insect injury are now effectively controlled by wheat varieties resistant to the insect and by planting the crop at the appropriate date, when the Hessian fly population is minimal.

Dr. Atkinson stated that wheat stem sawfly (Cephus cinctus) is an insect problem in Alberta which results from intensive culture of wheat involving a monoculture of the crop. In turn, if it were not for the wheat stem sawfly the growers would not have to consider growing solid-stemmed wheat varieties which as a group are more susceptible to common root rot than are the hollow-stemmed varieties. The Canadian researchers are hopeful of resolving this problem without changing the intensive culture practice of continuous planting of wheat by developing solid-stemmed varieties of wheat incorporating resistance to common root rot. This optimisitc view of being able to control both the insect and the fungus diseases is based on the fact that there is no association between inheritance of root rot reaction and the inheritance of stem solidness which determines resistance to the wheat stem sawfly. Therefore, the researchers anticipate no difficulty in incorporating root rot resistance into sawfly resistant varieties in the near future.

Fusarium root and foot rot also called dry-land root rot caused by Fusarium roseum (Lk.) Emend. Snyd. & Hans. f. sp. cereales (Cke) Snyd. & Hans. 'Culmorum' is an excellent example of a disease that has burgeoned with intensive wheat culture in the Pacific northwest and especially in Washington and Oregon. Dr. J. Cook of Washington State University and Dr. R.L. Powelson or Oregon State University have done elegent research in showing that intensive cultural practices such as high nitrogen fertilizer, early seeding, and high tillering wheat varieties lead to a severe outbreak of Fusarium root and foot rot. As a result of these studies it is now becoming clearer why these intensive culture practices increase the amount of the disease. Fusarium root and foot rot has been present in the dry-land, summer fallow regions of the Pacific Northwest and in other areas of the country for as long as wheat has been grown in these areas. However, the disease became economically important more recently with the introduction of new wheat varieties such as Gaines, with the application of high amounts of nitrogen and with early seeding dates.

The Washington State University researchers have evidence to indicate that Fusarium culmorum is strongly pathogenic on wheat that grows vigorously at first but eventually "suffers" from water stress. Thus, early planted wheat generally produces lush, well developed plants in the fall and by winter each plant of a high tillering variety like Gaines has 10 to 21 tillers. At the same time nitrogen fertility of the soil is high and may be supplemented further in the spring. This intensive culture practice of high nitrogen applications also contributes to the lush, vigorous growth of the plants in the fall and early winter which further depletes soil moisture.

Soil moisture in many areas of the Pacific Northwest is limited to that stored in the 6 foot profile during the winter and the subsequent following season. This limited water supply to sustain crop growth is depeleted very rapidly as very little useful rainfall occurs during the period from late May or June until the crop is harvested. Consequently, the rapidly growing wheat plant extracts all available water from the 6 foot soil profile. Meanwhile the soil-inhabiting fungus pathogen has invaded the lush crown of the plant in the fall where it remains relatively inactive until late in June when the plant is under severe water stress. At that time the pathogen destroys the crown and then rapidly invades the culms in late June. Dr. Cook believes that the intensive cultural practices of high nitrogen application, early seeding, and high tillering varieties cause water stress to occur a few days or weeks sooner than would happen with older varieties producing fewer tillers that are planted later in soil with a lighter application of nitrogen. A prolonged water stress soil environment is extremely favorable to the fungus pathogen. In this connection, it is noteworthy that Fusarium colmorum survives in soil primarily as chlamydospores formed within the conidiospores. It is obvious, of course, that chlamydospore germination and subsequent growth of the fungus germlings as young hyphae both are essential to infection of the underground tissues of the wheat plant. It is a fact that chlamydospores germinate and the resulting germlings continue to grow best in a relatively dry soil. Although a soil with a high water potential also is favorable to chlamydospore germination and to subsequent growth of the pathogen, it is also favorable to the growth of soil inhabiting bacteria that are antagonistic to the fungus pathogen. On the other hand, a soil with a low water potential is not conducive to the growth of antagonistic bacteria. This may be one reason, then, why intensive cultural practices which create water stress conditions in the soil lead to a high incidence of Fusarium root and foot rot.

It was shown that Fusarium culmorum apparently does not colonize wheat straw returned to the soil. Even in soil containing high levels of the inoculum, colonization of the straw by the pathogen generally was very low. However, the pathogen readily colonizes the lower stem base of wheat through parasitism originating at the roots or crown of the plant. Such basal-stem straw containing the pathogen is the main source of inoculum build-up in the soil which in turn may lead to severe outbreaks of the disease. Apparently, then, saprophytic colonization by the pathogen of wheat straw returned to the soil is of minor significance in increasing the inoculum in soil. The limited saprophytic growth of the pathogen in soil to colonize wheat straw helps to explain why a monoculture of the crop does not always result in a high buildup of inoculum and a high level of the disease. It is when the infested straw from the diseased crop is returned to the soil that the inoculum of the pathogen is increased sufficiently to cause heavy infections of the subsequent crops.

One of the most insidious and intractable soil-borne diseases associated with various intensive cultural practices is take-all of wheat caused by the fungus Ophiobolus graminis. Although the disease can infect spring-sown wheat, most of the big losses caused by the pathogen occur in fields of winter wheat. In recent years, the increased incidence of the disease in several areas of the country is attributed partly to certain intensive cultural practices.

A few pertinent facts concerning the biology of the pathogen are basic to a discussion of the relationship of intensive culture and take-all of wheat.

Ophiobolus graminis does not produce any type of dormant spore in soil. It survives in soil as mycelia in straw from diseased hosts. Under favorable conditions the pathogen can survive for up to a year in infested straw. This pathogen has a low competitive saprophytic establishment and multiplication on plant residue in soil is of no importance in the life-cycle of the pathogen. Most rapid loss of viability of Ophiobolus graminis occurs in soil under conditions conducive to maximum microbiological activity. Such conditions include a medium to high soil temperature, good soil aeration, an alkaline soil, a relatively moist soil or a nitrogen-poor soil. The pathogen spreads in the field by means of mycelia growing along the surface of roots. The host range of O. graminis is restricted to the Gramineae.

Take-all of wheat is increasing in importance in many areas of the United States and particularly in the Pacific Northwest. Losses caused by take-all in 1967 occurred primarily in the irrigated districts of the Pacific Northwest where about 650,000 acres of wheat were irrigated, representing approximately about 15% of the total wheat acreage and 30-35% of the total production. Losses caused by take-all in 1967 in the Pacific Northwest were between 1 and 2 million bushels. The increased incidence of this disease in this area is associated with wheat following wheat, together with irrigation on light-textured soils. It is also reported that early seeding (prior to October 15) and inadequate application of nitrogen (less than 80-100 pounds N/acre) also favor take-all. However, like so many other soil-borne diseases there are always exceptions with regard to any aspect of the disease. And in this case, take-all can be very severe with high fertility and late seeding. With regard to fertilization, Dr. Huber of the University of Idaho states that the form of nitrogen may have a pronounced effect on the severity of take-all. Applications of 60, 120, and 180 lbs. of nitrogen/acre as ammonium nitrage greatly increased the susceptibility of wheat to take-all. In contrast, applications of 40 lbs. of nitrogen/acre as ammonium sulfate markedly reduced the severity of the disease and increased the yield by 30 bu over the control treatment. It is theorized that more effective control of take-all with ammonium sulfate, compared with ammonium nitrate, may be related to the slower rate of nitrification of ammonium sulfate in soil and its more rapid utilization by competitive or antagonistic microorganisms. The mechanism of control with nitrogen fertilization also is probably related to host resistance, but just how this nutrient of ammonium sulfate imparts greater resistance to the host is unknown.

Of particular interest is the effect on continuous culture of wheat on the incidence to take-all. In many instances, take-all of wheat continues to be a devastating disease in an area for as long as the crop is planted continuously. However, there are many, many exceptions to this.

I should like to cite two examples of such exceptions. Dr. Cook indicated that take-all evidently is declining in the Columbia Basin in Washington State in fields continually planted to wheat longer than three years. This phenomenon of "take-all decline" reported by Dr. Cook is similar to that described by Fellows and Ficke in 1934 on take-all in Kansas. These investigators observed that "take-all patches" established in wheat fields continually cropped to wheat generally increased in size during the second year, often decreased in its third year, and might not appear at all after that. This sequence of events can be explained partially by the fact that the pathogen does not survive nearly as long on the roots of the small, early killed plants in the center of the diseased patch as it does on the larger roots and the stem bases of plants on the periphery of the patch that are infected late in the growing season. Secondly the early killing of plants in the center of the patch may conserve nutrients in this area which would impart greater resistance against the disease to the subsequent wheat crops.

The literature also reports that take-all may decline over much larger areas during the monoculture of wheat. In this case when wheat monoculture is started on virgin soil of low organic content and low fertility, the decline in incidence of take-all may be explained by a gradual increase in soil organic content and fertility under good farming management. An increased level of soil nutrients may promote disease escape of the wheat plant and stimulate a higher microbial population that is antagonistic to *Ophiobolus graminis*.

Observations on decline of take-all of wheat similar to those just described have been noted in association with a monoculture of wheat in many areas of this and other countries and especially in England.

There are many foliage diseases of wheat and other cereals that are associated with essentially the same intensive cultural practices as those involved with soil-borne diseases and some virus diseases of these crops. Here again a monoculture of wheat coupled with other practices such as stubble mulch tillage provide ideal conditions for the successful overwintering of large populations of the pathogen. The leaf blight disease of wheat caused by the fungus *Pyronophora trichostoma*, whose asexual stage is known as *Septoria avenae* var. *triticea*, is of great concern to the wheat growers in North Dakota as this disease has increased substantially since 1966 and could be a major threat to the crop. Dr. Hosford and his colleagues at North Dakota State have shown that this pathogen overwinters on wheat straw as perithecia.

Scharen showed that infested wheat which harbored pycnidia of *Septoria nodorum* through the winter can produce pycnidiospores to serve as primary inoculum for outbreaks of glume blotch. He also reported that infested straw yielded additional virulent spores with each cycle of wilting and drying the straw up to a total of 8 cycles. It was also found that *Septoria nodorum* continues to grow on dead wheat straw producing additional pycnidia and spores, thus, providing new inoculum during the growing season. I would assume from these findings that the infested wheat straw also provides the initial inoculum for seedling infection of fall-planted wheat. As stated by Dr. Scharen, wheat straw in the field after harvest not only harbors *Septoria nodorum* but it also acts as a medium for growth and reproduction in increasing the inoculum potential of the pathogen. Thus, the intensive cultural practice of monoculture of wheat in relationship to outbreaks of glume blotch is obvious.

The most destructive and threatening virus disease of wheat in the Great Plains area is wheat streak mosaic which is transmitted by the wheat curl mite.

Several closely related conditions are necessary for the development of extensive and severe epidemics of the disease. The occurrence of hail storms accompanied by wet weather during the latter part of the growing season initiates a series of events that culminate in heavy infection of the crop in the fall. And as we shall see, the intensive cultural practice of stubble mulch fallow, at least in Nebraska, plays an important role in all of the sequence of events that lead to an outbreak of western streak mosaic.

A major epidemic of wheat streak mosaic results when volunteer wheat bridges from one wheat crop to the next. The key to this phase of the disease is that the volunteer wheat emerges shortly before the crop is harvested to provide the necessary continuity of favorable host plants for the wheat mite vector. It is also essential that the volunteer crop not be destroyed through the fall season to insure a build up of the vector and the disease on the volunteer plants to provide large numbers of viruliferous mites to infect the adjacent wheat fields early in the fall. Stubble mulch fallow as used in the Great Plains area restores soil moisture and minimizes wind erosion and thus makes monoculture of wheat feasible in this area. This intensive culture practice also allows volunteer wheat to remain undisturbed until the following spring. At that time, the wheat stubble is partially buried in the soil and the volunteer wheat is destroyed. As you all know, the most serious epidemic of wheat streak mosaic develops when the crop is infected soon after emergence - for the younger the plants are when they are infected the more severely they are damaged. Some of the most interesting and important research on the relationship of hail, volunteer wheat and mites to the development of western streak mosaic was done by Dr. Weihing of our department and Drs. Staples and Anderson of the Entomology Department. I should like to summarize their findings. The greatest probability of volunteer wheat being infested with mites and infected with the disease occurs when the wheat crop approaches maturity - that is when the kernels are in the mid-dough stage. The reason for this is that the kernels in the mid-dough stage germinate very rapidly when a hail storm shatters them to the ground. Furthermore, the heads of wheat are still sufficiently green to maintain the mites until the volunteer plants emerge. As the intact heads of the hailed crop dry completely, the mites, some of which are viruliferous, move or are blown to the nearby volunteer wheat.

The severity of the hail storm determines the size of the mite population and the volunteer wheat stand. If the hail damage is slight, little grain is knocked to the ground and the stand of volunteer wheat is too small to support large numbers of mites. If the damage is very severe and most of the crop is hammered into the ground, most of the mites perish on the heads mired in mud so that a few mites infest the volunteer wheat. The type of damage most conducive to maximum mite infestation of volunteer wheat is that in which most of the tillers are broken and bent but the water and food-conducting vessels in the tillers are still intact. Under these conditions the heads remain sufficiently green and provide food and protection for the mites until the volunteer wheat emerges.

Any other type of hail storm or environmental condition that does not favor the quick establishment of lush volunteer wheat during the interim period between crop harvest and the emergence of next year's crop is not favorable for the development of epidemics of western streak mosaic. Such unfavorable conditions for disease epidemics include the lack of sufficient moisture following a well-timed hail storm to prevent seed germination, the hail storm hitting when the kernels are too mature or immature to germinate, and the emergence of volunteer wheat weeks after harvest. This knowledge regarding the time relationship of hail, volunteer wheat and viruliferous mites provides the framework for making sound recommendations for controlling the disease. With regard to hail storms, recommendations to destroy the volunteer wheat crop are made only when the volunteer plants are established shortly after the kernels are in the mid-dough stage. Destruction of the potentially dangerous volunteer wheat is accomplished by slightly modifying the stubble mulch fallow operation with out affecting its efficiency to restore soil moisture or to minimize wind erosion. This is done by a special cultivation operation which cuts the roots of the volunteer wheat without appreciably disturbing the wheat stubble. Results from Dr. Anderson's research also indicate that systemic miticides may be used in the future to destroy the mite vector without destroying the volunteer wheat.

In conclusions we can say that intensive cultural practices in many ways influence the development of infectious diseases of wheat. I have emphasized some of the principal intensive cultural practices such as monoculture, irrigation, fertilizers, residues, varieties and stubble mulch fallow as they relate to specific wheat diseases. More recent innovations of intensive culture of wheat also affect disease development. The recent production of dwarf varieties of wheat and the increased fertilization - particularly nitrogen nutrition are just two new intensive culture practices that may affect the incidence of wheat diseases. In this connection, the marked changes of the architecture of the plant with regard to size of the plant and foliage arrangement may change the micro-environment of the plant and render it more resistant or susceptible to diseases. For example the thicker canopy of leaves produced by some dwarf varieties of wheat may affect the amount of light intercepted by the plants and also the percentage of relative humidity in the immediate vicinity of the leaves, the temperature at the soil surface and the total leaf area hit by splashing rain. All of these factors associated with a change in the architecture of the plant may have a profound effect on the development and spread of many foliage diseases of wheat.

Much progress has been made up to now in gaining a better understanding on how some of the intensive cultural practices operate to influence disease development. In many cases the new knowledge gained from research is effectively used to control specific diseases without appreciably altering an intensive culture practice. However, much remains to be done in gaining new information concerning the intricate and complex relationships between intensive culture and disease development before we can further manipulate intensive cultural practices to reduce diseases lossses of wheat. I am not very optimistic, however, that we can achieve very much progress in this difficult area of research in the immediate future. It may seem unrealistic to make such pronouncement in view of the fact that there is a nucleus of competent dedicated researchers working on these problems, that there is now a large pool of available researchers and technicians to work on these problems and that there are adequate facilities including ample equipment to do the research. My pessimism regarding the future accomplishments from research on intensive cultural practices in relation to diseases stems from the fact that our country has embarked on a precipitous course of retrenchment in most areas of research. I think all of us in agricultural science have felt the ongoing drastic cut-backs of funds in support of research from all agencies including some of the Agricultural Experiment Stations. You gentlemen need not be convinced, I am sure, that these hugh cut-backs in research funds need to be restored and increased if we are going to meet the problems that effect the efficiency of agricultural production.

UTILIZATION OF GENES FOR RESISTANCE TO DISEASES OF WHEAT

John F. Schafer/Kansas State University

In viewing genes for resistance to diseases of wheat, we must first determine what we need to know about them. This may depend on viewpoint, which in our context, I believe, is strictly that of controlling economic loss due to disease. In a practical sense, differing amounts of information about genes for resistance may be required in various situations and circumstances.

Information which would facilitate the effective use of resistance genes in controlling disease losses would include the arithmetic concept of them, their effects (classified in several conceptual frameworks), their relative value, and proposals for tactics and strategies in their deployment.

ARITHMETIC CONCEPTS. As abstract arithmetic concepts, resistance genes can be genetically manipulated and utilized in a breeding program. At times knowledge of their number provides enough information. Sometimes breeding success has been attained without even this degree of understanding. Often, however, such numerical information alone is not adequate to bring success. The primary concern in the numerical context is in the extremes: Is resistance controlled by discrete, identifiable units or is it related to a continuum consisting of many genes, each with a small effect?

EFFECTS OF RESISTANCE GENES. Knowledge of the effects of genes in the conditioning of disease resistance is often useful or essential. These effects may be defined as categories of several useful classifications. For example, whether genes provide general or specific resistance is important. It is useful to know the functional nature of the resistance conditioned, such as 1) escape, 2) exclusion, 3) host-parasite interactions following infection, and 4) tolerance of disease. More specific physiological, anatomical, or biochemical effects within these categories may also be determined. A detailed listing and determination of the possible mechanisms of genes providing resistance to a given disease may be helpful, such as the sequence of possibilities for loose smut of wheat: 1) exclusion by closed flowering, 2) resistance to penetration of maternal (ovary) tissue, 3) resistance of penetration of embryos, 4) damage or death of infected embryos, 5) resistance to penetration of embryonic stem apices, 6) inhibition of maintenance of infection at growing points, 7) stunting or death of infected seedlings, and 8) stimulation of abnormal internode elongation. Referencing of such effects to numbers and sources of genes involved would be advantageous.

VALUE OF RESISTANCE GENES. Resistance genes may be evaluated on the degree of resistance that they impart or the level of protection from loss afforded. Van der Plank has also written of strong and weak genes for specific resistance in regard to the frequency of development of corresponding genes for virulence. It is now recognized that not only is a high level of protection desirable, but that duration of effectiveness is a very important criterion of evaluation.

STRATEGIES FOR DEPLOYMENT OF RESISTANCE GENES. The most important single concept in disease resistance strategy is the providing of diversity. This may be achieved on an intravarietal (multiline), intervarietal, or interregional basis. The lack, so far, of a systematic approach to interregional diversity may be one of our most serious errors.

Van der Plank recommended using genes for general (horizontal) resistance early in an epidemic and those for specific (vertical) resistance later, either in regard to varietal maturity or latitudinal progression. Watson supported genetic combination of several major, single genes for specific resistance. We have proposed pathological techniques to facilitate this for rust resistance.

Analysis of frequencies of specific virulence of a pathogen from survey data can provide information by which to identify and evaluate genes and upon which to base decisions for their deployment, in cases where we believe the concept of corresponding host and parasite genes to be valid.

TABULATION OF RESISTANCE GENES. Most of the proposals which follow from the principles identified here can be better achieved if we obtain a valid tabulation and characterization of the resistance genes which are available. I believe such research should be intensified, but in close coordination with the development of tactics and strategies aimed toward effective use.

GENES FOR INSECT RESISTANCE IN WHEAT

R. L. Gallun

Dr. Schafer in his excellent presentation has given you the basic concepts of developing disease resistant varieties and the philosophy of utilizing genes for resistance. These same concepts should and do apply to developing insect resistance varieties because of the similarities that exist between pathogens and insects relative to the host plant. All parts of the plant are attacked by pathogens or insects depending upon the specificity of the individual organism. They both have sexual forms which allow for genetic recombination although insects may have the edge here in not having to move to an alternate host for this purpose, as is the case for certain fungi. Cultures of both pathogens and insects can be maintained for evaluation purposes, and the reaction of the plant to the invading organism is also similar in most cases. The only great differences I see between pathogens and insects as related to host plant resistance is that insects are more mobile and have specific food preferences or non-preferences, whereas pathogens are at the mercy of environmental factors such as wind, rain or insects and other animals for their establishment.

Genes for resistance in wheat to both insect and diseases have been tabulated, although the magnitude of these studies has been much greater for disease resistance. Varieties have also been developed for insect resistance as well as disease resistance. As with disease studies, some insect resistance studies have gone beyond the stage of just tabulating genes.

Take the Hessian fly - wheat complex for example. There have been at least six specific dominant genes for resistance to specific races of Hessian fly that have been identified. Utilizing these resistance genes, we have studied the interrelationship that exists between the insect and the host plant and have accumulated substantial evidence, that there definitely is a gene-for-gene relationship between the genes for resistance in the host plant and the genes for virulence in the insect.

For every single dominant gene for resistance in the wheat plant to a specific race of Hessian fly, there is a single recessive gene for virulence in the insect. For instance, our Indiana wheats, Monon and Arthur, have the dominant H_3 gene for resistance to Hessian fly, and Knox 62 and Benhur have the dominant H_6 gene for resistance. Race A of the Hessian fly has two dominant gene pairs for avirulence to these two wheats, whereas Race B has a homozygous recessive gene pair for virulence to the H_3 gene and also a dominant gene pair for avirulence to the H_6 gene; whereas Race C has a dominant gene pair for avirulence to the H_3 gene but a recessive gene pair for virulence to the H_6 gene. Race D has two sets of gene pairs both recessive for virulence to the H_3 and the H_6 gene pairs in wheat. Also, reciprocal crosses between races of Hessian fly have shown that the virulence of the insect is controlled by genes at different loci and are not alleles of the same gene, and that virulence dominant to virulence at the same loci.

Further studies have also given us genetic evidence that paternally derived chromosomes of the male are eliminated during spermotogenesis and only the female derived chromosomes end up in the sperm. Oogenesis is normal with two kinds of ova being produced. What this means, is that essentially the females can be either homozygous or heterozygous whereas the males always act as homozygotes and their genotype is dependent upon the chromosomes derived from its mother. Recombination of genes still occurs, but only as the result of what could resemble a backcross, and the direction of the cross between the previous parents.

Now, how does all this genetics benefit the development of resistant varieties. I think this depends upon the wheat breeder and the amount of time and energy he wants to put on manipulating genes for resistance. We know from our population surveys, what kinds of races of Hessian fly are in the field and we know that genes for resistance will remain strong. We know the recombinations possible in the insect and can predict gene frequency for virulent genes in the fly population. We can then forecast with a good degree of accuracy what races of fly will be present in the field after years of selection pressure by resistant specific varieties. Knowing this and conducting a progressive breeding program, our resistant genes should last longer than if they were used only because of their availability.

An exciting offshoot of our genetics research that should be of interest to you as wheat breeders is that Hessian fly in certain areas of the eastern soft wheat region can be eliminated by the release of the Great Plains race of Hessian fly. Dr. Hatchett formerly of our lab and now at Columbia, Missouri and Dr. Foster of our laboratory, have studied this method of autocidal control and are developing a release program in the field. Briefly, the Great Plains race has dominant genes for avirulence to wheats having the H_3 and H_6 genes for resistance; in other words, it cannot survive on these wheats. Races B, C, and D which are prevalent in the eastern soft wheat region have genes for virulence to these specific wheats and can live on them. If the Great Plains race were released in areas where these virulent races have been building up, there would be three possible matings. There would be a GP x GP mating the progeny of which would not survive, there would be a GP x wild mating the progeny of which would not survive, and a wild x wild mating the progeny of which would survive. Theoretically by flooding the wild type population with the GP race at a ratio of 20 GP to every 1 wild type in the field for three generations, the wild type population would be eliminated in four generations. We have proven this in the lab and in small plot experiments in the field. We hope to take it to larger fields next fall.

I have been talking about resistance all this time, but have not defined it. It is generally accepted that resistance in the plant to insects is one of three mechanisms: (1) antibiosis where the insect dies or has had an adverse effect by the host plant, (2) non-preference where the insect for some reason or another does not prefer the host plant for oviposition or food, and (3) tolerance, where the infested plant responds by producing new plant parts or the plant has the ability to produce a good yield that is not affected by the presence of the insect. Of these three, I believe non-preference is the mechanism of resistance that is the most beneficial in the development of insect resistant varieties. Antibiosis leads to new

new races by its selective pressure, and tolerance does not reduce the numbers in an insect population which is what we are looking for. Non-preference may not either, if there is another preferred host, however it does reduce the insect population on the crop planted and this may lead to lower populations the following year. If the insect population moves to another host plant that was heretofore non-infested and this crop is of economic value, then we haven't benefited from the resistance, we only have made problems for somebody else. However, I still believe non-preference is the answer and coupled with antibiosis or tolerance, it should be an effective control measure.

Let's look at the Cereal leaf beetle for example. We have found that this insect does not prefer to oviposit on wheat leaves that have a high density of leaf pubescence. This is non-preference at its best. Also, if eggs are placed on pubescent leaves or one or two are oviposited by ever-burdened females, then antibiosis takes its toll in that the egg dessicates more readily perched high up on the hairs, and if first instar larvae would start to fee, they never make it past the second instar. Now, when non-preference and antibiosis mechanisms are brought together on a plant that could tolerate larval feeding if it did occur, then we would have the ultimate in insect control, and I would bet a good steak dinner that a race situation would never occur. We will find this out before very long, in the near future Indiana and Michigan will be releasing CLB resistant wheats with those mechanisms of resistance in the near future.

A few words about the mechanism antibiosis. In the case of insect resistance in wheats, this mechanism has been utilized the most, mainly as Dr. Schafer pointed out in his presentation, that a mechanism such as this is the easiest to come by. It is also very effective in reducing insect populations, but it leads to serious problems in the form of new races especially with insects that are more permanent residents than many of the fungi of wheat. I do not believe we should discard this mechanism, but we should be more discriminating in its use especially in releasing varieties having the same genes for resistance on large acreages.

Again using the Hessian fly as an example, we can see as a result of antibiosis how these races develop in the field. In 1955, Dual wheat was released in Indiana. It had the H_3 gene for resistance. In 1959, Monon was released, and in 1960, Redcoat was released. These three varieties had the H_3 gene for resistance and were grown on most of the Indiana wheat acreage. In 1962, we began to get reports that these wheats were becoming susceptible to Hessian fly. In 1962, we released Knox 62 which had the H_6 gene for resistance to the new race. This was not happenstance because we did know that the H_3 gene would not survive long before Race B developed into large field populations. We also knew that the H_6 gene would be resistant to Race B so this gene was utilized in the development of Knox 62 and then Benhur. These two varieties are still retaining their resistance because Race C which can attack them was wiped out by the H_3 gene. But we have Race D in the field in small numbers that can live on both. This year, we released an Arthur type wheat that has the H_5 gene which is resistant to all known races. How long it will retain its resistance is anybody's guess, but so far we have been unable to breed a race in the lab or isolate one from the field that can survive on this type of resistance. I won't bet a steak dinner that it will hold up though. What I did want to point out was that these so-called weak genes can be strong if utilized in a progressive breeding program, where we are not complacent with what we have, but continue to introduce new resistance into the breeding of wheats.

I did pass out a mimeographed sheet which has about 30 insects listed on it and grouped according to the kind of feeding they do. Actually, there are about 100 insect species that attack wheat. I have listed the most important ones. As you can see, most of these insects are either stem or leaf feeders, but some do feed on more than one part of the plant. I have also classed these insects into horizontal groupings. Those on the top, shown in capital letters, are the insects that have been studied the most for resistance in wheat. Some wheats have been developed that are resistant to these insects, and genes have been tabulated. Antibiosis is the main mechanism: Greenbug resistance in wheat is governed by a single recessive gene. No wheat varieties have been developed that are resistant to this insect, although some resistant barleys have been developed. For the Hessian fly, there are at least 6 different dominant genes established for resistance, and twenty-three resistant varieties have been developed. There are also 8 races established that are virulent to different gene combinations in the wheat. The wheat stem sawfly relies on solidness of stem for resistance. Three recessive factors govern stem solidness in wheat. Eight resistant varieties have been developed.

Resistance to the Cereal leaf beetle is dependent upon pubescent leaf surfaces. Genes for pubescence are partially dominant and quantitatively inherited. To date, no varieties have been developed. As for the second grouping of insects, those listed in lower case letters on the sheet, resistance in wheat is known for these insects, but no genes for resistance have been tabulated that I am aware of.

The last grouping of insects have had no studies to locate resistance to them or at least there isn't anything in the literature.

You can see from this list the road is open to develop insect resistant wheats, and how far we go is dependent upon how far we want to go. More and more entomologists are being trained in the field of host plant resistance and the excellent cooperative efforts that exists between pathologists and wheat breeders could also exist between entomologists and wheat breeders if breeding wheats for insect resistance is one of the objectives in your program of improving wheats.

INSECTS THAT ATTACK WHEAT AS RELATED TO HOST PLANT RESISTANCE

ROOT OR SEED FEEDERS	STEM FEEDERS	LEAF FEEDERS	HEAD FEEDERS
	GREENBUG HESSIAN FLY WHEAT STEM SAWFLY	CEREAL LEAF BEETLE GREENBUG	GREENBUG
True Wireworms	Chinch Bug Frit Fly Wheat Jointworm Wheat Stem Maggot Wheat Straw-worm	Grasshoppers Leafhoppers	Grasshoppers Stinkbug
crown aphid *cut worms* *false wireworms* *white grubs*	*apple grain aphid* *billbugs* *common stalk borer* *cutworms* *English grain aphid* *lesser corn stalk borer*	*apple grain aphid* *brown wheat mite* *English grain aphid* *leaf sawfly* *Mormon cricket* *wheat curl mite*	*armyworm* *thrips* *wheat blossom midge*

HAIL, DROUGHT, WEEDS, GRASSHOPPERS AND THE BLACKSTEM RUST

Gordon A. Brandes

I saw first hand the helplessness of farmers to cope with these problems when I was growing up in the Dakotas in the 1930's. The irony of the drouth ridden 30's is that when it did rain in 1935 and '37, stem rust took the crop. The agonies of these times forces some changes. Conservation practices and income stabilization were initiated because it was politically expedient but more importantly the nation's food producing capacity had to be preserved. Urban dwellers need constant reminding of this fact.

The chemical revolution in farming began in the 1940's. 2,4-D opened an entirely new concept in selective weed control. A few ounces of aldrin per acre did a job on hoppers never possible with mountains of arsenic baits. Other new insecticides handled some of the old pests that had plagued us for years. Effective low volume aerial or ground equipment resolved some earlier problems of logistics and economics.

But the blackstem rust, as it was called in the early days, is still around. Eventhough the current variety picture is favorable, who knows when another race will explode? The situation on leaf rust is still very fluid and what can we predict about stripe rust? There is no denying the tremendous benefits of the resistant varieties. These are about the ultimate in cost-performance ratio. But, if a new rust race develops, the wheat farmer can do little more until a new variety is ready than hope the weather will be wet enough to make a crop but dry enough to avoid the rust.

The explosion of race 15B in the 50's stimulated a flurry of interest in chemical control. Zineb was an effective protectant but required multiple applications and efficient low volume sprays for fungicides were not perfected.

The discovery of the specific activity of nickel compounds on the rusts appeared to be a real breakthrough. Nickel alone was insufficient but combined with a protectant such as maneb, two or three applications provided fair protection against any of the rusts. The cost-performance ratio was marginal but acceptable under emergency conditions. Bluegrass seed growers in Oregon have used the program for several years.

My company, Rohm and Haas, and the International Nickel Company actively pursued the nickel-maneb development including full scale toxicological and residue studies. Unfortunately, after several years and a few hundred thousand dollars were invested the residue problem could not be resolved. The nickel ion concentrated in the bran layer, an important ingredient in food and feedstuffs. The heavy metals such as nickel, tin, lead, and mercury pose some peculiar residue and toxicity problems. I predict their use will be severely restricted or prohibited entirely in foods in the future.

The nickel-maneb development also had a distressing logistics problem. Nickel was phytotoxic and showed no utility on other crops even though maneb is widely used. Thus, the nickel-maneb mixture could only have potential on cereal grain. Because of the erratic nature of rust disease outbreaks, large inventories could not be stocked of the mixture nor was it even practical to stockpile the nickel salts for last minute mixing with maneb.

It may be very difficult to commercialize a specific chemical limited to rust control on cereals because the market is so unpredictable; unless, it is so low in cost it can be used routinely as a preventive. The successful fungicide for cereal grains should have substantial volume potential on other imporant crops in order to justify the high cost of research, development, manufacturing plant and distribution. Today this cost of bringing a new agricultural chemical through R & D to commercial sale is estimated at two to four million dollars. This assumes that no unusually difficult problems are encountered on toxicology, residues, metabolites or environmental hazards. The residue question is frequently magnified with systemics.

We are apprehensive that further unnecessarily restrictive regulation may result with the moving of pesticide registration control from the Department of Agriculture to the new Environmental Protection Agency. Preservation of the environment is a matter of grave social and political concern but it cannot be accomplished by socialogists, lawyers, "instant environmentalists" and the politicians alone. Agricultural scientists, the original practicing ecologists, must become involved and insist that rational, balanced approaches be followed. I make no apologies for the agricultural uses of mercury fungicides or DDT. If mistakes have been made in their use it has been done unwittingly. We can validate the lives saved from disease and hunger through the use of modern pesticides. I am not convinced the allegations against agriculture as a major source of chemical pollution have been validated. We are all justifiably proud that a fellow plant scientist, Dr. Borlaug has been awarded the Nobel Peace Prize. I remind you that some years ago this same prize was awarded the developer of DDT. It is just as silly to talk about eliminating chemicals in agriculture as it is to claim all of the disease and insect problems can be controlled with resistant varieties. The two used judiciously together, however, have tremendous possibilities.

Perhaps we have put too much attention on a chemical for rust control while overlooking the insidious damage from Septoria, Helminthosporium and perhaps other organisms. Bissonnette and others have demonstrated the practical value of Septoria control on wheat and barley with a couple of aerial sprays of a protectant such as zinc-ion maneb.

It is time for all of us -- the United States Department of Agriculture, the State Experiment Stations and the agricultural application and chemical industries to take a more serious look at chemicals for disease control in cereal grains. Plant pathologists have dragged their feet on aerial application, insisting the low volume sprays would not give the necessary coverage for disease control. The aircraft haven't changed much but the spray distribution systems and the people running them have. If the chemical can be distributed evenly, the volume of water need only be sufficient to keep the mixture sprayable and fluid until it hits the plant. Most of the spores land on the same surfaces as the spray deposit and they won't germinate until free water is present which also redistributes the fungicide over the plant surfaces. Low volume aerial sprays or ordinary protective fungicides are working on dozens of crops throughout the world.

A systemic foliar spray may be even less critical on application requirements. We are even coming close to that "seed treatment that will protect the wheat plant until maturity" that the chemical industry was charged to discover "in the next year or so" at the Wheat Rust Conference in St. Paul in 1955. I cautioned at the time it was naive to expect us to come up with such a product overnight.

Well, it has been a long night but there are some new and exciting developments in chemical control. I was gratified by the response I had from so many people but regretted time did not permit them to actually make their presentations at the conference. However, abstracts and status reports are included. We will consider first those materials that are of interest primarily for the foliar diseases whether they be applied as sprays or as seed or soil treatments. Secondly, are reports on conventional seed protectants with special consideration to the apparent need for replacements for mercury.

MANAGING THE EVOLUTION OF STEM RUST

D. R. Knott

When I began to identify genes for stem rust resistance, I thought of backcrossing them into winter wheats. In my ignorance I thought that resistant winter wheats in the south would eliminate our rust problems in the north. Now, of course, we recognize that the use of resistance genes in the south results in the rapid evolution of races that are virulent on them. Thus the genes are rendered ineffective in the north. The gene Sr6 has remained effective in Selkirk and other spring wheats because the races coming from the south are avirulent on it.

Van der Plank's 1968 book stimulated my thinking further. It is clear that to control rust we must manage the evolution of the pathogen so that the host-pathogen system reaches a stable equilibrium at a point where serious damage does not occur. A number of procedures can be used to bring about such an equilibrium.

1. The wheat growing area of the Great Plains should be divided into three zones and specific genes for resistance assigned for use in each. The zones might be the overwintering area in the south, the remainder of the winter wheat area and the spring wheat area.

2. Highly effective genes for specific resistance should not be used in the south. In this area methods that do not put strong selective pressure on the rust must be developed. These include the use of general resistance, multiline varieties and genes that provide intermediate levels of resistance. The possible occurrence of general resistance must be explored further.

I was very much concerned by the recent report on the Uniform Cereal Rust Observation Nurseries for 1969. It appears that most of the sources of stem rust resistance in the winter wheat lines are varieties such as McMurachy, Selkirk and Kenya 58 which carry Sr6. If winter wheats carrying Sr6 come to dominate the winter wheat area, we are setting ourselves up for another disastrous rust epidemic in the spring wheat area such as hit in 1954.

GENERAL RUST RESISTANCE

J. Miller

A study was initiated at North Dakota State University to determine the relative reduction in kernel weight and seed quality of wheats which have had large to moderately large rust uredia in previous rust nurseries. This was accomplished by planting the test material in a split plot design in which half the field plot is protected from rust by spray applications of Manzate. The other half was exposed to natural inoculum and stem rust race 15B-2 inoculations of susceptible spreader rows surrounding the half plot. Rust development was recorded three times during plant development. The relative performance of each wheat was obtained by dividing the 500 kernel weight of seed from its rusted row by that of its corresponding rust free row. A kernel weight ratio of 1.0 indicates no damage from rust.

Among 100 bread and durum wheats tested, 12 lines had high kernel weight ratios of 0.9 to 1.0. Their stem rust infection was of a "susceptible" type, but the number of infections were low from the soft dough to milk stage through maturity. These lines are "slow rusters." The highest severities were 10 percent. Number of leaf rust infections were low (3 percent) on some lines, intermediate (20 percent) on others and high (60 percent) on one line. These lines showed "slow rusting" or "tolerance" of leaf rust.

One wheat showed faster rust development and higher number of infection to both leaf and stem rusts without a reduced kernel weight ratio (over 0.9). These wheats have had susceptible infections and relatively good performance in other rust nurseries indicating their resistance may be non-specific.

Studies are being made on the inheritance of general resistance. Crosses have been made between these "slow ruster" wheats and wheats with no known genes for stem rust resistance. F_2 populations will be tested in a field rust nursery this summer.

EFFECT OF WHEAT MILDEW ON YIELD

G. K. Middleton

An F_4 McNair wheat selection which was producing well, but which was not as uniform in growth habit as desired was reselected. In the winter of 1968-69, twenty of these selections were in a special yield test, along with the bulk from which they came.

The original selection had shown good leaf rust resistance in a number of tests, but was somewhat susceptible to mildew. In this special test, it was noted that the reselected lines varied to a wide degree as to susceptibility to mildew. In fact, of the twenty lines, ten had mildew readings ranging from a trace to 1.4%, while in the other ten, the range was 15.6 to 28.8 (figures given for each line was an average of 8 readings).

Average yield of the two groups was 66.8 and 57.8 bushels, respectively; a 9 bushel difference. There was a negative correlation between mildew and yield with a value for $r = 0.8279$.

"TOLERANCE" TO CERCOSPORELLA FOOT ROT

R. E. Allan

We obtained useful tolerance to Cercosporella foot rot by transferring the two-gene semidwarf height of Suwon 92 into an Omar background. We failed to obtain similar results when the two-gene semidwarf height of Nrn 10/Bvr 14 (C.I. 13253) was transferred to Omar. Results infer that foot rot tolerance of two-gene Suwon 92/6*Omar lines is either pleiotropic or closely linked with the Sd_1 and Sd_2 loci as they occur in Suwon 92. Although C.I. 13253 is known to have the same two loci that control semidwarf height as Suwon 92, no parellel increase in tolerance to the organism occurred for two-gene lines of C.I. 13253/5*Omar.

Circumstantial evidence has suggested tolerance to Cercosporella foot rot relates to late maturity. This observation has seemed particularly likely when late maturing European cultivars that have tolerance (Odin, Nord, and Druchamp) are utilized. Results in 1970 clearly showed that close, positive correlations prevail between yield and maturity under foot rot conditions among five populations studied. The r values ranged from 0.333 to 0.751. We conclude that tolerance to foot rot does relate to late maturity and this relationship can be demonstrated in populations capable of producing low, medium and high levels of tolerance. The relation does not appear to be so restrictive that we would be prevented from selecting moderately early types tolerant to the foot rot organism.

RESISTANCE TO SNOWMOLD

W. K. Pope

Snowmold was prevalent in much of the Western Region in the spring of 1969. From what I saw and heard and what I observed in my own plots at Moscow, it hit me on the weekend of July 19-20 that I was seeing the generalized solution to the problem of tolerance to snowmold in winter wheat. It has the same pattern of multigenic stairstep increments of resistance that I had previously seen for stripe rust.

In brief, tolerance to snowmold (and I think this fits for most diseases) is a pyramid of many parts. Under severe disease conditions only a few superbly resistant wheat types such as C.I. 14106 (Sunderman) will survive. Under milder levels of disease more and more resistant types can be recognized just as one can see more of a drowned pyramid as the water level of a lake recedes.

GENES FOR RESISTANCE TO RACE 15B-1L OF *PUCCINIA GRAMINIS TRITICI*

E. L. Sharp and F. H. McNeal

In working towards developing varieties of semi-dwarf spring wheats resistant to stem rust, near isogenic susceptible-resistant wheat lines containing the various Sr genes were evaluated to race 15B-1L. The paired near isogenics evaluated contained the stem rust resistance genes: Sr_5, Sr_6, Sr_7, Sr_8, Sr_9, Sr_{11}, Sr_{16}, Thatcher 3B, Hope 2B, Hope 1D, and all possible combinations of Sr_6, Sr_8, and Sr_9. Only Sr_6, Sr_8, and Sr_9 resulted in appreciable resistance to race 15B-1L in both seedling greenhouse tests and in mature plant tests in the field. Sr_6 conditioned a (1) infection type while Sr_8 and Sr_9 alone or combined conditioned a (1, 2) infection type. Combination of Sr_6 with Sr_8 or Sr_9 gave a (0; 1) while Sr_6, Sr_8 and Sr_9 combined conditioned a (0;) infection type.

Potential spring wheat varieties representing infections types (0;), (1) and (2) were test crossed to Thatcher. Analysis of the F_2 data indicated that plants representing (0;) and (0;1) contained the Sr_6 gene plus at least one other resistance gene. All possible combinations of Sr_6, Sr_8, and Sr_9 appeared to be present in the potential spring wheat varieties. Further evaluations are being performed to confirm the specific Sr genes contained by the spring wheat variety candidates.

BREEDING WHEAT RESISTANT TO THE BARLEY YELLOW DWARF VIRUS

C. O. Qualset

BYDV apparently is a serious disease of wheat in California. Symptom expression is not as obvious as in barley or oats, but sterility is common and yield losses are evident. Recent experience in California with BYDV-resistant barley varieties indicates that losses due to BYDV were much greater than anticipated from field observation of symptoms. It is believed that a similar situation occurs in wheat. This suggests that if the disease is obvious in barley or oats, it is quite likely that nearby wheat will also be infected and subtle yield losses will be experienced.

In 1961, a program of screening the wheat World Collection for BYDV resistance was begun at David by J. C. Williams. More than 5,000 entries were examined for symptom expression in inoculated tests. A number of entries were selected with tolerance but none with extremely high levels of resistance were found. Among those with some promise were the following:

C.I. 4571
C.I. 5246
C.I. 5523
C.I. 5857
C.I. 6564
C.I.10999
C.I.11005
C.I.13232

P.I. 94570-11
P.I. 94570-12
P.I. 94577
P.I.152257
P.I.165156
P.I.165179
P.I.166253
P.I.166657

P.I. 167631
P.I. 168662
P.I. 190990
P.I. 191360
P.I. 191407
P.I. 191976
P.I. 192371
P.I. 193109

C.I.13232 = Coker 55-9 = Chancellor^2 x T. Hybrid, a late-maturing variety in California, has been crossed with Ramona 50 and Big Club 60. F_3 lines were observed in a disease nursery and about 8% (out of more than 800) of the lines in each cross were classified as resistant. Selections were made from resistant and segregating rows and tested for resistance. The most resistant derivatives were reselected until we now have F_8 lines which approach the earliness of Ramona 50 and have the limited symptom expression of C.I.13232. As yet these derivatives have not been tested for yield reduction after infection with BYDV.

A second variety which also has limited BYDV symptom expression and extremely high grain yield was identified in the International Spring Wheat Yield Nursery. This variety, D6923 = (Lerma Rojo x Norin 10-Brevor) x Andes^3, has been crossed to the C.I.13232 derivatives and other early generation materials in an attempt to combine resistance from several sources. We anticipate that a recurrent selection program will be the most effective method of developing populations highly resistant to BYDV because of yearly variations in severity of infection and sources of resistance with lower than the desired level of resistance.

A METHOD FOR TESTING WHEAT FOR TOLERANCE TO SEPTORIA NODORUM BERK

A. Bronnimann

Because of potential high losses in yield caused by Septoria nodorum, a method for selecting tolerance or resistance has been developed, The method consists of cultivating the breeding lines in the field in two parts, one to be infected and one as a non infected control. Guard rows of oats are used between the infected plots and the control

The inoculation is made after heading with a spore suspension (spore concentration appr. 10^6-10^7 spores per ml). So far no physiological races could be found. For the inoculation a mixture of different cultures is used.

Estimation of attack is made in the milk stage, only as a measure of infection. Estimation of attack cannot be used as a criterion for selection because of small correlation with the damage.

The judgements are therefore made by means of the thousand kernel weight. Evaluation of the grain appearance is often sufficient. This criterion has a good correlation with the thousand kernel weight.

Up to now, no resistance could be found; only differences in tolerance. The causes of tolerance are largely unknow. In addition to the destruction of the assimilation area probably also a toxic effect of the fungus is involved.

In general, semi-dwarf types are more heavily injured than normal types. The genetical base of tolerance is largely unknown. Preliminary results indicate an additive gene effect.

THE REACTION OF SEVERAL MINOR GENES TO *PUCCINIA STRIIFORMIS* WEST

G. Allan Taylor and Eugene L. Sharp

Major genes for disease resistance have been used extensively in plant breeding programs. The use of major genes has certain disadvantages of which we are all aware. In situations where a one-to-one relationship exists between the host and parasite genotypes a single mutation or recombination in the parasite may result in changing an avirulent race to a virulent one. A recent occurrence of this is probably exemplified by the white club wheat cultivar 'Moro.' Moro, released in Oregon in 1966, possesses one major gene for stripe rust resistance from P.I.178383. In 1969 an isolate was found at Bonner's Ferry, Idaho which could attack Moro.

In addition to the major gene, P.I.178383 has three minor, recessive, additive genes for resistance to stripe rust. The major gene is epistatic to the minor genes. These genes were incorporated into four HRWW lines in combinations of zero, one, two and three per line in absence of the major gene.

The three minor gene lines were exposed to at least 11 isolates of stripe rust in controlled environment chambers at Bozeman, in field situations in the International Stripe Rust Nursery and in greenhouse and field experiments in Europe.

A summary of all locations indicates the line with *no* minor genes was susceptible to stripe rust, exhibiting a 3, 4 infection type. The *one* minor gene line was moderately resistant with a 3^-, 3 infection type; and *two* minor gene line was resistant, 1, 2 infection type; and the *three* minor gene line was very resistant, 0, 1^- infection type.

Although the infection type of the four minor gene lines varied slightly at different locations, depending on temperature, their ranking remained *unchanged* for all locations and isolates. This indicates that these minor, recessive, additive genes from P.I.178383 are not specific in their reaction with the parasite and in fact are a form of non-specific resistance.

In 1967 the Montana Agricultural Experiment Station released the HRWW cultivar 'Crest,' which was known to possess the major gene for stripe rust resistance from P.I.178383. With the discovery of the isolate which attacks the major gene, it was revealed that Crest was heterogenous with respect to the three minor genes from P.I.178383 (major espistatic to the 3 minor genes). We have isolated several "line row components" of Crest which possess the dominant major gene and the three recessive, additive, minor genes. These line rows will provide the nucleus for an immediate new variety if and when the "Moro" isolate of stripe rust is found to occur in Montana.

From the wheat breeders viewpoint, quantitative, or nonspecific, types of disease resistance are less desirable due to the increased complexity of incorporating them into acceptable cultivars. However, this type of resistance may not have a one-to-one relationship between the host and pathogen. A combination of several nonspecific factors may impart an acceptable level of resistance, and be more stable to race changes than resistance conditioned by major genes.

As time progresses we may be depending more on nonspecific sources of disease resistance. It would seem that if mutations for virulence occurred, the pathogen would have little selective advantage. Wheat cultivars possessing both specific and nonspecific types of resistance, or nonspecific alone, would be resistant to a wider range of races and should remain in production for longer periods of time.

If a race does occur which will attack a minor gene, the remaining resistance (assuming more than one minor) should still be effective. That is, an abrupt change from a resistant reaction to a susceptible one should not occur, as in the case of major specific genes, but rather a small change in infection type would be noted.

RECEPTIVITY TO INFECTION BY STEM RUST OF SOME "SLOW-RUSTING" WHEAT VARIETIES

J. B. Rowell

Field observations have indicated that stem rust epidemics develop at different rates on some susceptible wheat varieties. The characters of wheat that cause slow development of virulent races of stem rust could be useful sources of generalized resistance. A method is needed that readily detects these characters and easily scores the level of such resistance in different wheat lines. We tested a promising procedure in 1970. Six varieties susceptible to race 15B-2, but known to differ widely in rate of rust development, were planted together in a block. Individual blocks were located at four widely separate sites on the Experiment Station Farm at Rosemount, Minnesota. All varieties in a block were uniformly inoculated with heavy inoculum of race 15B-2 carried in a light mineral oil and applied to all varieties by means of a back-pack mist-blower. A different block was inoculated each week for four successive weeks after the early tillering stage of wheat development. Natural infection was too scant to compete with the artificial inoculations until after heading when the fourth block was inoculated. In each block, the number of primary infections per tiller that developed on the varieties from equal loads of inoculum was determined 12 days after inoculation. A highly susceptible wheat line, 'Purdue 5481C,' was used as a standard for comparing amount of infection on the different varieties. The ratio between the amount of infection on a variety and the standard gave a relative index of the receptivity to infection.

Marked differences were observed in the receptivity of the varieties to infections, ranging from 2% to 300% of the infection on the variety used as a control. Furthermore, the receptivity to infection of some varieties differed with the stage of development and with type of tissue (i.e. leaf blades and sheaths) of the plant. In addition, differences were observed in the size of uredia developing on the varieties at different stages of host development. Thus, the method appears to be useful for the recognition of characters affecting the rate of development of epidemics on varieties with generalized resistance.

EXPERIMENTS ON CONTROL OF LEAF AND STEM RUSTS AND SEPTORIA LEAF BLOTCH OF WHEAT WITH RH124

(4-N-BUTYL-1,2,4-TRIAZOLE)

R. M. Caldwell, G. E. Shaner and J. J. Roberts

Leaf rust, race 9, was completely suppressed in greenhouse-grown seedlings of Axminster wheat by concentrations of .5, 1.0 and 2.0 pounds/acre of RH124 applied either as a soil drench or foliage spray.

Foliage sprays at 0.1 and 0.2 pounds per acre allowed only a trace of infection, but significant infection (15 and 25 percent of that of the check) resulted from soil drenches. The .05 pound/A rate gave incomplete control as either a soil drench or foliage spray.

Mature plants inoculated with leaf rust, race 2, following a lapse of 28 days after treatment developed only 0 to trace infections in the soil drench treatments at the 0.2, 0.1 and 0.05 pounds/acre rates. The foliage treatments at 0.1 and .05 rates reduced infection but gave incomplete control.

Stem rust was not controlled by soil or foliar applications at 4.0 mg and 40 mg per 4 inch pot in greenhouse trials. The 40 mg rate was sufficient however to induce foliage necrosis.

Urediospores of both leaf rust and stem rust germinated normally on 1% water agar containing 20.0, 2.0 and 0.2 ppm of RH124.

Small drenches of 4.0 mg per 4' pot reduced germination of leaf rust on leaves of Axminster wheat by 36% and penetration by 75%.

Eight varieties, ranging from highly leaf-rust susceptible to highly resistant, were grown in 10 replications, and treated with foliage sprays of 1 pound/acre of RH124 in 36 gal. of water. One application, to 5 of the replications in the shooting stage, gave nearly perfect control of leaf rust under severe inoculations while check replications were severely rusted. Yields were reduced from 25.6% in the most susceptible Butler to 3.2% in the most resistant. This significant protection was gained with apparently little damage to the wheat crop as indicated by the comparable yield of the sprayed and unsprayed plots or resistant varieties.

The results were counfounded by the development of a severe epidemic of Septoria tritici leaf blotch that destroyed foliage equally in both the "rust-free" sprayed plots and the unsprayed plots. This is believed to have greatly reduced the measured degree of protection afforded by RH124 as judged by comparisons of sprayed and unsprayed plots of leaf-rust susceptible varieties.

CONTROLLING WHEAT RUSTS WITH SYSTEMIC FUNGICIDES

Earl D. Hansing

Leaf Rust (1969). Single applications of benomyl and oxycarboxin applied at 1# and 5#/acre, partially controlled natural infections of leaf rust and increased yields and test weights of the cultivars Parker and Shawnee. Applications of benomyl and oxycarboxin at 5#/acre increased mean yields by 6 and 7 bu/acre, respectively, and test weights each by 2#/bu. RH-124 partially controlled leaf rust of Bison wheat, increased the yield by 4 bu/acre, and the test weight by 1 1/2#/bu.

Leaf Rust and Stem Rust (1969). Both leaf rust and stem rust developed in the cultivar Yorkstar. Single applications of benomyl and oxycarbon applied at 1# and 5#/acre, partially controlled both rusts, and at 5#/acre increased yields of grain by 2 and 4 bu/acre, respectively, and test weights by 4 and 5#/bu, respectively.

Leaf Rust and Stem Rust (1970). During 1970 natural infections of leaf rust and stem rust developed in Shawnee wheat to a maximum of high and low intensities, respectively. Single applications of benomyl, oxycarboxin, and RH-124 were applied during early jointing at 1# and 5# active/acre. Benomyl and oxycarboxin partially controlled both leaf rust and stem rust. RH-124 completely controlled leaf rust but no control of stem rust was obtained.

STATUS OF RH-124

V. H. Unger

RH-124 is a systemic fungicide. Its activity is limited to the control of wheat leaf rust (*Puccinia recondita*). It will not control other wheat diseases and it is not known to control rusts of any other crop.

The control of leaf rust by RH-124 is outstanding. The compound is effective when applied to the seed, soil, or foliage. Technical RH-124 is phytotoxic to wheat but wettable powder formulations are acceptably safe when they are used on the seed at 1-2 ounces active per hundred weight. Seed treatments provide excellent residual disease control for at least ten weeks.

Applications of RH-124 to the soil surface following the seeding of winter wheat protect the crop against leaf rust infection through to harvest the following June. This full season control is achieved with RH-124 at about 0.5 lb/A.

Excellent leaf rust control is also seen from the application of granular fertilizer impregnated with RH-124.

When used as a foliar spray RH-124 is equally effective whether applied alone or in combination with 2,4-D or Dithane M-45. Best results from foliar sprays are seed when the application of RH-124 is followed by enough rainfall to wash the compound to the root zone. Upward translocation to the newest leaves appears more efficient via the roots than from older foliage

Significant wheat yield increases from RH-124 control of leaf rust are seen with single applications of RH-124 at rates as low as 0.1 pound active per acre.

Development of RH-124 in 1971 will stress the seed treatment approach, but samples of the water-soluble liquid formulation will remain available for those wishing to continue study of foliar sprays.

"BENLATE" BENOMYL FUNGICIDE FOR WHEAT

T. C. Ryker

"Benlate" has shown promise for the control of a number of diseases of wheat. The product is presently registered in the United States for ornamentals, turf and sugarcane and pineapple seed pieces. Development efforts are being pursued on a wide front. Potential uses for wheat follow.

Benomyl, with its high activity for bunt, loose smut and Fusarium spp., has been combined with thiram as "Benlate" T. This product is a 30-30 mixture for use as a dust or slurry treatment of seeds at 3 1/3 ozs. per bu. It has particular applicability for foundation and increase seed. Seed application to winter grains in Europe has aided in the control of Fusarium nivale and seedling-stage powdery mildew. Thiram, the active ingredient in "Arasan" products, is one of the registered replacement treatments for mercurials. It augments benomyl by aiding in the control of seed rot and seedling blights.

"Benlate" applied as a foliar spray in the spring at 1 to 2 lbs. per acre has resulted in promising control of foot rot or eye spot. (Cercosporella herpotrichoides).

"Benlate" has given good control of powdery mildew of small grains where applied as multiple sprays at rates of 1/2 to 1 lb. product per acre.

"Benlate" has also shown some activity against ergot when applied as a spray at flowering time.

PLANT DISEASES: CHEMICAL CONTROL

R. L. Powelson

Fungicides were tested in field plots for control of stripe rust, powdery mildew, Take-all and Fusarium root rot. The systemic rusticide dichlorotertafluroacefone (Allied, 4-FK) has been the most effective chemical tested against stripe rust, Plantvax (UniRoyal) was effective against stripe rust as both a seed of foliage treatment. Foliage applications just prior to the "boot stage" of growth give the greatest yield response. Benlate (DuPont) was effective as a seed and foliage treatment against powdery mildew and controlled Cercosporella foot rot when applied as a spray in November or December. An infurrow application of Duter (Thompson-Hayward) gave control of Take-all. Chemical seed treatments have not given control of Fusarium root rot.

FUNGICIDAL RECOMMENDATIONS IN MICHIGAN

N. A. Smith

As for Extension with the elimination of volatile mercuries and the comparative ineffectiveness of PMA, we are suggesting maneb plus hexachlorobenzene for wheat and just maneb for oats and barley. For loose smut of barley and wheat it remains Vitavax when possible. Foliar sprays are not used to my knowledge in Michigan.

EXPERIMENTAL FUNGICIDE EL-273: ELI LILLY COMPANY

Research is continuing with this product and with some of its analogues. It will be done mostly by their own personnel but they will be contacting a few key pathologists in strategic locations.

NONMERCURIAL SEED TREATMENTS FOR WHEAT

Earl D. Hansing

Anticipating cancellation of mercurial fungicides, research has been conducted with nonmercurial fungicides as potential replacements. One significant development has been that carboxin and benomyl control loose smut (*Ustilago nuda*) of wheat. This smut was not controlled with mercurial seed treatments.

Bunt (*Tilletia foetida*) not only reduces the yield of grain but the grower receives dockage for smutty wheat. Therefore, it is essential to have complete control. Benomyl, HCB, and PCNB have given control comparable to mercurial fungicides. However, these nonmercurial fungicides are not effective against seed decay and seedling blight under our growing conditions. Fungicides such as captan, carboxin, maneb, terrazole, and thiram are effective against seed decay and seedling blight but they are not comparable to volatile mercurial fungicides for control of bunt. Combinations of nonmercurial fungicides such as benomyl + thiram, captan + HCB, maneb + HCB, maneb + captan + HCB, and PCNB + terrazole not only effectively control bunt but seed decay and seedling blight as well.

Some nonmercurial fungicides and combination fungicides have been tested extensively as seed treatments for wheat while others have been tested only once or twice. Additional research on some is essential on the effect of storage of treated seed before planting, and on planting of treated seed under different environmental conditions.

SEED TREATMENTS

John L. Weihing

From the reports that I have been receiving, there have been significant increases in yields with some of the nonmercury seed treatment compounds and, perhaps, in the final analysis the cost-benefit ratio may be better than it was with the mercuries. I certainly look forward to fungicide combinations for cereal seed treatment and broader control of a broader disease spectrum. Covered smut has become a historical disease and is not seen in Nebraska. Loose smut could very well follow the same route with the use of certain new systemic fungicides. The mercury problem may very well bring about another significant step of advancement in cereal seed treatment.

MERCURIALS

D. G. Wells and R. C. Kinch

Mercury contamination of land, water and food has recently been revealed. A mercury compound has long been used to treat seed of cereal grains. With one exception, the use of mercury has not been justified. No data apparently exist to show a yield advantage from such treated seed. The exception has involved bunt infested seed which gave a yield response after seed treatment. However, new and clean seed could have taken care of the problem. Professor R. C. Kinch says plant pathologists over the years have failed to produce evidence that treatment of seed with mercurials increases yields. Many data show of course increases in stands but not yields. Use of mercurials is dangerous to workers and to the environment and is an economic waste and must be discontinued.

THE PRESENT STATUS OF VITAVAX

Robert E. Grahame

Vitavax continues to give excellent control of seedling blights, smuts and bunts of wheat, barley, oats, cotton and peanuts.

UniRoyal expects to have Vitavax Seed Protectant and Vitavax combinations with thiram and captan fully registered on cotton by late 1971.

However, full registration on wheat, barley, oats and peanuts will not be accomplished until 1972. Unfortunately, commercialization of Vitavax has been slower than hoped for due to its systemic nature and the necessity for new data on its fate in the environment.

In 1971 we will continue to have our present label on Vitavax for use on foundation and registered wheat and barley seed. We will also attempt to obtain an experimental label on small grains and peanuts for use this fall to obtain additional information under commercial conditions. However, the amounts that can be used will be limited to a small percentage of the total acreage.

At the present time the only formulations of Vitavax and its combinations available are 75% wettable powders. We are, however, actively pursuing the development of several Vitavax-thiram flowable formulations and will be doing limited field testing on these in 1971.

BREEDING OBJECTIVES FOR THE 1970'S IN INTERNATIONAL PROGRAMS

Joseph A. Rupert

This discussion is limited largely to breeding objectives in those developing countries with wheat deficits. Most of these countries have a greater or lesser area of wheat grown under irrigation and are expanding this area where this is possible, as in the case of Egypt. Substantial increases in yield through varietal improvement are being achieved primarily on these irrigated areas. In areas where water is a limiting factor, yield increases have been more difficult and have come through better management practices, such as moisture conservation, rather than through improved varieties.

The short stature wheats of the 1960's which have made such an enormous impact in many of these counties, notably India and Pakistan, have stimulated a great increase in the use of fertilizer--to the point where the original semi-dwarf varieties now tend to lodge. There is, consequently, a demand for shorter varieties which will permit the use of even greater applications of fertilizer, and these are on the way to becoming a reality. However, one of the difficulties being encountered is that yields of these shorter wheats are difficult to maintain at the same levels as those of the original semi-dwarfs. There is no ready explanation for this, but there are indications that so-called "triple dwarfs" with a yield potential surpassing that of the present semi-dwarfs can be developed.

As shorter wheats become widespread, losses from foliar diseases can be expected to increase and this will require renewed efforts at incorporating better resistance to such diseases as powdery mildew and septoria, as well as to leaf and stripe rust. Aphid infestations can be expected to become more prevalent and cause additional losses through the spread of barley yellow dwarf virus.

Fortunately, adequate sources of resistance are available for the most part, or can be found, if the required intensive search is undertaken. A good place to look is the World Wheat Collection maintained by the USDA. This is a veritable gold mine whose potential has hardly been scratched. Its value increases year by year as it becomes better studied and cataloged, and as the number of entries grows.

A recent expansion of the CIMMYT program involves spring x winter wheat crosses in a cooperative effort with the Department of Agronomy, University of California at Davis. Given the existence of two elite, but surprisingly isolated, germplasm pools in the form of spring and winter wheats, it is believed that much can be gained by a systematic blending of these pools. The limited amount of spring x winter crossing in the past has given some outstanding varieties, such as Mentana and Thatcher, and the whole series of newer Mexican spring semi-dwarfs carrying dwarfing genes from the winter parent, Norin 10-Brevor.

Spring x winter F_2 populations constituting a large infusion of new genetic recombinations are being sent for screening to a number of regions where CIMMYT has program commitments, such as North Africa and the Near East. It is hoped that these populations will be equally useful to spring and to winter wheat breeders anywhere in the world. As a point of departure the highest yielding winter wheats from the International Winter Wheat Performance Nursery, such as Gaines, Bezostaya, Arthur, Sturdy, and others are crossed with the best yielders in the International Spring Wheat Yield Trial, such as Pitic 62, Sonora 64, Siete Cerros 66, Penjamo 62 and others. These lines are further crossed in early generations, including F_1, with both spring and winter lines. The winter wheats offer excellent sources of resistance to powdery mildew and stripe rust, which are being transferred to the spring wheats along with such useful traits as profuse tillering, short stature and large, highly fertile square heads. The spring wheats possess valuable sources of resistance to leaf and stem rust, which should be more widely used in winter wheat breeding.

A mention of the Triticales and their potential should be made. Although the main thrust in the work with this man-made species must continue to come from the developed countries, it is not too early for cereal breeders everywhere to become acquainted with this fascinating plant. It is hoped that the International Triticales Yield Nursery, begun last year by CIMMYT, will have a wide distribution comparable to that reached by the International Spring and Winter Yield Nurseries.

Triticales lines in early generations are on hand with spikes up to 12 inches long and some lines have exceptionally high lysine content of the grain. It is not unrealistic to expect that within the next 10 or 15 years some, if not all, of this spike length will be transferred to both the tetraploid and hexaploid wheats. If we thus succeed in doubling the size of the wheat head (and the number of grains per spike) Dr. Reitz' predictions of a 50% increase in wheat yields by the year 2000 may yet turn out to be relatively conservative!

BREEDING OBJECTIVES FOR THE 70'S

N. F. Jensen

The speaker characterized the next 10 years as 1) the decade of the tight, competitive budget which will make difficult the continuance of programs on present levels; 2) the decade of socio-environmental concern which could mark the end of conspicuous waste and bring conservation of resources back in vogue. This opens opportunities to find biological answers to replace chemical aids, and emphasizes the role of plant efficiency in production; 3) the decade in which the probable role of hybrid wheat and triticales will be determined; 4) the decade of accelerating rural-urban shifts and agricultural readjustments. It is possible that varietal development structures may need to change, e.g. on a regional basis, to meet the needs of a changing agricultural constituency; 5) the decade to a more sophisticated approach to the quality of wheat, wherein it may be useful to develop multiple profiles of quality to meet new uses of the crop (e.g., high protein wheats not intended for milling). Finally, the speaker devoted considerable attention to the thought that the coming decade will be a good period in which to do basic research to set the stage for advances in the applied area. Areas mentioned as favorable for research were: general and specific disease resistance, seed dormancy and sprouting, roots, chromosome engineering, mass screening techniques, design of stress tests to measure ranges of reaction of genotypes, and studies of plant types and their physiology. The speaker stressed the necessity to improve our efficiency of use of the world's wheat germplasm and particularly noted the need to preserve amicable relations between public and private plant breeders--the state of this relationship may be deduced from the manner in which breeding materials are exchanged.

QUALITY, MARKET CLASSES AND MARKETING

R. K. Bequette

I do not feel that quality evaluation is a serious problem to breeders and would like to limit this session to a discussion of an old problem which has frustrated wheat breeders since 1917: the role of plant breeders and associated cereal technologists in maintaining an orderly marketing system. We should also explore possibilities for making the U. S. Grain Standards less restrictive to plant breeders, and elimination of the most common classification problems. But we should not forget the need to maintain or improve the value of our Grain Standards as a marketing tool.

The purpose of the U. S. Grain Standards is to permit segregation and marketing of grains according to their best end-use potential. If the standards are to be useful, they must provide a yardstick by which the different qualities and conditions of commercial grain may be expressed to potential buyers.

The Market Classes for wheat were designed to group wheats according to processing potential--that is suitability for yeast leavened, chemically leavened or extruded semolina products. The subclasses (except White Club and Western White) provide an estimate of protein content while the grades indicate condition of the grain.

Reliable classification and grading procedures are becoming more, rather than less, important. Changes in domestic and export transportation patterns, relocation of domestic flour mills, construction of modern mills and bakeries in developing nations, increased world competition and trade and the awakening quality consciousness of importing nations have increased the need for classification and grading systems which provide buyers with reliable information regarding the suitability of any particular lot of commercial wheat for a given use.

Producers of agricultural products have historically assumed that the market will somehow absorb whatever is produced and, until recently, have given little thought to marketing beyond the first point of delivery. This is in marked contrast to other industries which place marketing equal to product development and production.

I once read a short story about 2 men sailing a small boat across the ocean. A severe storm nearly swamped their craft. The story centered on the meal preparation problems which developed after they found that salt water had soaked the labels off all canned goods and had ruined all other food on board. How could they, or your wife, plan a meal if limited to unlabeled canned goods? The first 5 cans opened might contain fruits for the dessert, but no meat or vegetables for the main course. She could continue to open cans until she found meat and vegetables for the main course. She would have a problem saving all the unwanted cans she had opened. And the problem would probably increase with each succeeding meal.

Sound ridiculous? A similar condition could develop in wheat marketing, especially in export channels, if we do not develop realistic Market Classes and insure that our varieties and hybrids fit within these standards.

I would be the first to agree that unrealistic standards impose needless restrictions on wheat improvement. In fact, Dr. Barmore and I once proposed (Agronomy Journal 60:223-228, 1968) less-restrictive Market Classes based on simply inherited, visually distinguishable kernel characters. We suggested that all:

a. Hard endosperm bread wheats be red
b. Soft endosperm pastry wheats be white
c. Durums have large amber kernels
d. Varieties with useful, but unusual or different properties should have distinctive visible, physical kernel characters which would provide ready identification. Such varieties would initiate a new market class. Unmillable, blue, feed wheats might be an example.

Although our proposal was primarily intended to stimulate creative thinking, we felt that it would give breeders more latitude, would eliminate many grading problems, and would create a minimum of confusion during the transition period. However, we recognized that serious consideration of the proposal would be opposed by certain vested interests, and by the tradition-minded.

The foregoing seems to be one of the few serious suggestions for modifying the Market Classes for wheat since the U. S. Grain Standards were adopted in 1917. It was developed by two persons having limited knowledge of the everyday problems encountered by grain merchandisers, processors, and Licensed Grain Inspectors. I have asked persons with experience in these fields to outline their problems for us.

YIELD VS. QUALITY

V. A. Johnson

I am somewhat distressed by the title given to my presentation "yield vs. quality". It implies an incompatibility between yield and quality and the necessity for the plant breeder to choose between them. I cannot accept this as a working assumption.

My treatment of what quality will have to do with nutritional value rather than the more commonly considered conventional milling and baking quality. It is no longer realistic to be concerned only with how a wheat variety mills and what kind of a loaf of bread it will produce. How good the wheat is as food for the hungry person who must rely upon it for sustenance is an equally important question.

Nutritional improvement of wheat may not be entirely compatible with processing quality. Non-endosperm proteins of wheat are relatively rich in lysine--the amino acid most critically short in the cereals. Whereas the endosperm proteins are low in lysine, the non-endosperm proteins are largely emiminated from high-grade wheat flour. Further incompatibility may exist in the endosperm proteins themselves which can be divided into the gluten and the H_2O-salt-soluble fractions. Their ratio is variable. Wheat high in protein generally has more gluten protein, the fraction with lowest lysine content. This accounts for the tendency of lysine content to be depressed in high protein wheat. Wheats high in the H_2O soluble protein fraction tend to have soft texture and poor baking properties.

The Agricultural Research Service, USDA, and the University of Nebraska have engaged in cooperative research on protein improvement in wheat since 1955. They have successfully transferred the high protein trait from Atlas 66 to highly productive hard red winter wheat lines with excellent potential as commercial varieties. Most of the lines appear to have acceptable milling and baking quality.

The high protein trait has been determined to be a relatively stable trait. In Nebraska tests a high protein selection maintained its protein superiority over the Lancer variety in an array of soil fertility situations. Three wheats with genes for high protein which were grown in the 1st International Winter Wheat Performance Nursery remained consistently superior in protein content to 25 other varieties tested at 16 different international sites in 1969. Several apparent new sources of high protein in wheat have been identified. They include:

Aniversario
Ky58/2/Nth/3/Cnn/Tm/Mi/Hope lines
Nebr. Fertility Restorer 542437
Nap Hal (PI 176217)
Hybrid English (C.I.6225)

Laboratory amino acid profiles of a number of high protein Atlas 66-derived lines indicate that in many of them, there was no change in the ratio of lysine, threonine, and methionine from that of the low protein Comanche parent. Because of their higher protein content all of the lines possessed substantially more of each amino acid per unit weight of grain than did the Comanche parent variety. If there has been no change in biological availability and/or digestibility all of the lines should be nutritionally superior to Comanche. Small animal feeding trials are planned to test this. The Meadow Vole is under consideration as the test animal.

The Nebraska Agricultural Experiment Station, under a contract with the Agency for International Development, U. S. Department of State, has screened the World Collection of Wheats for differences in lysine and protein content. Lysine content of 12,000 common wheats ranged from 2 to 4 percent. Environmental effect on lysine level appears to be substantial. The genetic component of lysine variation is not larger than 0.5 percent based on analyses to date. Wheats from the World Collection with the best possibilities for usable above-normal lysine content include:

Nap Hal (P.I.176217)
Pearl (CI 3285)
April Bearded (CI 7337)
Hybrid English (CI6225)
Fultz x Hungarian (CI 11849)
Fultz Sel-Hungarian x
 Minturki-Fultz Sel. (CI 12756)

Nap Hal is of particular interest because it has been determined to combine both high protein and above-normal lysine content in 3 years of greenhouse evaluation.

There is increasing interest in wheat grain as livestock feed and the use of the wheat plant for silage or haylage. Future research on wheat quality should include comprehensive evaluation of wheat varieties for feed value of their grain and silage value of their stover.

YIELD VS. QUALITY

E. G. Heyne

Study of progeny of Triumph and Kaw hard wheats crossed with Atlas 50 and Atlas 66 soft wheats has demonstrated that the high protein content of the Atlas cultivars can be transferred to hard wheats. Other quality factors relating to bread making have not been easily combined with this high protein content. The highest quality lines come from the Atlas 50/Kaw crosses. Roughly four levels of protein were obtained:

similar to Atlas 66	± 17%
similar to Atlas 50	± 16%
a level of	± 14%
similar to Kaw	± 12%

No high quality high protein lines have been isolated from these crosses that equal the magnitude of the respective parents, i.e., the high protein content of Atlas 66 and excellent bread making properties. Lines with about two percent more protein than Kaw with excellent bread making properties have been obtained from the Atlas 50/Kaw crosses but not from the Atlas 66/Kaw crosses. There appears to be no association with low yield and high protein.

CLASSIFYING WHEAT VARIETIES

C. A. Watson

Grain inspectors are required to classify wheats as HRW, HRS, SRW, WW, Durum, Red Durum, or Mixed. Some areas of the U.S. are growing wheat varieties that are nearly impossible to properly classify. This has come about by the use of more diverse genetic material by plant breeders. There is no need to elaborate.

Cereal Chemists are continually being asked to develop a single, rapid, and simple test to determine essentially all there is to know about the quality of a given wheat sample. I do not believe in the foreseeable future this type of test will be developed because quality is a complex interaction of chemical and biophysical phenomenons.

I understand the problem of grain inspectors not being able to distinguish, or classify, some of our present wheat varieties. Especially some of the semi-dwarfs. However, I believe they are fighting an outdated grading system. This is a good example of where our grading system has not kept pace with the times. If varieties are developed, as private, state, and federal plant breeders are presently talking, the grain inspectors' problems have only begun.

I would suggest that we phase out the present grading system and in a newly established grading system provide the following information:

1. Percent foreign material, broken and shrunken kernels, dockage, etc. (no tolerances).
2. Percent protein
3. Hardness index
4. Test Weight (?)
5. 1,000 kernel weight
6. Moisture content
7. Color
8. Those items that designate a sample as fit for food or feed, i.e., cleanliness, odors, etc.

Further, I suggest the information be provided without designation of any class, subclass or grade. That is, market our wheat on the above information alone. This would avoid establishing tolerances, ranges for grades, etc. Also, as other methods are developed that give more meaningful marketing information, incorporate them into the grading system, either as additional information, or as a replacement for one of the above. Rheology information could be added if a satisfactory method is developed.

My question is, can we not provide the information as outlined above or any additional information as deemed necessary, and market our wheats on this basis? Do we need to go through statistical gyrations with the information to arrive at a meaningless market class and grade.

Some people have told me that the system as outlined above would give the wheat merchandisers fits because they are so familiar with the present system. Are we so engrained in our present grading system we cannot change? I hope not. I believe we should use our best present known technology, including the most modern communications to market our wheats.

MARKET CLASSES, THE PLANT VARIETY PROTECTION ACT, AND VARIETY IDENTIFICATION

C. O. Qualset

It has become very evident that many changes in the production, marketing and usage of wheat are upon us. New high-yielding varieties with broad adaptation are now available. There is new emphasis on the development of wheats for special usages, for example soft-textured, high protein feed wheats. Proprietory varieties are now being marketed widely and a vehicle for protection of the developers of these varieties is available through Public Law 91-577, the Plant Variety Protection Act.

These new developments focus attention on the wheat variety with its special characteristics rather than the market class. The new varieties may or may not find a niche in the time-honored market class system. It is apparent that if a new variety provides higher grain yield or has other useful properties, it should not be discriminated against because of the existing definitions of market classes.

It is believed that, because of extensive evaluation prior to distribution, the characteristics and usefulness of a variety are well known. The key issue then becomes production, marketing, and consumer usage of wheat on a varietal basis. Of course, several varieties do have similar properties and can be considered as a group or class, but this is incidental to recognizing the value of a growers crop and the delivery of this crop to the ultimate user. This view has rather far-reaching implications because it implies that the wheat from seedsman to grower, to elevator, to miller or feeder must be identifiable by variety. This means that it must be possible at any point to establish varietal identity so that each handler of the wheat can certify its name. This further implies that blending of varieties for milling or other purposes can be certified by the agency making the blend.

The concept of varietal identity at all stages of the wheat industry is certainly not new as evidenced by the annual list of wheats not eligible for federal price support and by acknowledged industry and grower preferences. An increased emphasis on the varietal identity approach has obvious advantages to all phases of the industry. The grower will know with assurance which variety he is planting. The buyer will know the potential uses for each variety and the possible effect of environment on its properties. A miller or feeder by knowing varietal performance characteristics can determine the eventual use after milling or the prefeeding treatment needed before mixing in rations for livestock or poultry. Because of the imminent use of varieties protected by the Plant Variety Protection Act varietal identification is necessary and increased emphasis at the varietal level provides a built in method of protecting the originators of varieties.

The need for a variety-oriented industry is easily seen. What is not so easily established however, is the means of providing unambiguous variety identification. Recent developments using electrophoretic differences among proteins indicate a promising way to rapid and accurate discrimination among varieties. Genetic differences in migration distances of proteins from crude juices from seeds or seedlings in an electric field are widely known in plants and animals. These differences are generally simply inherited and, after standardization of technique, are not subject to large environmental effects. The proteins (isoenzymes) are stained after migration providing a distinct pattern of bands. Several stains can be used thus increasing the number of possibilities for detecting differences among varieties. We have, for example, been able to distinguish several varieties by using a stain for esterase. Preliminary work at Davis, suggests that this technique is rapid, requires only a small amount of equipment, and can be used by a technologist with minimal training.

Varietal identification throughout the wheat industry seems to be a sophistication that is now necessary because of a specialized industry and it is apparently possible with biochemical fingerprinting of varieties. Variety identification does not eliminate the need for quality monitoring because we are still faced with the widely known environmental effects on quality.

BREEDING OBJECTIVES OF THE JENKINS FOUNDATION FOR RESEARCH

B. C. Jenkins

The Jenkins Foundation for Research is a non-profit California corporation formed "to receive, administer and expend funds for religious, charitable, scientific, literary or educational purposes in furtherance of the public welfare and the well-being of mankind," including, but not limited to research and development of the new grain, triticale. Specific objectives for triticale include:

1. BREEDING:

(a) A continuing plant breeding program aimed at developing high yielding commercially acceptable varieties of triticale with either spring or winter growth habit suited to both irrigated and dryland farming. Special emphasis is placed on dwarf, light insensitive, disease resistant, smooth grained highly fertile types with acceptable grain quality and nutritionally superior Protein Efficiency Ratios.

(b) The use of chemical mutagens which have at the moment proven highly successful in causing desirable variation.

2. CYTOGENETICAL:

(a) Create additional variation in hexaploid triticale using all presently valuable techniques.

(b) Utilize the Nulli 5 B complex to obtain new recombinations from intergenomic pairing.

(c) Establish cytoplasmic male sterility and genetic restoration systems in triticale.

(d) Explore the possibility of developing stable aneuploid types.

(e) Construct new genomes utilizing related species and genera.

(f) Survey the relationship between aneuploidy and seed development.

(g) Study the mechanism of gamete formation in crosses between triticale and wheat.

3. PHYSIOLOGICAL:

(a) Study seed dormancy as related to after-harvest sprouting.

(b) Study seed development in relation to seed vitality (germinability).

(c) Study the relation between sugar composition of the grains and seed development.

(d) Study the relationship between glaucous covering on leaves and resistance to drought.

4. AGRONOMICAL:

(a) Conduct tests involving rates and dates of seeding, population density, and fertilizer response under both irrigated and dryland farming in areas of both spring and winter production.

(b) Make yield trial comparisons with other grains to establish comparative economic returns.

Since hexaploid and tetraploid wheat, together with rye, is used in the improvement of triticale we will take advantage of any improvement in these cereal crops as superior varietites appear. For example, in hexaploid spring and winter wheat, we will develop dwarf, light insensitive, rust resistant types of various grain classes and quality characteristics. In tetraploid spring and winter wheat we will develop dwarf, light insensitive, rust resistant types with good macaroni qualities. In common rye we will multiply either diploid or tetraploid spring and winter types as may appear worthy of distribution.

In order to reach these objectives the Foundation has its research center and operational headquarters at Salinas, California. In addition to making crosses at Salinas there are two types of plant breeding nuseries, one for spring grains and one for winter grains. For the spring grains, two generations in one calendar year can be obtained by growing a nursery at Tulelake, California from May to October; and one at Holtville, California from November to May. For winter grains we are limited to one generation in one calendar year, but one nursery is maintained in California near Salinas and one in Texas on the high plains at Hereford, Texas. We may add additional winter nurseries as our program develops. A disease nursery, particularly for rusts is maintained in the Rio Grande Valley of Texas and at Independence, Missouri. We are able to grow four generations per year in underground quaries at Independence, Missouri and this facility greatly speeds the program where rapid generations are required. In addition to these facilities, Experiment Station and Research Centers in United States and many countries of the world, test materials produced by the Foundation to determine adaptability to climates, soils and day length differences. We also have tests conducted to determine quality of the grain for human and animal consumption and there are presently in progress, tests of grazing and forage value of triticale.

EVALUATION OF A MINIMUM STANDARD SYSTEM FOR WHEAT QUALITY CHARACTERISTICS

R. Busch and W. Shuey

Minimum standard check varieties were determined from their response to environments and their mean performance. Each potential variety could then be evaluated against the predicted minimum check variety in each environment for each quality characteristic. A faulting value based on an arbitrary weighting system of potential economic value was assigned for each quality characteristic. The quality score of the potential variety at a location was then determined by summing all the faulting values for each quality characteristic. Thus, a mean faulting score over locations allows a ranking of potential varieties and a statistical analysis for a more objective evaluation. The use of check varieties, whose response to environments is known, helps minimize genotype environment interactions.

COMMENTS ON "BREEDING OBJECTIVES FOR THE 70'S"

R. E. Allan

We are currently placing strong emphasis on the improvement of so-called two-gene semidwarf types. At present we have about 1,500 F_4 lines from 126 crosses in preliminary yield trials. Our main purpose is to locate both hard red winter and soft white winter types that will be adapted to the intensively farmed regions of the Pacific Northwest. In this area Nugaines and Gaines frequently lodge from 50 to 90%. Management studies have shown certain of these lines possess extremely high yield potential when they achieve good stands from early seedings and are disease resistant. Useful tolerance to Cercosporella foot rot has been located among Suwon 92/5*Omar material of this height level. Comparative studies with Norin 10/Brevor 14/5*Omar lines of similar height do not show tolerance. Hence, we believe that the Suwon 92 semidwarf genes are linked to factor(s) for tolerance to foot rot when placed in the Omar background. We are maintaining a bulk population of two-gene semidwarf germplasm that will serve as a mass-reservoir with a broad genetic base which may be exploited at a later date by the "evolutionary plant breeding" approach.

Three year's testing indicates we can select from Norin 10/Brevor 14 by standard height crosses, high yielding standard height lines. We believe we should be able to develop highly productive standard height lines with yielding ability comparable to Gaines where lodging is not a factor. This evidence suggests the high yield genes carried by semidwarf Norin 10/Brevor 14 (C.I. 13253) are linked to the semidwarf genes but can be separated.

FOOD WHEAT AND FEED WHEAT FROM THE ELEVATOR'S VIEWPOINT

J. S. Schlesinger

All of you, as agronomists, recognize several classes and qualities of wheats such as hard and soft, red and white, spring, winter and durum. You are the ones who develop newer and better wheats from the basic kinds and classes.

As long as the wheat has distinctive habits, color, hardness or other identifying characteristics, it can be properly handled in commercial channels. Much money and effort is expended to bin and handle wheats of different quality separately. As spring and winter wheats are harvested at different times and in different areas, this is easily accomplished for them. In addition, in uncomplicated cases, the kernels of spring, winter and durum wheats are distinctive. At present in this area it is usually relatively easy to distinguish between hard and soft wheats.

However there are areas where it is becoming much more difficult to distinguish wheats because of two things, 1) similar looking wheats of differing maturity habits and qualities are often unintentionally mixed in the local elevator and 2) wheats of different ancestry are often cross-bred to obtain new varieties with specific qualities or characteristics. This cross breeding can make identification extremely difficult if not impossible.

It is generally recognized that wheats of various classes have distinctive quality characteristics. Soft wheats are usually of lower protein content and are most useful for the production of cake, cooky, cracker and pastry flours. Durum wheat is admirably suited for flour for macaroni and spaghetti. Similarly the hard spring and hard winter wheats make excellent bread flours when the protein is adequate and the varieties are suitable. Again, the lower protein hard winters mill into fine family or all-purpose flours. To date, we have been reasonably successful in storing and marketing the various wheats to the general satisfaction of all concerned.

Now, however, in the interests of higher yields, greater disease resistance and/or improved quality, we are cross-breeding and hybridizing wheats so that their distinctive characteristics are blended and balanced with one another to such a degree that it is difficult to tell whether they are fish or fowl.

In the matter of identification, this makes for extreme difficulty at the point of original reception and also further down the marketing chain. Quality is always of importance, especially uniform quality. When wheats of various characteristics and qualities are haphazardly mixed, these attributes become variable and confused and of lesser value to the trade. Visualize the mixing of durum and hard red spring or of hard red winter with soft red winter wheats. Neither mixture is worth as much as the individual wheats would be if marketed separately.

As you know, the winter wheat crop is often harvested from Texas through Kansas within a two week period. This results in a huge rush at all local and terminal elevators and puts a great strain on all systems of bulk transportation. Picture the lines of trucks waiting to be dumped and the problems of the local elevator operator in trying to handle them.

If all of the wheats were similar, then all that would be needed would be to weigh and dump as quickly as the equipment would allow. When there are wheats of different classes or qualities and a correct binning job is attempted, the operator must either have two dumps and route the correct wheat to the correct dump or he must empty the pit and change bins for each change in class or quality. This is considerable added detail and effort which is hard to accomplish when you are working 16 to 18 hours per day, day after day.

Presently the wheat breeders are blithely talking of breeding a "feed" wheat, one of low protein and low baking value with a high yield in bushels per acre. If successful and this wheat looks like other wheat and ripens like other wheat, it will be harvested like the other wheats and will be mixed with the better wheats at the local elevator. Then we come up with a mixture of feed wheat and food wheat to the detriment of the good quality grain. When this mixture arrives at the terminal, it may be bought at the feed wheat price. At best it would be ordinary low protein wheat.

Grain merchandisers attempt to sell all of the producers wheat to either the domestic flour mills, the export markets, the animal feeders or to industry. Choice wheats go primarily to the domestic flour mills. Some high quality wheat goes into export for dollar buyers in Europe and Asia. The balance of the export market takes a low protein ordinary wheat. Wheat that is unsuited for the export trade is usually sold at a discount for animal feed. Some wheats are unsafe for animal feed but may be used as industrial raw material.

Should we produce a large amount of feed wheat, there is nothing to prevent India, for instance, from buying feed wheat at feed wheat prices and using it to feed humans. If the feed wheat was low protein, as it probably would be, this would lower the nutritional level of the Indian diet. Should India buy the lower protein feed wheat in place of the ordinary wheat that is presently being bought the price structure of the market is weakened because the normal outlet for ordinary wheat is supplanted by feed wheat. To be sold, ordinary wheat would need to be priced close to feed wheat and thus the basic price structure is lowered.

However, the feed wheat problem may be approached from a "high quality" angle. Since we have demonstrated the ability to breed just about what we desire, given time, and since we have already bred some very high yielding high quality bread wheats, such as Satanta, which in 1970 produced over 100 bushels per acre at Sublette, Kansas, wouldn't it be wise to place our emphasis, when breeding for bushels per acre, on the high protein strong varieties rather than on a poor quality wheat? Then, in this case, the new high yielding wheats would go into the regular trade channels leaving the poorer ordinary wheat available for feed as at present. If sufficient wheat is produced, the price of ordinary wheat will drop to a level that is competitive with the other grains for feed.

Further, this type of wheat, that is, the high yielding high quality wheat, will raise the protein level of all of the crop and thus tend to furnish wheat of a higher protein level for that which is used as feed. This would make wheat an even more valuable feeding material and more desirable than most other grains. It has been demonstrated that high protein wheat is a more efficient animal feed than low protein wheat. Even though India continued to buy ordinary wheat the protein level would average higher and thus improve the Indian diet in the area where it is most needed, protein.

It behooves the wheat breeder to pay considerable attention to the end use of this product and what the wheat that he breeds will do to the market and to agriculture generally. Let's not forget what the breeding and release of poor wheats did to Kansas a generation ago. Let's not breed wheats for which there is no profitable market but let's do breed those wheats for which buyers gladly pay premiums.

If the United States of America is to sell more wheat profitably, our wheat must be BETTER than that of Russia, Canada, Australia or the Argentine. Competition holds prices in line and premium prices are paid ONLY for premium quality. Our wheat will be in demand only when it is the BEST available at competitive prices.

THE NEW PLANT VARIETY PROTECTION ACT

John I. Sutherland*

I appreciate the invitation to meet with the Interregional Wheat Workers Conference to discuss the recently enacted Plant Variety Protection Act. The signing of the Plant Variety Protection Act, now Public Law 91-577, by the President on December 24th was a historic milestone in this country's agricultural progress and unquestionably marked the beginning of a new era for the U.S. seed industry. This will be a new era not only for the seed industry, but also for the American farmer, the consumers of the products of the American farmer and our entire agricultural economy. This era will be characterized by new and exciting advances in development of new sexually reproduced crop varieties resulting from a seed industry operating in the economic environment of free enterprise in the true competitive spirit that has characterized our nation. These changes will not occur overnight but the foundation provided by the Plant Variety Protection Act makes such changes inevitable.

Before talking about the effect of the Plant Variety Protection Act, I would like to review the principles around which this legislation was built. The Breeders' Rights Committee of ASTA formulated early in its efforts to obtain variety protection legislation five basic principles which any legislation should embody. These principles are:

1. Participation on the part of the breeder and the company shall be completely voluntary.
2. The granting of protection is to be done on the basis of distinctiveness and novelty alone. (This leaves out the yield factors and avoids the complexity of official trials).
3. There shall be no requirement for official performance tests.
4. The system shall not interfere iwth the availability and distribution of germ plasm. (In other words, we want to preserve the relationship that exists between the seed industry, the colleges and experiment stations, and all the public institutions).
5. The defense of any rights provided shall be the responsibility of the owner. (In other words, there will be no policing action on the part of Government officials. This must be done in the civil courts just as is done with patent rights).

I believe it is fair to say that all of these principles have been preserved in the final Act. In fact, we have held to our original objective to develop a protection system that would work for the entire seed industry --not just one or two segments of it. There is one possible exception. When we were in the final phases of legislative debate, we encountered severe opposition to our Bill from the Heinz and Campbell Soup interests.

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* Executive Vice President of the American Seed Trade Association and National Council of Commercial Plant Breeders, Washington, D. C.

We have never been completely sure what their objections were--we know they weren't valid--but in the legislative process and in order to get our Bill through, we had to make exemptions for six kinds of seed:

celery
tomatoes
okra
peppers
carrots
cucumbers

I must confess that this was an expeditious move but I can assure each of you that we will work now to get these exemptions removed.

Now, just how will the new system work?

1. The law will be administered by a new office created within the Department of Agriculture. This bureau will be known as the Plant Variety Protection Office and it will be headed by a "Commissioner." The office address is Plant Variety Protection Office, Consumer & Marketing Service, USDA, Federal Center Building, Hyattsville, Maryland. The Commissioner will have a staff consisting of examiners, technicians and clerical people. A request has already been made for an appropriation for funds to operate the office during the first six months period. After that time a better evaluation of the work load will be avilable, a fee schedule will have been finalized, and the amount of income from it will be known.

2. Application for plant variety protection will be handled in much the same manner as patent applications. The breeder will submit a detailed written description of his new variety and he will include his claims for novelty and reproducibility. A sample of basic seed will be deposited at the time of issuing the approved certificate of ownership.

3. The Act also provides for the establishment of a Plant Variety Protection Board. This Board has two purposes:
    (a) To receive appeals from decisions of the examiner in case the breeder is not satisfied with the examiners ruling.
    (b) The Board also has the responsibility to advise the Commissioner on the rules and regulations which will implement the Act.

    The Board is to be made up of members appointed by the Secretary of Agriculture and consist of equal of representation from industry and public sectors. This Board is now in the process of being appointed.

4. Fees to be charged.
    At the present time the fee schedule has not been completely finalized but it is the intent of the Act that the whole program will be essentially self-supporting.

    We in ASTA have been working with the USDA officials on the development of a fee schedule and I will say this--their ideas are somewhat higher than ours! We would expect that when the final cost is known it will work out to somewhere about $750 per variety registered. This may be payable in two steps. For example, $250 at the time of the application, and a final payment of $300 at the time the certificate is granted.

5. Now, what type plants can be protected? Any sexually reproduced plantother than hybrids, fungi and bacteria are protectable under the Act. Note that hybrids are excluded--this is important--however, inbred lines would come under the classification of varieties.

6. What is the timing schedule? A breeder or developer has one year after commercial sale to apply for protection. The important point here is that the bench mark for protection is the time of the first commercial sale. For those varieties now being sold, the guideline for protection under the Act is whether or not they have been in commercial channels for less than one year. In other words, a variety that has been sold for more than one year cannot be protected by the Act.

   The length of the protection is 17 years just as is the case of inventions and asexual plants under the patent law.

7. Labeling.
   When the application has been submitted to the Plant Variety Protection Office, the applicant must label the seed "Propagation Prohibited - U. S. Variety Protection Applied For". When the application has been examined, approved by the Plant Variety Protection Office, and the certificate is issued, the owner must label it "Propagation Prohibited - U. S. Protected Variety No. _____(optional)."

   A third labeling practice is also permitted for seed which is distributed for testing purposes. This seed should be labeled "Propagation Prohibited - For Testing Only - Application for U. S. Variety Protection Contemplated." These labeling practices thus notify the public that the variety could not be reproduced without permission.

   One company contemplates using the following labeling statement on seed for testing only--"For Testing Only - Propagation Prohibited - Plant Variety Protection Contemplated." Seed of the experimental variety in the container may not be reproduced for seed without the express written consent of xyc company. It is the present intention of the company to apply for Plant Variety Protection under Public Law 91-577 which Law, under Section 111, makes it an infringement of the property rights of the owner to propagate seed bearing this kind of notice against which infringement the owner of the property may seek redress by civil action.

8. Assignability.
   Both the applications and the certificates of protection will be assignable. The owner or breeder may grant rights to use his variety within the U. S. or any part of it.

9. Special Exemption for Farmers.
   The law includes a special exemption for farmers. They will be allowed to produce seed of a protected variety for their own use only. This feature was included for two reasons:
   (a) It was important for political purposes.
   (b) It was felt it would be impossible to police it in any event.

10. Infringement of the Rights.

Let's look now at what constitutes infringement of the rights and wheat can be done about it.

(a) First, infringement will result when any person without authority sells or offers for sale the protected variety.
(b) Reproduces the variety as a step in the production of another variety or hybrid.
(c) Imports or exports the variety to or from the U. S.
(d) Multiplies the variety as a step in marketing the variety.

Now, suppose that you discover that someone is infringing upon your protection--what do you do?

First of all, all such matters are to be handled in the civil courts and it is assumed that the certificate of plant variety protection is valid--it will be the burden of proof on the defendant to show that there is any reason at all for the certificate not to be valid--you own the protection. The damages will be adequate compensation for the infringement, but in no event less than a reasonable royalty that should have been paid by the infringer.

11. Certification.

Section 83 of the Act provides for protection under the certification program. The Act reads:

> "If the owner so elects, the certificate shall also specify that in the United States, seed of the variety shall be sold by variety name only as a class of certified seed. . . ."

Once the certificate is issued, and the owner so designates in the application that the variety is to be certified, no non-certified seed can be sold by that variety name.

The second situation would be if the certificate of ownership is issued and the owner did not designate in the application that the variety is to be certified. This means the owner could do exactly the same as he is doing today, that is--the owner could sell the variety both as certified or non-certified seed. If, however, at some later date (say five years) the owner decides to request certification only, the Secretary of Agriculture has the right to grant such a waiver.

The advantage of designating in the application that the variety is to be certified, is one of infringement. The certifying agency records will become extremely important in an infringement case.

Enforcement of a certified protected variety will be by the Federal Government through the Federal Seed Act.

It appears it will take the U. S. Department of Agriculture about six months to prepare the Rules and Regulations to implement the program. Once the regulations are drafted and announced, a public hearing will be scheduled to permit all interested parties to submit their comments. During this interim period, however, plant breeders are urged to submit applications to the Plant Variety Protection Office on the unofficial application which is available for this purpose. I have left a copy with your Chairman.

When submitting the application form, a check in the amount of $50 should accompany the application. This $50 fee will be applied towards the total cost of the certificate once the final fee schedule is established.

The USDA is currently in the process of appointing the Plant Variety Protection Board which will act in an advisory capacity on drafting the regulations.

In conclusion, I would like to state that in many respects it seems inconceivable in our American free enterprise system that the plant breeder has not been previously awarded protection for his creative developments in the same sense that an inventor has been awarded a patent. It is especially hard to conceive of this in view of the fact that horticulturists, (the developers of roses, shrubs and fruit trees) have had this protection for many years. The passage of Public Law 91-577 has changed this inequity. We now face a future with unlimited opportunities and benefits for all segments of the seed indistry and benefits to every segment of American agriculture and the consumer of the products from our farms. How well we meet the challanges and capitalize on the opportunities will determine the future prosperity of each of us.

Prior to the questions I wish to briefly comment on the CI collection. This collection of germ plasm is now available to all plant breeders as a source of plant characteristics for new novel varieties and the law does not change this program. The law does, however, require that materials placed in a testing program be labeled "Propagation Prohibited - For Testing Only - U. S. Variety Protection Contemplated," and that the material be described--this serving as a bar.

Two sections of the law are quoted for your information:

> "Section 42. Right to Plant Variety Protection; Plant Varieties Protectable.
>
> (a) The breeder of any novel variety of sexually reproduced plant (other than fungi, bacteria, or first generation hybrids) who has so reproduced the variety, or his successor in interest, shall be entitled to plant variety protection therefor, subject to the conditions and requirements of this title unless one of the following bars exists:
>
> > (1) Before the date of determination thereof by the breeder, or more than one year before the effective filing date of the application therefor, the variety was (A) a public variety in this country, or (B) effectively available to workers in this country and adequately described by a publication reasonably deemed a part of the public technical knowledge in this country which description must include a disclosure of the principal characteristics by which the variety is distinguished.

(2) An application for protection of the variety based on the same breeder's acts, was filed in a foreign country by the owner of his privies more than one year before the effective filing date of the application filed in the United States.

(3) Another is entitled to an earlier date of determination for the same variety and such other (A) has a certificate of plant variety protection hereunder or (B) has been engaged in a continuing program of development and testing to commercialization, or (C) has within six months after such earlier date of determination adequately described the variety by a publication reasonably deemed a part of the public technical knowledge in this country which description must include a disclosure of the principal characteristics by which the variety is distinguished.

(b) The Secretary may, by regulation, extend for a reasonable period of time the one year time period provided in subsection (a) for filing applications, and may in that event provide for at least commensurate reduction of the term of protection."

"Section 102. Ownership During Testing.

An owner who, with notice that release is for testing only, releases possession of seed or other sexually reproducible plant material for testing retains ownership with respect thereto; and any diversion from authorized testing or any unauthorized retention, of such material by anyone who has knowledge that it is under such notice, or who is chargeable with notice, is prohibited, and violates the property rights of the owner. Anyone receiving the material tagged or labeled with the notice is chargeable with the notice. The owner is entitled to remedy and redress in a civil action hereunder. No remedy available by State or local law is hereby excluded. No such notice shall be used, or if used be effective, when the owner has made identical sexually reproducible plant material available to the public, as by sale thereof."

FUTURE RELATIONS BETWEEN PUBLIC AND INDUSTRY PROGRAMS

I. J. Johnson

An increasing awareness exists today regarding the need to expand food production to meet current and anticipated increases in population. A part of this future need for greater food supplies can be met by utilizing more fully the existing potential for crop production. Although this may be uniquely true in the USA, for the world as a whole the present land resources at today's levels of food production may not be adequate to meet anticipated needs.

Previous experience has clearly shown that the most effective way to expand crop production is through the development of improved crop varieties and hybrids. Genotypes capable of matching the needs for higher production characteristic of today's farming operations surely are different than those acceptable a decade or more ago. Production goals of 100 bushels per acre for wheat, 250 bushels per acre for corn, 10 tons of alfalfa (in the corn belt), etc., are characteristic of the corn yields attainable by some of the top managers. There can be little question concerning the important role of plant breeders in the years ahead - just as there has been in the past. The Nobel Peace Prize award to Dr. Borlaung is ample proof of the role of plant breeding in helping to solve world food needs.

The history of organized plant breeding in the United States has provided important guide lines for the future. In the early years during the establishment of experiment stations there was clear direction given through allocation of funds for support of plant breeding at public institutions. This was an essential and necessary part of agricultural progress. In the early years, as even now, the farmer himself could not develop improved varieties. Private research in plant breeding was relatively unknown in the United States and consequently it was clearly a responsibility for public agencies to meet these needs with support from public funds and benefits available to all who wished to utilize them.

The emergence of private enterprise in plant breeding created new opportunities for extending the total capital investment in research. It also created new problems, largely centered around the roles that experiment stations might adopt to most effectively utilize the total manpower and financial resources now emerging on two fronts to serve the same goal. This subject was very well covered in a speech presented by Mr. Thomas H. Roberts, Jr., then President of the National Council of Commercial Plant Breeders, at the annual meeting of the American Society of Agronomy at Stillwater, Oklahoma, in August 1966, entitled, "Policy Guidelines for Public-Private Research Cooperation." Mr. Roberts expressed the viewpoints of industry by concluding that (1) public funds should be used for support of research not being performed adequately or competitively by industry, (2) that changing technology will alter the incentives for private investments in research, (3) that maximum public and private research should be encouraged, (4) that some form of breeders rights should be encouraged to give greater incentive for private investments, (5) that public administrators should recognize the basic right of private breeders to breeding materials developed with public funds, and (6) regular discussions of public-private research problems should be held at both administrative and operational levels.

From the beginnings of private breeding programs in the early 1930's to the present time covers one of the most significant periods in the history of agricultural research. There can be little question but that the trends which have so clearly emerged in the past 30-40 years probably will continue to move forward at an accelerated pace as food needs become more pressing and as opportunities to utilize new technologies in the plant breeding give increased incentives for private investments in research.

The manpower from industry presently engaged in private research in plant breeding has grown in numbers to over 300 of which more than 100 have academic training to the doctorate level. Although it is difficult to quote exact expenditures of private funds for specific areas of research, a summary published in Agricultural Science Review in 1967 shows the contribution to research from private organizations was $460,000,000 and exceeded the combined contributions of $394,000,000 from the State Agricultural Experiment Stations and the U.S. Department of Agriculture. Of the total research expenditures by industry, 28%, or nearly $130,000,000, was oriented toward crops. Obviously, not all crop research was on plant breeding -- a substantial proportion was utilized for these purposes.

When an analysis is made of the crops on which major effort is given by private plant breeders, it is evident that two factors determine the choice of such enterprises. These are: 1. The volume of seed usage of this crop and 2. The extent to which the products of research can be protected from re-multiplication on an open competitive basis. Based on these criteria, it is not surprising that the hybrid seed corn industry is a prime example of extensive capital investments in private breeding -- seed purchase is higher than for any other crop and hybrids have a build-in breeders rights protection.

In contrast, although the seed usage of cereal grains and soybeans is very high, there has been up to the present time, relatively less private investment in breeding because of the lack of protection against seed multiplication. The single new breeding advance resulting in the potentials for producing controlled hybrids in wheat and barley and the enactment of breeders rights legislation illustrates how rapidly industry can move forward with major programs in these crops.

In those crops in which industry has made its greatest contribution there has been, over the years, a gradual transition in the type of research effort given to these crops by public research agencies. There also has been a very wholesome and open exchange of research information between public and private plant breeders. The corn breeder at an experiment station -- to cite one example -- is today generally more concerned with problems of gene action as related to heterosis than with the development of a hybrid for distribution to farmers. He is more concerned with basic research in genetics, cytology, physiology, pathology, entomology, and with chemical constituents because of the long-range benefits that come from pioneering into basic sciences. And, of equal importance, the corn research worker at public institutions has developed genetic stocks from his research and has made such stocks available to the private breeding industry.

This transition in corn breeding at experiment stations from major emphasis on applied to major emphasis on basic research did not come rapidly. It came, perhaps, only after the industry had fully demonstrated to the farmer that its research products did indeed meet the needs of the consuming public. And the transition did not come rapidly because many stations had large applied breeding programs in operation for which good judgment dictated that prior investments in time and capital had to be carried to completion. And -- finally -- the interests and capabilities of staff often could not be rapidly diverted from applied to basic research. Another important factor in the transition in emphasis from applied to basic research in corn was related to the seed industry itself. Many smaller seed producers required dependence upon public agencies to develop hybrids for their seed production and sales.

I have chosen to recite the "case history" of corn breeding as an example of the role of industry in plant breeding because in reality all the problems that were initially present and the solutions for them are inherent in any other crop that could be cited, namely:

1. The need for a mechanism by which the industry investment in breeding may be protected through genetic or other methods of insuring breeders rights.

2. The need for the product of sufficient magnitude to justify expenditure of funds by private research.

3. A wholesome cooperative relationship between public and private plant breeders operating through joint research -- education conferences.

4. A recognition that both public and private plant breeders have equally important roles to play in serving the best interests of the farmer and in the expenditure of manpower resources and funds.

5. A recognition that the products of basic and pioneering research can be converted into useful products most rapidly through the "many hands" available in industry.

Private plant breeding programs also must recognize and discharge their responsibility to continually create a favorable environment for public administrative support and recognition of accomplishments in basic research. Fortunately, the public at large is each year becoming more aware of the need for basic research as the driving force for progress. Perhaps the time is not too far off when accomplishment and rewards in terms of academic advancement will be determined more by the number and quality of research contributions than by the number and performance of the varieties released.

Although private research in plant breeding at its present stage of development may be dependent largely upon public programs for much of its basic knowledge, it should not be inferred that private research itself does not develop new concepts. As previously stated, a recent survey by the National Council of Commercial Plant Breeders has shown that the number and level of training by industry plant breeders represents a considerable manpower resource, trained to the same high degree of proficiency as those on university staffs.

Although idealistically one might wish to conclude that industry should engage in the applied and experiment stations in basic research in plant breeding, realistically this cannot be so. There are many crops in which the seed needs for improved varieties is so small that industry cannot afford to undertake the cost of their development. A possible solution to these problems both to industry and experiment stations is the development of contracts or special arrangements between the industry and research agencies to solve these problems as they arise.

Training of graduate students for ultimate careers in plant breeding is one field of endeavor in which universities stand alone. But one should not overlook the opportunities for "in-job" training that become possible in industry research programs. Graduate students who desire to establish a career in private research can gain worthwhile experience and insight from a period in private firms.

To conclude this presentation your speaker hopes he has made a few points reasonably clear. It is evident that private plant breeding is becoming an expanding force in our agricultural economy. This is good for agriculture because competition for markets requires the best possible products. The farmer cannot but gain when several firms seek to expand their sales by developing superior products.

Basic research often produces two kinds of products -- new knowledge and genetic stocks used by the scientist to develop or test the validity of new biological principles. Although many experiment stations have developed well organized procedures for release of new crop varieties, very few have developed policies and procedures for multiplication and distribution of genetic stocks. These by-products of basic research may have a great deal of usefulness in agriculture as genes to overcome defects in present varieties. I am hopeful that the present emphasis given to this subject by committees in scientific societies may result in actions mutually beneficial to all.

In this period of agricultural history in which increasing demands are being made by the public to critically examine new goals and objectives it will be most appropriate for <u>both</u> public and private research administrators to jointly seek to find ways by which our combined resources can be used to fulfill a common objective. To strengthen the image of agricultural research there is no need to excessively duplicate efforts nor does it make good sense to overlook areas of responsibility that each assumes the other is doing. To me, the real challenges that lay ahead in crop research are to more effectively utilize our scientific manpower resources.

FUTURE PROCEDURES FOR RELEASING NEW VARIETIES

James W. Echols

Variety is Goal

I consider the development of new varieties the primary goal of wheat breeding programs. Certainly there are intermediate steps of accomplishment, but the job is not complete until a farmer is growing the variety developed by the breeder.

Coattail Accomplishments

Each of us recognizes the increases made by the use of improved genetic material. However, the real accomplishment of a new variety is more than the genetic increase. New varieties have served as the communication media to get farmers to adapt other improved practices such as proper fertilization, use of herbicides, irrigation, and others. This "coattail" increase is often more significant than the increase from the breeding material. Gentlemen, new varieties are the lifeblood of our programs.

Rewards

Plant breeders have not received true rewards for their achievements in most cases. This obviously is the reason why we have breeders rights, as discussed by John Sutherland. Financial compensation is the goal of the private breeding programs. Public breeders have used new varieties to convince legislators and administrators to appropriate funds. The desire for new varieties has stimulated commodity groups such as wheat growers, research foundations, breeders, and others to donate funds for research by public breeders.

Appropriations

In talking with public agricultural workers, I find extreme concern about the future of appropriated funds for research and Extension. We are in trouble in Colorado, and I am told that many of you gentlemen are finding it more difficult each year to obtain the necessary funding.

Alternatives

What are the alternatives? 1. Convince legislators to appropriate more money. I do not think that legislators are going to be convinced until a food shortage or potential food shortage exists. 2. Obtain funds from commodity groups, research foundations, etc. This willw work for some researchers. 3. Collect revenue from variety developments. Many breeders will attempt to get revenue from their varietal developments.

Farmer Selling Seed

Most commercial seed dealers have not placed much emphasis on the sale of small grain seed because they could not make a profit. Their competitor is the farmer who saves his own seed or the neighbor who sells seed from the bin. A few years ago, the traditional wheat researcher and our Seed Certification agencies encouraged this method of seed distribution.

Drill Box Survey

Drill box surveys have proven beyond any doubt that the average farmer who plants his own seed or his neighbor's seed is sacrificing considerable yield and often quality.

Companies Releasing Seed

Significant accomplishments away from this trend have been made, but we still have a long way to go. Recent variety release procedures by commercial wheat breeding organizations show that the farmer who saves his own seed or a neighbor who sells bin run seed is the competitor that they cannot cope with. In other words, they have produced sizeable quantities of seed and sold it for a high price. This means they obtain sizeable amounts of revenue on a one time basis because farmers are in the seed business the following year. This technique cannot work for a prolonged period of time. Breeders cannot develop good new varieties that rapidly, and farmers will become saturated with new varieties.

If breeders are to obtain significant revenue from varieties, it must be spread out over a prolonged period of time. We must have a better production and marketing system than a farmer saving his seed or buying from a neighbor.

Transparency

In Colorado, one of our Certified Seed processors recently constructed a new plant equipped with the most efficient equipment obtainable. He is contract producing Certified Seed of small grains in lots of 2,000 to 10,000 bushels. The transparencies show his production prices and his selling price of Certified Seed.

Contract for Colorado Certified Seed Wheat

Payment to Grower: market price + 25¢ (from combine)
market price + 30¢ (if grower stored and delivered later)

Grower can pick time for selling wheat at market price.

Certified Wheat Seed Selling Price by Seed Dealer:
(Seed is cleaned and treated)

Bulk-Retail	$2.00
Bagged-Jobber	$1.98
Bagged-Wholesale	$2.07
Bagged-Retail	$2.40

Gentlemen, production and marketing with this kind of efficiency is a must if significant returns are made to breeding programs. Seed must by handled so efficiently that a farmer can't afford to save his own seed. This will permit seed companies to get in the seed distribution business. This is the first step in considering procedures for the release of varieties.

Release of Varieties

The Plant Variety Protection Act has opened new avenues of approach for public breeders, private breeders, and maybe even USDA. It is so new that we can only speculate on how it can be used. Get a copy of Public Law 91-577 and study it carefully. Several alternatives are available for your use. When Byrd asked me to talk about the future release of varieties, I sent questionnaires to my colleagues in Seed Certification and to companies with private wheat breeding programs. I certainly want to thank these people for their contributions. I have summarized the results, and I am distributing copies for your information. Keep in mind that all people do not interpret questionnaires the same way, and that considerable bias is present. I have tried to ask the questions that need some thought before Experiment Stations and companies make decisions about the use of the Plant Variety Protection Act.

Discussion of Private Company Questionnaires

Discussion of Experiment Station Questionnaires

I do not have a crystal ball for predicting how new varieties will be released. By the results of the questionnaires, it is obvious that private companies will use the PVPA or obtain revenues from hybrids. Experiment stations are leaning in this direction. I think that most of them will be forced to use it or get out of the variety development business.

Challenge to Certification

Where do we stand with Certification? We must be service agencies, and we must provide a service that is worth more than it costs or we are dead. We can be used by Experiment Stations and industry for quality control. We have the growers with the know-how. We are impartial agents to help with the liaison. We must have uniformity, and we must cut red tape to the bone. We must divorce Certification and Recommendations. We must convince industry and growers that Certification is the tool that can get varieties in the hands of farmers in the exact genetic state as developed by the originator, do it efficiently, and for a reasonable price. Gentlemen, I think each of us has a new challenge.

PRIVATE COMPANIES Replies to Plant Variety Protection Questionnaire
Summary
(6 of 7 companies replied)

* Since the Plant Variety Protection Act has become law, will the amount breeding increase or decrease?

It will increase 4 One indicated that it would increase "appreciably."
Two indicated that it would increase 25%.
One indicated that it would increase 20%.

It will decrease 0

It will remain about the same 2

* Will your company apply for protection under the PVPA?

Unanimously yes.

* Will you :	Yes	No	Undecided
Collect royalty	3		
Sell variety to exclusive	4		1
Designate for certification with royalty	2		
Depends on circumstances	3		

One comment: "We hope that certification will help in policing the program and in collecting royalties."

The totals above are not exact because most companies indicated more than one of the above choices.

* What will be your future procedures for releasing new varieties?

1. On a generation basis under certification programs.
2. We will use state certification as one method of insuring seed purity.
3. We will inscribe for certification prior to release.
4. We will probably designate for certification with royalty, and then work with state certification programs for final multiplication of seed.
5. We will probably continue to contract for distribution and receive royalties.
6. We are undecided at this point.

* How can Seed Certification best serve the public breeding programs?

1. Make the value of high quality seed known to the farmer.
2. Assure purity and aid in the distribution of improved varieties.
3. Help assure the farmer of high quality seed.

(Note: Not all those queried responded to this question.)

* How can Seed Certification best serve the private breeding program.

1. By maintaining prompt up to date information on tonnage of varieties in the program and by making this information available to private persons.
2. By aid in the policing of seed purity.
3. By control of seed sales, especially interstate. And by assuring some device for establishing ownership.
4. Our company cannot live with the minimum testing period and still certify seed.
5. By preventing exploitation and undue promotion.

* Will Certification increase or decrease because of the PVPA?

Five indicated they expected some degree of increase.
One indicated they expected some decrease.

* What changes need to be made in the Certification program.

1. Complete and detailed records of amounts of all private varieties under certification programs to facilitate control of royalties and royalty obligations.
2. Base certification only on the uniqueness of a cultivar and the methods used to maintain pure seed. Do not consider performance. We also need a shake-up of the mechanics of seed certification agencies.

AOSCA Replies to Plant Variety Questionnaire - Summary

Note: 30 of 46 queried responded. Some answered only part of the questions; some gave more than one answer to a question. Therefore, the totals will not be exact.

* How many people, including USDA, does your state or experiment station employ for wheat breeding?

FULL TIME PROFESSIONALS

Twenty states employ a total of 52 1/2 persons. Four have none. One did not reply. The range is from 1/3 person to 14 persons.

FULL TIME SUBPROFESSIONALS

Nineteen states employ a total of 40 1/4 persons. Four have none. One did not reply. The range is from 1/4 person to 9 persons.

* How many people in your total breeding program for all crops?

FULL TIME PROFESSIONALS

Twenty-one states employ a total of 194 1/2 persons. Two have none. Two did not reply.
The range is from 2 1/2 persons to 19 persons.

FULL TIME SUBPROFESSIONALS

Nineteen states employ a total of 178 1/2 persons. Two have none. One did not know how many. Three did not reply.
The range is from 2 persons to 21 persons.

* Since the Plant Variety Protection Act has become law, will the amount of plant breeding increase or decrease, in your opinion?

It will increase 4 How much? 10-15% 1
20% 1
100% 1

It will decrease 1

It will remain the same 18

Unknown 1

* Will your state, in your opinion, apply for Plant Variety Protection on your new varieties or on certain germ plasm.

Yes 11 No 5

Unknown 5 Both 3

* If yes, which of the following do you expect to do?

Collect royalty on seed sold 4

Sell variety to an exclusive agent 2

Designate it for certification with royalty 6

Designate it for certification without royalty 8

Other 0

Undecided, as yet 3

> One comment of interest: " As a public institution, operating on tax money, it would be difficult to justify charging someone for the use of a new variety which their tax money helped to develop. But Plant Variety Protection should be applied for in order to protect the public variety from misappropriation by some undiscriminating individual."

* What will be your future procedures for releasing new varieties?

Suggestion:	No. of states which will do this:
1. Continue to follow ESCOP and/or USDA.	2
2. No change at this time.	8
3. None. (No procedure)	1
4. Continued cooperation with other states and private cos.	1
5. Release through certification with generations allowed for each crop and mode of pollination.	1
6. Release through official variety release committee prior to becoming eligible for certification.	1
7. Unknown at this time.	5
8. "Patent" forage varieties; other crops to be determined later.	1
9. Breeder will submit proposed variety to the naming and release committee. This committee will recommend it to the Director of AES. The Director will submit it to the Plant Variety Protection Board.	1
10. Variable according to needs of producers and consumers.	1
11. Breeder will request protection in the name of the Experiment Station.	1

* How can Seed Certification best serve public breeding programs?

Suggestion:	No. of states which will do this:
1. By maintaining standards of genetic purity.	14
2. By maintaining accurate records on distribution of classes of seed.	2
3. By assuring the orderly increased distribution of new varieties.	1
4. By more promotion.	2
5. By aiding in the release of new varieties.	1
6. Through the limited generation program.	3
7. By maintaining good supplies of foundation or registered seed.	1

Suggestion:	No. of states which will do this:
8. By maintaining good supplies of improved varieties.	1
9. By providing the mechanism for the functioning of a workable program of seed increase, the collection of royalties, and the protection against uncertified seed of protected varieties.	1
10. By providing the means for the breeder to get his variety to the consumer.	1
11. By continuing present procedures.	3
12. By avoiding nit-picking on inconsequential items but standing firm on important ones.	1
13. By adjusting operational procedures to keep up with current needs.	1
14. By support of variety breeding and development.	1
15. By providing a way to release and multiply publicly developed varieties.	1
16. In the same manner as private varieties that are protected.	1

* How can Seed Certification best serve private breeding programs?

1. By providing a method for small companies to increase and maintain varieties. Large companies probably don't need.	1
2. Through limited generation programs.	2
3. By maintaining genetic purity standards.	8
4. By providing for the orderly distribution of new varieties.	1
5. By the certification of private varieties, and thus protection.	3
6. By insisting on proper testing.	1
7. By encouraging statewide testing.	1
8. By aiding in record keeping.	2
9. By inspecting and maintaining seed stocks for companies.	2
10. By not certifying the variety without the consent of the owner.	1
11. By adhering to requests of private breeders on the number of generations.	1
12. By promotion.	2
13. By providing protection under the Plant Variety Protection Act.	2
14. By providing the mechanism for the functioning of a workable program of seed increase, the collection of royalties, and the protection against uncertified seed of protected varieties.	1
15. By providing better supervision of seed produced.	1
16. By streamlining certification procedures.	1
17. By contract production of foundation and certified seed.	1
18. By serving as "bookkeepers" for companies franchising seed.	1

* What effect will the PVPA have on Certification?

Certification will increase 14

5-10% 1
20% 1
25% 1
25-50% 1
Unknown 5
By a significant amount if we adapt 1

Certification will decrease 1
Certification will remain the same 4
Unknown 5

* What changes are needed in the certification program and its objectives?

	Suggestion:	No. of states which suggested this:
1.	Eliminate all mechanical standards.	1
2.	Change rules and policies to encourage private breeders.	1
3.	Permit certification while keeping pedigree, etc., in confidence.	1
4.	Alter requirements so less time is involved in getting variety eligible for certification.	2
5.	Assure timely and efficient certification eligibility designation and certification procedures.	1
6.	By increased promotion.	1
7.	By encouraging uniformity among the states.	2
8.	More objectivity toward private varieties.	1
9.	Make requirements more flexible so they meet the demands of a rapidly changing industry.	1
10.	No changes needed.	4
11.	Unknown	1
12.	Certify protected varieties for genetic purity only--not for seed quality.	1

REPORT OF THE RESOLUTIONS COMMITTEE OF THE INTERREGIONAL WHEAT WORKERS

Be it resolved that the Interregional Wheat Workers express their appreciation to the Administration of Oklahoma State University for the use of their facilities; to Dr. E. L. Smith and the local arrangement committee for their hospitality as host of this conference; and the Conference Coordinators, Dr. L. Calpouzos and Dr. J. R. Welsh for their excellent program planning.

Be it further resolved that the Interregional Wheat Workers express their pleasure in having met jointly with the other wheat workers of the U.S., Canada, Mexico and other countries. This enrichment of cooperation and the exchange of new ideas and information makes research more effective and rewarding. Appreciation is expressed to all chairmen of the various sections and to all participants that contributed to the Interregional Wheat Workers Conference.

Be it further resolved that the Interregional Wheat Workers express their recognition of the substantial and stimulating contribution of private research workers participating in this conference.

Be it further resolved that the Chairman of the National Wheat Improvement Committee write a letter of appreciation to the Oklahoma Wheat Commission for sponsoring the noon luncheon and to the Commercial Research Groups of Cargill, DeKalb, Funk Brothers, McNair, Northrup King and Pioneer for sponsoring the social hour. We also express our thanks to the Kansas Wheat Improvement Association for their memento and enter these resolutions in th official record of this conference.

Be it further resolved that the Interregional Wheat Workers express their appreciation to Dr. E. G. Heyne, Dr. D. R. Knott, and Dr. A. B. Campbell for their unselfish contribution of time and effort in developing the Wheat Newsletter into an effective means of communication among wheat workers.

Committee: Ralph E. Finkner
Bernard J. Kolp
Allan Taylor
Kenneth L. Lebsock
Robert Heiner
Harry McNeal

EASTERN WHEAT IMPROVEMENT COMMITTEE

Minutes of the Business Meeting
Interregional Wheat Workers Conference
Stillwater, Oklahoma
February 9-11, 1971

Eastern wheat workers met informally, February 9, 1971, in conjunction with the Interregional Wheat Workers Conference, Stillwater, Oklahoma. No formal agenda had been prepared. Attendance was very good, with 23 scientists representing major cereal breeding and testing programs in the eastern states.

Dr. H. N. Lafever, OARDC, Wooster, Ohio, chaired the meeting in place of Dr. E. H. Everson.

Items of Business: H. N. Lafever was elected new Chairman of the Eastern Soft Wheat Workers Conference. K. L. Lebsock, Beltsville, will be Secretary.

Other items discussed but without official action taken were:

The Eastern and Southern Regional Soft Wheat Nurseries. Future plans include use of a computer program for summarizing data. Uniformity of recording data and use of the metric system were considered. There is a need to develop meaningful ways to rate diseases such as Septoria. The consensus seemed to be that we should convert to use of the metric system as soon as practical. Arrangements must first be made with Biometrical Services, ARS, USDA, before going to the computer system. Cooperators will be consulted as plans are developed. Changes undoubtedly will have to be made as we gain experience.

It was recommended that cooperators use the system described by Purdy, et al. Crop Sci. 8: 405-406, 1968, for writing pedigrees. This system works well for computer print-out.

Urgency was expressed for development of micro-quality tests that can be applied to large breeding populations. Possibly techniques can be developed which can be used at a breeding station. Dr. Trupp already has contacted Dr. Yamazaki in this regard. Further research on micro tests is needed for breeding programs in this region, particularly because some states plan to expand wheat breeding efforts. Dr. Lafever will consult with Dr. Yamazaki concerning possibilities of developing new tests or modifying current tests.

From a discussion on future conferences, the consensus seemed to be that the eastern workers should hold separate intra-regional meetings as needed (possibly every 3 years) and that we join in the larger inter-regional conference occasionally (possibly every 6 years) if they are called in the future. Considerable interest was expressed in holding the next Eastern Conference at Wooster, Ohio, in order to visit the new facilities of the Soft Wheat Quality Laboratory in the next two or three years.

(Contacts with other regional coordinators after their meetings, February 9, revealed their groups also would prefer to hold separate intra-regional meetings, and to join with other regions only occasionally. All indicated each region has specific problems which can be considered more thoroughly in the smaller meetings).

The meeting adjourned shortly after 10:00 p.m.

Attendance:

H. N. Lafever, Acting Chairman	Ohio
K. L. Lebsock, Secretary, USDA	Beltsville
R. D. Barnett	Florida
C. M. Brown	Illinois
R. M. Caldwell	Indiana
Fred Collins	Arkansas
A. E. Ellingboe	Michigan
Russell Freed	Michigan
N. F. Jensen	New York
J. P. Jones	Arkansas
D. D. Morey	Georgia
G. K. Middleton	(McNair) N. Carolina
E. H. Mueller	(DeKalb) Indiana
F. L. Patterson	Indiana
V. H. Reich	Tennessee
J. J. Roberts	Indiana
A. L. Scharen, USDA	Beltsville
D. T. Sechler	Missouri
H. L. Shands	(DeKalb) Indiana
Rex Shepherd	(DeKalb) Indiana
Clyde Trupp	Michigan
Earl Watt	Missouri
M. V. Wiese	Michigan

HARD RED SPRING WHEAT IMPROVEMENT COMMITTEE

Minutes of the Business Meeting
Interregional Wheat Workers Conference
Stillwater, Oklahoma
February 9-11, 1971

Dr. Heiner chaired the meeting since Dr. Wells resigned as chairman to attend the Regional Winter Wheat Workers' session. There were 19 workers present.

The first order of business was discussion of the Uniform Regional Nursery samples. It was decided that commercial company selections, hybrids, and other nominated varieties could be included as long as the number was reasonable (approximately 30). The nursery will be grown on State or Federal land under federal control.

Robert Pylman of Funk Brothers Seed Co. expressed a desire to have samples in the nursery but would need the results before October for winter plantings and two generations of information. He also mentioned the Pembina Valley Testing Association in Canada.

Some discussion evolved around the format of the regional reports. Dr. Busch expressed the possibility of stability parameters being established. In this same vein, the proposed Konzak and McNeal manual being prepared for the Northwest region might be applicable to the spring wheat region--this will be investigated by the incoming officers. The workers are to be polled as to their opinion of using the metric system in lieu of or along with the present day system.

Future regional and inter-regional meetings were discussed. Several suggestions were made as to the format, but it was agreed that there should be a minimum amount of topical and formal presentation and more opportunity for discussion. It was suggested that possibly smaller groups should meet on specific problems and disciplines, as well as the broader more general type of discussion and meeting in which all disiplines would participate.

It was generally felt that the frequency of the meetings should be regulated by the need and desire of the workers to hold such a conference.

Dr. R. Frohberg, N.D.S.U. was elected chairman and Dr. L. Colpouzos was elected secretary of the Spring Wheat Regional Workers' Section.

Meeting adjourned.

Respectfully submitted,

William C. Shuey
Acting Secretary

HARD RED WINTER WHEAT IMPROVEMENT COMMITTEE

Minutes of the Business Meeting
Interregional Wheat Workers Conference
Stillwater, Oklahoma
February 9-11, 1971

The meeting was called to order at 8:45 p.m. by Chairman Porter.

Members present:

B. J. Kolp, Wyoming
J. R. Welsh, Colorado
E. D. Hansing, Kansas
E. R. Heyne, Kansas
R. W. Livers, Kansas
E. L. Sharp, Montana
V. R. Stewart, Montana
G. A. Taylor, Montana
V. A. Johnson, Nebraska
P. J. Mattern, Nebraska
J. W. Schmidt, Nebraska
R. E. Finkner, New Mexico
L. H. Edwards, Oklahoma
E. L. Smith, Oklahoma
H. C. Young, Jr., Oklahoma
D. G. Wells, South Dakota
K. B. Porter, Texas
E. C. Gilmore, Texas
N. A. Tuleen
L. P. Reitz, Maryland

Members absent:

R. E. Atkins, Iowa
W. J. Hoover, Kansas
L. W. Schruben, Kansas
M. R. Morris, Nebraska
B. B. Tucker, Oklahoma
N. E. Daniels, Texas
L. W. Rooney, Texas
R. W. Toler, Texas
G. E. Hart, Texas

Minutes of the February 7, 1968, meeting at Manhattan, Kansas, were read and approved.

Members of the Industry Advisory Committee in attendance were introduced. They included B. C. Curtis, Cargill, Inc.; J. A. Wilson, DeKalb Agricultural Research Association; and R. I. Throckmorton, Jr., representing R. E. Baumheckal, International Harvester Company.

The following actions were taken:

Regional Nurseries

Discontinue Comanche and Early Blackhull as check varieties in the Southern Regional Performance Nursery. Retain Kharkof as the long-time check variety.

Limit number of entries in SRPN and NRPN to maximum of 30.

Henceforth, experimental entries in the SRPN to be automatically dropped from testing after the second year unless originating state or organization specifically requests retention. This does not preclude removal of an entry after only one year if originator so desires.

Retain Kharkof and Warrior as check varieties in the Northern Regional Performance Nursery.

Continue policy of accepting commercially-developed hybrids and varieties in the SRPN and NRPN so long as there is room for them without exceeding the 30-entry limit.

No changes in the Uniform Winterhardiness Nursery (Southern and Northern Materials Sections). North Dakota requested seed for a second planting site beginning with the 1972 nursery.

No changes in the Soil-borne Mosaic Nursery.

Regional Reports

Beginning in 1972 regional data will be reported in metric weights and measures only. Since 1968 grain yield summaries have been reported in both English and metric units.

Data reporting in the future will be adapted to electronic data processing. It was voted to utilize in-so-far as feasible the system being followed by the western wheat region. Consideration of a 10-class (0-9) coding system, particularly for reporting of disease data, was suggested.

Quality Evaluation

It was voted that the committee go on record as favoring only one year of collaborative testing of experimental varieties prior to release action by originating state--provided that quality development in the region was sufficiently normal to permit a valid test. E. L. Smith and V. A. Johnson, committee representatives on the Hard Winter Wheat Quality Advisory Council, were directed to convey this sentiment to the Council.

Future Conferences

The secretary was directed to poll the membership regarding reaction to the Interregional Wheat Workers Conference held at Stillwater, Oklahoma, and future conferences.

It was voted that our next conference be a Hard Red Winter Wheat Workers Conference.

Election of Committee Chairman

K. B. Porter was re-elected chairman.

Resolutions Committee

R. E. Finkner (Ch), B. J. Kolp and G. A. Taylor were appointed by chairman Porter to prepare, in cooperation with other regions, appropriate conference resolutions.

Meeting adjourned 11:15 p.m.

WESTERN WHEAT IMPROVEMENT COMMITTEE

Minutes of Business Meeting
Interregional Wheat Workers Conference
Stillwater, Oklahoma
February 9, 1971

The meeting was called to order by R. J. Metzger, acting for chairman W. E. Kronstad, at 8:30 p.m. in the Student Union Exhibit Room, Oklahoma State University, Stillwater, Oklahoma, February 9, 1971. Current membership and attendance* at the meeting is a follows:

Arizona	A. D. Day
California	C. O. Qualset*
Colorado	J. R. Welsh
Idaho	W. K. Pope*
Montana	G. A. Taylor
Nevada	H. P. Cords
New Mexico	No Representative
Oregon	C. R. Rohde* for W. E. Kronstad
Utah	W. G. Dewey*
Washington	R. E. Allan* for C. F. Konzak
Wyoming	B. J. Kolp
Quality Laboratory	G. L. Rubenthaler
Cereal Disease Laboratory	R. J. Cook
Western Wheat Improvement Leader	F. H. McNeal*

Others in attendance included D. W. Sunderman, C. R. Rohde, B. C. Jenkins, Larry Robertson, and Don Kaminski. Minutes of the June 12, 1968, meeting held at Logan, Utah, were read and approved.

Testing of varieties, selections and hybrids developed by commercial companies in Regional nurseries was discussed. Commercial Company representatives who were present did not feel strongly either way. W. K. Pope moved and W. G. Dewey seconded a motion that we reaffirm our policy as adopted at Corvallis, Oregon, June 23, 1965, that, "commercially developed wheats should not be accepted as entries in Regional Nurseries, since testing of such entries should be at the discretion of individual states." The motion carried unanimously.

Moving to the metric system on a regional basis was discussed by R. E. Allan since he is chairman of a committee appointed June 12, 1968, to study this problem. R. E. Allan moved and C. O. Qualset seconded a motion that we table action on conversion to the metric system until all Regions agree to act simultaneously. The motion carried unanimously.

Moved by W. G. Dewey, seconded by C. R. Rohde, and carried, that the secretary revise and distribute copies of the Western Wheat Manual.

Discussion was held concerning establishment of a Regional Durum Nursery and a Regional Hard Red Spring Wheat Nursery. There was general agreement that we need only the currently grown spring wheat nursery, in which various wheat classes have been included, and that other arrangements involving only a few cooperators should be on an informal basis.

Standard and check varieties included in the three Regional Nurseries were reviewed as follows: Spring Wheat - Retain Federation but drop Marfed, Lemhi, Idaed 59, Baart, and Thatcher. White Winter - Retain Kharkof, Elgin, Moro, and Nugaines, but drop Golden, Omar, Brevor, Triplet, and Burt. Hard Red Winter - Retain Kharkof and Wanser but drop Itana, Itana 65, Rio, Cheyenne, Tendoy, McCall, Crest, and Bridger.

C. R. Rohde moved and C. O. Qualset seconded that nurseries averaging more than 30 bushels per acre be averaged separately from those of 30 bushels or less when preparing tables of averages for the Regional Report. Motion carried.

There was some discussion of the Variety Protection Act. Most members felt there would be no problem with improper use of the C. I. Collection.

C. O. Qualset moved and R. E. Allen seconded that W. E. Kronstad and F. H. McNeal serve as chairman and secretary, respectively, for another three years. Motion carried.

The meeting adjourned at 10:20 p.m.

F. H. McNeal
Secretary

P.S. The National Wheat Improvement Committee met at Stillwater and discussed ways and means to finance the Wheat Newsletter. In addition to various kinds of solicitation, we were encouraged to explore the idea of a registration fee at future workers conferences, the fee to be deposited to the Newsletter account. Student exemptions should be established. A separate collection desk (with a pretty girl) might be preferred, or we could "pass the hat" or use some other method. Since the Newsletter is costing about $1,000 annually, some means of finance must be assured. Convey your ideas to Chairman W. E. Kronstad if you want the Newsletter continued.

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