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IMPROVEMENT OF THE

NUTRITIVE QUALITY

and

PRODUCTIVITY OF BARLEY

for

SEMI ARID REGIONS

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Principal Investigators

REPORT NO. 4 FINAL REPORT  
March 25, 1974 - July 31, 1978  
Contract ta-C-1024 AID  
MONTANA STATE UNIVERSITY  
BOZEMAN, MONTANA 59715

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## PROJECT OBJECTIVES

Two interim sub-objectives are common to the three major objectives of this project:

1. In cooperation with appropriate International Centers to survey representative target countries to evaluate present cultivars for general agronomic desirability, barley utilization and significance of disease and other pests.
2. To develop workshops or seminars in cooperation with appropriate International Centers to report on progress of the project and to exchange information and experiences.

The following are specific objectives under the three major areas of this research project.

Objective I - To increase the nutritive value of barleys consumed by peoples throughout the world, particularly in LDC's.

### Interim sub-objectives

- a. Compare methods for screening for lysine content including the development of a half-seed method.
- b. Continue with the task of screening the world collection of barleys for high lysine lines.
- c. Investigate protein fractionation and characterization of fractions as a means of allele identifications.
- d. Determine a translocation breakpoint that is suitable for transferring the hi-lysine gene of Hiproly into a population without lysine analysis.
- e. Determine if amylose:amylopectin ratio of the endosperm has nutritional significance.
- f. Develop some fertile, plump-seeded, hi-lysine lines for use as donor parents.
- g. Assign the Glacier hi-lysine gene to a chromosome.
- h. Initiate evaluations of the biological value of proteins in lines determined to be high in lysine.
- i. Initiate studies on protein inheritance, including maternal inheritance.
- j. Determine the effect of environment, including soil fertility, on lysine stability across environments.
- k. Initiate the development of homozygous hi-lysine composites in heterogeneous populations.

Objective II - To increase the yield of barley grown in semi-arid regions of the world, particularly in LDC's.

### Interim sub-objectives

- a. In cooperation with CIMMYT, survey representative target countries to evaluate those agronomic characters that may be of most value.
- b. Screen barley varieties by use of the "elastic modulus" technique for drought resistance.
- c. Determine the effect of plant color on reducing heat loads, including conditions of extreme heat loads.
- d. Determine the influence of leaf area on water use efficiency and the relationship of leaf area to "photosynthetic sink".

- e. Determine the influence of moisture stress on the function of the awn.
- f. Identify and determine the inheritance of day length insensitive gene (or genes) in barley.
- g. Grow isogenes for some of the desirable traits as determined in "a" above, to verify conclusions.
- h. Initiate the production of homozygous day-length insensitive composites segregating for other characters.

Objective III - To decrease losses caused by barley diseases, particularly in LDC's.

Interim sub-objectives

- a. In cooperation with other interested agencies, survey representative target countries for prevalence of plant diseases, collect samples, and identify races.
- b. Establish contacts for field evaluations of specific diseases.
- c. Initiate work on homozygous combined stem rust, smut resistant composites segregating for the other characteristics.
- d. Distribute disease resistant-susceptible isogenes for evaluation of economic importance of certain diseases.
- e. Initiate work on at least one more disease based on survey in target countries.

### SUMMARY STATEMENT

In 1972 Montana State University developed a comprehensive proposal dealing with the improvement of barley as a significant and important crop in a large number of Less Developed Countries of the world. This proposal was submitted to the Agency for International Development for consideration and after a lapse of over two years a contract was finally signed in 1974.

Repeated efforts were made to establish linkage with CIMMYT because of what could have been a very complimentary relationship between them and the MSU AID sponsored project. We were unseccessful in establishing that linkage until 1976 when we started efforts to establish a linkage with ICARDA (ALAD at that time) for jointly sponsoring a barley improvement workshop in the middle east. At that point CIMMYT joined the sponsorship and it was agreed that it would become the "Fourth Regional Winter Cereal Workshop-Barley". The lack of cooperation by CIMMYT personnel during the establishment of the project and during the first two years did not contribute appreciable to the early success of the outreach objectives of this project.

It was not until efforts to successfully establish ICARDA were accomplished that we had any success in establishing an effective linkage with international centers. This was extremely unfortunate because our research efforts were progressing toward accomplishment of the project objectives but because of international center in-fighting, it was impossible to make effective headway in our outreach efforts. We were not skilled on the politics of international agricultural research center manipulations and were unable at first to understand why our well-intended efforts were being shunned. In retrospect it is quite apparent that we were caught in these rather petty manipulations and it did little to enhance the outreach efforts that we were attempting to accomplish.

We finally did, with excellent cooperation from ICARDA (at that time ALAD) establish the dates for the Fourth Regional Winter Cereal Workshop on Barley for the spring of 1976 in Lebanon. However due to political unrest in that country which eventually erupted into war the workshop was postponed.

We immediately started efforts for an alternate site and finally, with excellent cooperation and joint efforts and financing from the Montana State University, AID Project, ICARDA and CIMMYT the Fourth Regional Winter Cereal Workshop-Barley was very successfully held April 24-28, 1977 in Amman, Jordan. (See Appendix A for Program). Over 150 scientists involved with research on barley from over 30 nations participated in this workshop. The proceedings of this workshop have been published in two volumes, Proceedings: Fourth Regional Winter Cereal Workshop-Barley, Amman, Jordan, April 24-28, 1977. Vol. I, 273 pages and Vol. II, 420 pages. (Distributed in 1978).

Successful efforts to establish linkages with individual scientists in many areas of the world were made throughout the life of the project, but to accomplish our major outreach objectives, linkage with the international centers was essential. After three years linkages for outreach were finally successfully established. However in February of 1977 a project review was scheduled and several months later we were informed that Contract ta-C-1094 was to be terminated.

In view of the above discussion we feel that we fulfilled the outreach objectives set forth in our contract as well as they could be fulfilled under the circumstances that prevailed. (7)

The following is an abbreviated summary of the research theory, approaches, progress, successes, and failures encountered during the 4 year duration of this project. We fulfilled the obligations specified in the contract and, actually, in most areas went far beyond the obligations we were committed to fulfill.

The general objectives of the approach were to: obtain immediate national breeder participation, supply genetic materials to LDC's for immediate exploitation, reduce the need for well-trained barley improvement scientists and sophisticated laboratories in LDC's, perform the initial selection of cultivars in the environment in which they were to be used, and make it possible to do these things on minimum budgets (always less than wheat). To accomplish this, male sterile facilitated recurrent selection populations were selected as the method of breeding. Some 26 recurrent selection populations are reported in this summary of accomplishments.

The second general approach concerned more basic studies that would increase the odds of success with these populations. These consisted principally of research related to forming the recurrent selection populations and methods of manipulating and selecting from the populations. (1)

## RESEARCH ACCOMPLISHMENTS

Objective I - To increase the nutritive value of barleys consumed by peoples throughout the world, particularly LDC's.

Upon the recommendation of AID approximately 50% of the project effort was allotted to this objective. When it became apparent that we could obtain certain types of high-lysine mutants almost at will we reduced the effort on locating additional mutants and concentrated more on characterizing the available mutants and overcoming some of the difficulties in using these mutants. (1)

### I. Agronomic Evaluation

1. Throughout the duration of this project we have worked toward a more efficient method of lysine determination.
  - a. For the bulk of the work we used an improved version of the microbiological (Pediococcus cerevisiae) assay that had been developed here. The sample was prepared by acid hydrolysis, properly diluted, and the growth of the bacteria in lysine free broth (+ lysine from sample) measured by pH.
  - b. Subsequently we developed a method using the same organism on a lysine free agar plate medium using bacterial growth around the distal end of a halved seed as a measure of lysine in the seed. This non-destructive technique can be quite valuable when searching for plump mutants among a bulk of seed grown from mutated materials.
  - c. A modification of this assay (b) consists of placing half seeds in 5 mls. of assay broth and after 48 hrs. measuring with a spectrophotometer. We believe this to be more accurate, as a quantitative measure, than the agar plate technique. We believe the latter two methods are a better measure of bio-available lysine since they measure free lysine and perhaps some readily hydrolyzed protein lysine. We consider methods b and c to be major breakthroughs as the technique is applicable to any essential amino acid in any crop.
  - d. Recently we have acquired a Technicon Infraanalyzer. Limited evaluation comparing AAA determined lysine indicates correlation coefficients of .91 using 28 samples of Hiproly and Hiproly Normal barley. (1)
2. Eight induced mutants and their normal isotypes were obtained from Denmark. All mutants were higher in lysine and lower in kernel weight when grown under a multitude (26-48) of environments. No environments were encountered where kernel weights were normal. Mutant normal differences were maintained under all environments. Hiproly also has shrunken seed compared to its' normal isotypes. (1)
3. We had previously obtained a number of spontaneous shrunken endosperm mutants, determined 9 of them to be non-allelic, and assigned them

to chromosomes. These were grown in 2-26 environments and determined to be high in lysine in the grain and all but two had a higher percent lysine in the protein than their normal isotypes. No environments were encountered where the mutant isotype equalled the normal isotype in kernel weights or lysine in the protein. Both induced, chemically selected, and spontaneous, visually selected, mutants produced a similar spectrum of high lysine, shrunken endosperm mutants. In fact one of the chemically induced mutants was allelic to one of the visually selected mutants. We demonstrated that we could go to commercial fields of adapted varieties and visually select additional high lysine mutants. Thus we added 8 new high lysine mutants to the current list and demonstrated that others could be added at will. (1)

4. By performing allele tests within and among groups we demonstrated that we had represented in the two groups 15 non-allelic genes for high lysine, all with reduced seed weight.

By crossing with trisomics and from previous work we were able to assign 12 of the 15 genes to chromosomes. At least 1 mutant occurred on each of the 7 chromosomes of barley. For a number of the genes we were able to approximate the position on the chromosome. (1)

5. One of the objectives of the lysine work was to establish gene transfer systems so that large, homozygous for lysine, outcrossing populations could be established without testing for the presence of lysine, and also could be used to establish plants with two genes known to be homozygous for detecting if epistatic gene action might restore plumpness without loss of the high lysine trait.

As determined on relatively small populations (100+) transfer mechanisms are available for 5 of the mutants. We concentrated on establishing a transfer system for the Hiproly gene. We have not been able to improve appreciably on the use of the linkage with short rachilla hairs to follow the gene, without testing for lysine. The lethal translocation homozygotes, discussed under objective III H1 and H2, will be particularly useful as a gene transfer system of plump high lysine genes. (1)

6. It became apparent early in the project that the available high lysine mutants were associated with shrunken endosperms. If one examines the problem several possibilities are apparent, the ones considered were (a) find a gene that suppresses the shrunken character only, (b) If the shrunken and high lysine are separate linked genes, not pleiotropic, break the linkage, (c) develop exceptionally large seed, and even though they are shrunken they might be sufficiently heavy that yields are not reduced, (d) accumulate minor genes, meaning those that result in only modest increases in lysine and that seem to have no effect on plumpness, thus increasing the lysine level without a loss in kernel weight, (e) intercross available genes, looking for epistatic gene action that results in plump high lysine seed.

One approach to the problem would be based on the propositions that

1. given a fairly wide set of normal cultivars they might contain suppressor genes for the shrunken endosperm, 2. Frequent recombination could result in the breaking of linkages between shrunken endosperms and high lysine in the protein, and 3. sieving of a segregating population will increase seed size. To accomplish this, two male sterile facilitated recurrent selection populations were established, one with the Hiproly gene for high lysine and the second with the high lysine gene of Risø 1508. Seed of these populations, originally homozygous for the high lysine gene, are available.

1. RSP15lys F6S1F1S1FS1F3\* (Hiproly gene)  
5 parental cultivars, 4 generations of sieving
2. RSP16lys F2S1F1S1F2\* (Risø 1508 gene)  
24 parental cultivars, 3 generations of sieving.

To retain the male sterile population with integrity for homozygosity of the high lysine gene it is necessary to grow each population in complete isolation from sources of normal pollen. As the generations have advanced the percent plump has moved up very rapidly. In the plump portion of the population are what appear to be normal seed and also shrunken seed. At the same time the percent lysine in the protein has decreased but not to the level of a normal barley. We are in the process of evaluating lines from these populations.

To test the suppressor gene hypothesis M2 seed of mutagen (DES) treated Hiproly seed was sieved, the plump seed planted, and 700 M4 rows (including checks) grown in 1978 to be evaluated. Initial analysis indicates that we have recovered several very plump high lysine lines indicating support for the "suppressor" gene hypothesis.

The testing of the epistatic gene hypothesis is dependent on the development of successful gene transfer systems to establish plants, in large numbers that are known to be homozygous for two genes. (See No. 5) above.

To accumulate minor genes in plump barleys about 5500 accessions from the world collection of two row barleys were grown and analyzed by microbiological assay for protein, lysine in the grain, and lysine in the protein. Currently we have 10 verified (2 environments) high lysine lines of which at least 5 have definitely shrunken endosperms. From early USDA accessions we have determined 4 older varieties that have slightly higher lysine contents that perform very well in feeding trials. These are: Hanna C.I.906, Balder C.I. 7131, Lenta C.I.7622 (all three interrelated through breeding) and Bargiers C.I.3383.

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\*Throughout this summary, in population designations the F and number indicate generations of bulk harvest, and S and number indicates generations of harvesting male steriles, only, in sequence.

7. Early in the project we completed evaluation of the waxy endosperm gene and its effect on nutritional value and yield. We continued to develop a few additional isogenics for further tests and as donor parents. The waxy gene has little or no effect on yield.
8. We have continued to develop and evaluate a number of covered and naked isogenes both agronomically and nutrition wise. In terms of yield, the hulless isotypes yield about 12% less than their comparable covered isotypes. Less dormancy and greater speed of germination is associated with the hulless gene. (1)

## II. Nutritional Evaluation

A total of 38 barley cultivars were evaluated for nutritional quality through analyses for (1) proximate composition, (2) Osborne protein fractions (3) amino acid composition and (4) growth and nitrogen and or energy balance trials with rats. These cultivars are listed on the attached table. Barleys that were evaluated were either selected because of known differences in nutrient and chemical composition or were discovered in an earlier screening project for barleys having greater potential nutritional quality than the average feed or malting barley.

The data from these studies are reported in Annual Reports No. 1, 1974-75. No. 2, 1975-76 and No. 3, 1976-77. The complete data for 1977-78 is available upon request from Montana State University. Publications resulting from these studies are cited later in this report. (6)

### Effect of starch structure on nutritional quality of barley

The waxy gene (wx) produces a starch in barley that is 100% amylopectin which is quite different from starch occurring in the average barley. The latter starch is composed of amylopectin and amylose in an approximate 3:1 ratio, respectively. The high-amylose mutant of Glacier contains an approximate 1:1 ratio of amylopectin and amylose in the starch. We hypothesized that the differences in starch structure would alter the nutritional value of these barleys.

The waxy gene had no effect on the nutritional value of barley starch or whole barley as determined in rat growth and nitrogen-energy balance trials. Amino acid composition was not altered by the waxy gene in the two cultivars, Compana and Wapana, normal and waxy, respectively.

High amylose starch from the Glacier mutant was somewhat less nutritious than the starch from Glacier as measured by rat growth and energy balance trials. High amylose Glacier was superior to Glacier and to the Compana and Wapana cultivars as well, when compared as whole barleys. This superiority is attributed to the greater percentage of lysine in the protein of the high amylose mutant. We concluded that the approximately 9% increase in lysine (g/16 g N) was due to a shift in the Osborne protein fractions. High amylose Glacier contains less of

the low-lysine hordien and more of the high-lysine salt soluble albumen and globulin proteins than the parent Glacier. Although rats grew faster, produced higher protein efficiency ratios (PER) and higher biological values (BV) on high amylose Glacier barley diets, the protein was less digestible than that in Glacier. The Glacier mutant seed is not shrunken although it is slightly smaller than Glacier seeds as measured by kernel weight. The improved nutritional value of high amylose Glacier compared to Compana, Wapana and Glacier is in all probability due to the altered protein type that is either associated with the altered starch type or is a separate mutation effect independent of starch. (6)

#### Effect of protein structure on nutritional quality of barley

Several barleys were identified that differ in protein and amino acid composition. Some of these differences were created through (1) chemical and nuclear mutation (Risø mutants), or were (2) spontaneous mutations (high amylose Glacier) and (3) certain cultivars just naturally differ (MSG series) slightly from the average feed or malting barley. We undertook the evaluation of barleys known to have or suspected to have more lysine (g/16 g N) than average barleys because lysine is the first limiting amino acid in barley as well as in other cereals.

We hypothesized that a barley having a greater percentage of lysine (g/16 g N) would improve the nutritional status of man, especially in those regions of the world where barley is an integral part of the human food chain or is fed to food producing animals and or/poultry.

The nutritional effect of altering the ratio of hordein to albumins and globulin proteins was previously presented in the discussion of high amylose Glacier. Five mutant barleys of Bomi and three mutants of Carlsberg II produced at the Danish Atomic Energy Commission at Risø were compared chemically, physically and biologically in our laboratory to the respective parent barleys. All of the mutants had lighter kernels due to shrunken endosperms and with the exception of the Bomi Risø mutant 9, all mutants have a greater percentage of albumin and globulin and less hordein than the parent barleys. This is reflected in an increase in lysine (g/16 g N) in these barleys. The lysine in the mutants range from 5.6% in Bomi Risø 1508 to 3.79% in Bomi Risø 9. The low lysine in the latter barley is a reflection of the relatively lower albumin and globulin content in this barleys protein which is consistent with the parent Bomi. A paradox in nutritional quality became evident as we began to accumulate animal growth and metabolism data. The high-lysine barleys have a higher BV and PER than their parent barleys and these values are highly correlated to the percent lysine in the proteins. However, six of the seven cultivars also exhibited a low protein digestibility compared to the parent barleys. The one exception to this negative correlation of BV and protein digestibility is the Carlsberg II Risø 56 mutant. This barley did not follow the pattern of the other mutants. An examination of the protein fractions revealed that the albumin and globulin fractions was greatest in the mutant 56 but not statistically different from that of the mutant 29. However BV of the two mutants were not different (80.5 vs. 83.5% for mutants 56 and 29, respectively) and the

digestibility of protein in the mutant 56 barley was 85.9% compared to 71.4% in the 29 mutant. Thus we feel that the Carlsberg II Risø 56 barley deserves further testing and nutritional evaluation as the protein appears to be one of superior quality and is also highly digestible.

The discussion thus far has dealt with barley cultivars that are either spontaneous or induced mutations. Prior to the initiation of the AID contract with Montana State University, we began a screening program looking for barleys having higher than normal lysine content. Approximately 2500 were screened in the MSU Plant and Soils Science Cereal Quality Laboratory using the DBC technique. Approximately 65 cultivars were selected and subjected to total amino acid analysis. Of these, 19 were found to be higher than normal in lysine. These 19 barleys plus two commercial feed barleys and one malting cultivar were incorporated in some of the first work supported by the US AID contract. These were referred to as the MSG series because of earlier support in this area by the Montana Swine Growers (now Montana Pork Producers Council) organization.

Of the original 19 cultivars selected for feeding trials, six were found to contain from 10 to 18% more lysine (g/16 g N) than Compana barley which is considered to be an average feed barley in Montana. These data were obtained from four generations of seed including the original seed source. However, the cultivar having the highest average percent lysine over the four generations was only 89.5% of Hiproly in this measurement.

An analysis of protein composition revealed that the six selected cultivars contained an average 16% more albumin and globulin in the protein and 27% less hordein than Compana. We believe that this difference in protein composition is the determining factor in the higher lysine content of these cultivars. In contrast to the shrunken seed associated with the induced Danish high-lysine mutants, these barleys have a normal kernel weight and are not really that bad in other agronomic characteristics.

Rat feeding trial data with three generations of seed confirmed the protein superiority of the six selected MSG barleys. Average PER ranged from a low of 2.0 to a high of 2.13 in the MSG barleys compared to 1.86 in Compana. The average BV of the six MSG barleys obtained from the three generations of seed was 74.2% compared to 69.4% for Compana. However, the paradox of high BV and low protein digestibility was also evident in these barleys. The true protein digestibility of the MSG barleys averaged 81.7% compared to 84.7% for Compana.

Nitrogen fertilizer was shown to increase protein content of two common Montana feed barleys but had no effect on Hiproly and very little effect on the Hiproly Normal. Increased protein in the feed barleys was inversely related to protein quality. As protein increased, albumin tended to decrease and hordein tended to increase resulting in decreased lysine in the protein (g/16 g N). Protein efficiency ratios and BV decreased with increased protein but protein digestibility increased. An interesting difference was noted in the response of Hiproly to nitrogen fertilizer compared to the two feed barleys. Total protein was not altered significantly in Hiproly but albumin and globulins increased at the expense of glutelins with increment increases in nitrogen fertilizer and hordein

did not appear to change very much. Protein from the two feed barleys was equal in BV to that of Hiproly when they were compared at the low protein level produced by the low nitrogen fertilizer treatment.

Efforts made during the course of this project to find barley containing greater amounts of fat were mostly unsuccessful. However, it was noted from routine proximate analysis that four of the eight Risø mutants contained significantly more ether extract than the parent barleys. These were the mutants 13 and 1508 from Bomi and mutants 29 and 56 from Carlsberg II. The ether extract ranged from 3.1 in the 1508 mutant to 4.6% in the 13 mutant. (6)

#### Conclusions and suggestions for further study on the nutritional value of barley

There are obvious nutritional differences in barley cultivars that are due to cultivar, environment and cultivar x environment interactions. The increased lysine in the known high-lysine cultivars is not as biologically available to animals in the raw (uncooked or milled) state as that from sources such as casein. It is strongly indicated in the data accumulated during the course of this project, that the high-lysine proteins of barley, namely albumins and globulins, are the least digestible whereas the low-lysine proteins, the hordeins are the most digestible.

Future studies should explore the Carlsberg II Risø 56 mutant as it apparently has high quality protein and relatively good protein digestibility. Also, the reason for low digestibility in the salt soluble proteins should be investigated in the known high-lysine mutants and other high-lysine barleys. Protein structure of barley albumins and globulins and the association of cell wall constituents (cellulose, hemicellulose, and lignin, etc.) with protein structure as well as other polymolecular compounds should be investigated. It is also suggested that those barleys found to contain a higher percentage of ether extract should be further investigated as to the nutritional value of the additional lipids and these identified and characterized. The effect of processing during milling, cooking and the type & intensity of heat, and length of cooking time should reveal interesting findings with normal and high-lysine barley and barleys varying in amylose: amylopectin ratio.

Finally, I would like to respectfully make a few suggestions to any future group undertaking such a project as we have attempted. First the problem of nutritional quality should be thoroughly researched prior to the initiation of any project. This must include on-site short term or perhaps long term studies to uncover the real problems that pertain to a given locality and people that will benefit from the research effort. Such a study should include a survey of the foods normally consumed by the people to be benefitted, the animal and poultry agriculture, and the agronomic and physical problems associated with growing the crop. It must be undertaken by scientists who are trained in nutrition and crop production but also these people must be realists and accept what can't be changed in a population or an area. Reports by bureaucrats, economist and uninformed people must be avoided at the cost of not conducting the research. The total use of a cereal by humans, animals, poultry and etc. must be considered

and the research not regulated to studies that may or may not have application.

Although we can see many mistakes made in our efforts, we believe that the funds expended by US AID in supporting the nutritional evaluation of barley were well invested and the knowledge gained has provided a base from which we will launch future studies that should be more directly useful to man and animal agriculture. If nothing else this study clearly points out that a chemical analyses for an amino acid such as lysine does not tell the whole story! (6)

Objective II. To increase the yield of barley grown in semi-arid regions of the world, particularly in LDC's.

The work on drouth resistance was phased in about 1 year later than the other two major objectives. Basically this portion of the work was funded for only two years. It represented about 25% of the total effort for the two year period. (1)

If one is to search for drouth resistance the term must be defined. For the purposes of this project, drouth resistance was defined as grain production under a moisture stress situation. When defined in these terms it will be noted that the two categories drouth escape (e.g. due to earliness) and "true" drouth resistance (all other) are not separated. It should be apparen. that a given cultivar could be either or both.

There are three possible approaches to obtaining genotypes for determining true drouth resistance.

- (a) One method is to apply some quantative determination that is suspected to be associated with drouth resistance to a series of cultivars. If correlations are to be obtained some reliable measure of a number of cultivars for drouth resistance (as defined above) must be available.
- (b) Another method is to determine drouth resistance of isogenics or near isogenics that differ for some trait that might be associated with drouth resistance.
- (c) A third method would be to select surviving plants under severe drouth conditions or select for early maturity, drouth escaping genotypes. All three approaches or modification were initiated. (1)

#### Development of a set of cultivars of known drouth resistance

##### A. Cultivar-trait correlations

One major thrust was to develop a drouth resistance ranking of 49 cultivars that had been grown commercially and in replicated yield trials in the Pacific Northwest and Northern Great Plains area where leaf diseases are seldom a factor influencing yields. An historical tabulation from 1936 to 1976 yielded 17,000 yield comparisons for evaluation.

Yields of each set of varietal pairs were correlated and prediction equations for each variety were developed (a possible 49 prediction equations for each variety). These equations were then used to predict the yield of a given variety at 10 bushel increments from 10 to 120 bushels per acre and the weighted predicted values entered into a table and the slope calculated. We are in the process of recalculating this table using orthogonal regressions which we believe will be an even more acceptable and reliable estimate.

Since the above table reflects drouth resistance that is due to both drouth escape and "true" drouth resistance, a second table will remove the effect of maturity by covariance analysis, to allow some measure of relative "true" drouth resistance for these 49 varieties. These tables may be used to correlate measurements thought to be associated with drouth resistance at each yield level 10 through 120 bu. per acre, as well as with the slope of the line. If a trait is associated with drouth resistance then correlations with predicted yield should be high at low yield levels and low at high yield levels.

Indirect proof of the validity of the rankings is possible. It is based on three stages in the development of the barley plant. If drouth strikes early the number of seeds per unit area (number of tillers or seeds per spike) will be reduced. If drouth is a factor during the jointing and heading stage, height will be reduced. If drouth is a factor during the filling stage, seed weights will be reduced.

These reductions expressed as percentage of the maximum observed (spaced plants) and considering sequential development should be an expression of drouth resistance at these respective growth stages. Three years or more of measurements of the above type of data on the 49 varieties are available to test the validity of the rankings. (1)

#### Measures of drouth resistance

Data collected on the 49 varieties to determine associations with drouth resistance includes leaf areas (3 yrs.), morning and afternoon osmotic potentials (3 yrs.), soil moisture removal by depths (3 yrs.), continuously monitored soil water consumption (1 yr.), rate of in vivo dry down of seedling plants (2 yrs.), rate of leaf dry down (1 yr.), and modulus of elasticity (2 yrs., limited no. varieties). (1)

From preliminary analysis osmotic potential does not appear to be a promising test because of its unreliability and inability to significantly differentiate between cultivars. However, morning potentials early in the season and afternoon osmotic potentials late in the season appear to be correlated with drouth resistance. The best differentiator as to drought resistance is the osmotic potential difference late in the season. In nearly all cases the lower the potential, the greater the drought resistance. (3)

Soil water use does have some potential as a screening test. The best correlations with drought resistance occur with the shallow and deep depths. The best approach is a single determination after the crop has been harvested. Generally, the less water used, the greater the drought resistance. (3)

A better test appears to be the measure of water retention or loss when seedling plants are dried down. Good differentiation occurs by 24 hr., with whole plants being the best sample. The smaller the water loss, the greater the drought resistance (3).

It seems logical to assume that "true" drought resistance is a complex trait and no single criteria of measurement is adequate. If we examine combinations of measurements (with the exclusion of the osmotic potential test), we find that while simple correlations gave values in the .20's, multiple correlations with two measurements gave values in the .30's, multiple correlations of three measurements gave values in the .40's, and multiple correlations of four measurements gave values in the .50's. (3)

The above analyses need to be re-examined using yield predictions at specified levels based on orthogonal regression and similar statistical evaluations for yields freed of the effect of heading date and maturity. The validity of the tables should be verified. It is possible that some of the simple correlations observed are the result of pleiotropic effects or an artifact of the method of determining predicted yields. The short duration of the project did not permit complete analysis of the data, however, this is proceeding at a slower pace utilizing state funds. (1).

#### B. Isogenic analysis

In connection with this project we have continued to develop near isogenic pairs of barley, particularly for traits that may be associated with drought resistance. For the purposes of this project we concentrated on the following types of isogenics. 17 (non-allelic) isogenic pairs for plant color in the variety Betzes; 18 plant height isogenics, only 4 of which are allelic, for plant height in Betzes; 3 isogenic pairs for leaf area in Betzes; and 10 maturity isotypes in Betzes that represent a range of 20 days in heading at 2 day intervals throughout the range. The above are listed as a sample of the types of isogenics currently available in a collection of several hundred representing a number of varieties and a number of other traits. A summary of studies of work with some of the isogenics is presented. (1)

#### Plant color

Since Golden Liberty barley usually outyields Liberty (its dark green isotype) on dryland at Bozeman, Montana we have yield tested it at additional locations. At most locations Liberty was the higher yielding line. A partial explanation for this discrepancy may be the observation (1977-78) that Golden Liberty has an advantage when the land aspect increases temperatures. Some Bozeman soil moisture depletion data suggests that the delayed maturity and therefore water use of Golden Liberty may provide more available soil water during the critical grain filling period. (2)

Golden Liberty heads up to 13 days later on dryland and averages about 14 cm shorter in plant height than Liberty. This reduced height of Golden Liberty reduced the severity of lodging at the higher rainfall Kalispell, MT. location. Golden Liberty has more seeds per head but smaller seed than Liberty. (2).

The percentage retention of visible quanta was reduced only about 1% for Golden Compana and about 2% for the lighter colored Golden Liberty. Our photosynthetic light saturation curves suggest that this small difference should not significantly affect dry matter production. (2)

Both soil water use data and the Bowen ratio energy balance data show that in an arid region the light isogene uses more water than the dark isogene. This surprising finding is apparently related to the higher stomatal resistances of the dark isogene from mid-season on. These higher stomatal resistances of the dark isogene are in turn related to the faster growth rate and higher canopy temperature of the dark isogene. In this instance, a predominant drought resistance trait(s), stomatal resistance and/or maturation rate, has more than compensated for a less influential drought resistance trait, color. The result is that with the two isogenic pairs studied, the dark isogene is better adapted to arid regions. Light colored isogenes still may offer real promise for drought conditions in that they do reflect a significant quantity of light, reducing leaf temperatures. Use of these isogenes are a possibility only if light colors with high stomatal resistance can be found. (3).

Light colored isogenes that remain dark green until heading time and then yellow or those that are equal in maturity to normal barley may prove to be of the most value. (1)

#### Leaf area

The effects of leaf area were evaluated in the field without irrigation using three different leaf width isotypes, narrow (N), midwide (MW) which is normal, and wide (W) of Hannchen barley for 3 years. The third year a second 2-row barley, Betzes, was added. Lines with wider than normal leaves (W) had both a greater leaf area per unit ground area (LAI) and a greater leaf area duration (LAI summed over time LAD). Most of our differences in relative leaf area (LAI) were affected by differing leaf widths. In addition in the first year both planting densities and planting patterns were varied. (2)

Total evapotranspiration (ET), yield and water use efficiency were lower for the wide-leaved isotypes. Grain yields were similar for the narrow and midwide-leaved isotypes the first and last year but the midwide (normal) leaf width yielded more the second year. The efficiency of water use was best for the midwide leaved isotype the last years, but narrow and midwide leaves gave similar results the first year. (2)

Equidistant plant spacing of dryland barley plants in the field appears to be better than planting in rows only with a lower than normal plant density. Our plant densities of about 400,000 plants/ha is about one-half the normal dryland rate. At this lower plant density, equidistant plant spacing increased barley grain yield by 10% giving yields similar to those for the higher (normal) density. Since water use was similar for all planting patterns, higher grain yields reflected greater water use efficiency (hg/ha/cm of H<sub>2</sub>O). (2)

Root samples taken during the second year indicated that narrow-

leaved Hannchen had less root mass in the top 61 cm of soil than the wider leaf isotypes. In the 122 to 183 cm soil depth where most of the late season moisture was located, however, the three leaf widths had similar root mass. (2)

If one observes a number (25 and 25) of commercial 2-row and 6-row cultivars it will be noted that on a per culm basis the 2-row cultivars, almost without exception, have less leaf area (narrower leaves) than 6-row cultivars. The general observation may also be made that those cultivars within a row-type with the narrowest leaves, have in general yielded more on dryland than those with wider leaves. To determine if this was a pleiotropic effect 2 and 6-row isogenic lines of 12 different cultivars were compared with the finding that there were no differences in leaf area between 2 and 6-row isotypes. It is possible that the plant breeder has unknowingly balanced leaf area with photosynthetic sink in order to obtain maximum water use efficiency. (1)

#### Plant height

It could be argued that short plants would be more drought resistant than tall plants. Brachytic type isotypes of Betzes were evaluated. These included the non-allelic genes br1 br1, br2 br2, uzu uzu, and Beebe. Two different genetic nodes of height reduction were measured, one in which the culm internodes were reduced to about equal lengths and the second, a proportional internode reduction as compared to normal. All short isotypes yielded less than the normal isotype. At a soil depth between 120-150 cm., all reduced height isotypes removed less soil moisture than their derived normals. An early maturing derived normal showed less soil moisture removal than other derived normals. (1).

#### Maturity

Sixty-eight accessions of barley including 50 varieties and 18 pairs of isogenic for earliness, were evaluated for day length sensitivity using growth chambers (See Appendix Table 25, 1975-76 annual report.) Day length response for flowering of spring wheat appears to be quantitative long day rather than qualitative or absolute long day. Our photoperiod treatments did not detect a critical day length. It was shown that under long day conditions the vegetative condition of spring barleys is highly correlated with the reproductive development of the growing point. By the time the plant possesses four visible leaves, the growing point can be seen to be in the reproductive node. (2)

From the above evaluations it may be observed that Briggs, Beecher, Atsel, Attiki, and backcross derived early isogenic types of Titan, Hannchen, Betzes and an ert d derivative of Compana were the most day-length insensitive types observed (1).

Six Titan isolines differing in increments of heading date spanning a 13-day period were grown in 15 environments using commercial planting rates and 1 environment planted at a 1 plant/30 cm<sup>2</sup> rate. Yield, spikes/30 cm<sup>2</sup>, kernels/spike, and kernel weights, as well as 10 other morphological traits, were measured at each environment. Three methods of analysis were

utilized to interpret different aspects of the effect of maturity isolines on the developmental allometry of the plant as expressed through yield and yield component responses. Using a two-dimensional version of the parallelepiped analysis it was noted that whether space planted or drilled the isolines exhibited strong yield component differences. In the space planted environment no yield component compensation was observed resulting in marked yield differences. The mean response over 15 environments of the yield trial showed marked yield component compensation and no significant yield differences. A regression analysis of each isoline with mean performance over each environment revealed strong isoline x environment interactions for the three yield components and minimal interactions for yield responses among the isolines. Path coefficient analysis revealed that across environments and isolines, tillers per unit area, and seeds per spike had the highest direct effect on yields. Kernel weights showed a moderate but consistent effect. Across environments and within isolines (environmentally induced variation), tillers per unit area and kernel weights had the highest direct effect on yield. Kernels per spike had a consistently minimal effect on the yield of the isolines. By utilizing all three methods of analysis not only was it possible to determine a pattern of isoline yield and yield component responses caused by the differences in planting dates between environments, but it was also possible to gain a clearer understanding of the plants developmental allometry in different environments. The consistently high correlation response between kernels per spike and isotype heading data at all environments, as well as the pattern of path coefficients imply that the kernels per spike response is the yield component controlling the response in tillering, kernel development and yield. A physiological control mechanism placing a priority on nutrient and water allocation to developing heads, over developing tillers, was suggested. (1)

Data similar to the above has been collected for the possible combination of early and late, 2 and 6-row isogenes in three varieties, and extensive comparisons between Betzes and Erbet, isolines differing by 8-10 days in maturity. A number of isolines were compared for maturation rate by harvesting on alternate days to determine the date of physiological maturity (40% moisture) and the rate of drydown thereafter. Several isogenic varieties were used for each character. These included 2 vs 6-row, dehiscent vs. non-dehiscent awns, erectoides vs. non-erectoides spikes, awn lengths, and black vs. white-lemma. It was concluded that probably the most obvious influential factor on dry down rate was seed size, although isogenics for this trait were not studied directly. Up to 3 days difference was observed for the isotypes studies. Even these few days could be important when barley is used in a double cropping system with rice. (1)

#### C. Drouth Resistant Populations

Two mechanisms for drouth resistance may be separated. The drouth escaping, early, genotypes may be readily selected from a segregating population as represented by a recurrent selection population (RSP).

CC XXX F (basically the world collection of barleys crossed onto

male sterile barley) was used to develop the early populations. Available for distribution where only early heading has been the basis for selection, is seed of the following populations:

1. CCXXXF (Early 1)-----S<sub>1</sub>F<sub>5</sub> or S1F<sub>4</sub>S1 4 generations selections for early heading
2. CCXXXF (Early 2)-----S1F2S1F2 or S1F2S1F1S1 4 generations selections for early heading

In conjunction with K. T. Ramage, University of Arizona, additional early populations are available. These include a population selected for earliness in Arizona and another selected for earliness in both Arizona and Montana. The latter would probably have a higher frequency of early day length insensitive plants.

CCXXXF was used to initiate a recurrent selection population for drought resistance based on sieving for plump seed. This population is grown under conditions of drought stress and sieved. Plants producing plump seed will be early (drought escaping), have few seed per spike (perhaps low yielding), be a 2-row rather than a 6-row barley, or possess "true" drought resistance. After drought stress selection, the very earliest heading plants may be rogued, and perhaps those with very few seed per spike, as well as the very latest plants. The remaining population may be harvested and planted for harvest of outcrossed male steriles (recombination), and the cycle repeated. The most advanced material from this program has had only two cycles of recombination but is available for distribution. Additional cycles would probably be necessary to show advance.

3. CCXXXF (Dro 1) S1F3S1F2 2 generations sieving, after drought

It became obvious that if pale plant color types were to be of value in drought situations that they must also include earliness. A number of crosses of the yellow gene, f<sub>4</sub>f<sub>4</sub>, with male sterile cultivars were bulked to form RSP 2 (yel) and by a combination of selecting early plants and/or sieving two populations were developed. Available are:

4. RSP 2 (yel,early) F7S1 or F8 3 generations selection for early
5. RSP 2 (yel,dro.) F7S1 1 generation selection for each, Early and drought resistance plus sieving.

Populations 4 and 5 are probably only of academic interest at present.

Objective III. To decrease the losses caused by barley diseases, particularly in LDC's.

This objective of the project was to represent about 25% of the total input. This summary is represented by two sections, A-1 through H-1 which sets forth the general approach to the disease problem on a "world wide" basis and the basic concepts involved and a second section A-2 through H-2 which reports on the progress made in the stepwise approaches set forth. It will be noted that 19 male sterile facilitated recurrent selection populations are reported as available for distribution.(1)

As a breeder we have appreciated the "genetic vulnerability" concept and have wondered how to overcome the problem. If one is breeding for disease resistance to be used on a world-wide basis several things become apparent.

A1. If new sources of resistance are needed the usual place to look for resistance is in the world collection. When the resistance is found it usually is in completely unacceptable agronomic types. This suggested the first approach (A) Cross all known sources for resistance onto adapted varieties then at least 50% of the gene pool might be usable. (1)

B1. The second observation is that most breeding programs concentrate on the virulences at hand. Sustained resistance, particularly to new pathogen mutations of old virulences, could be maintained if a cultivar included the appropriate known resistant gene(s). This suggested the second approach (B) Intercross known sources of resistance to a multitude of virulences, rogue susceptibles. Continue intercrossing and selecting (recurrent selection) as long as progress is evident, thus accumulating several genes for resistance in each plant. (1)

C1. The third observation is that selection for resistance to a particular local virulence pool does not necessarily provide the needed resistance to all virulences that may occur around the world. This suggests a third approach (C) grow and select mature plant resistance where indigenous virulence pools exist, rather than form a world-wide virulence pool at one location with the accompanying dangers. The incorporation (crossing) of these exotic resistances into the basic resistant population can be accomplished anywhere. (1)

D1. The fourth observation is that extensive crossing in such a program is necessary. If 4 to 5 lbs of crossed seed is required in each recombination generation, then (D) this can be obtained only if genetic male sterile genes are included in the population and grown where random outcrossing will be good. (1)

E1. The fifth observation concerns the selection of agronomic types (cultivars) to include in the population if the populations are to be used on a worldwide basis. On the basis of trials conducted by workers in various areas around the world, literature search, much use as parents, long life as a cultivar, good performance over a wide area, visitations to major barley producing areas including target countries, etc. (E) a set of 15 6-row varieties and a set of 15 2-row varieties were selected

for inclusion in the base recurrent selection population. In addition to the previous stipulations it was required that the population contain at least one cultivar contributing a gene for resistance to the following diseases (a) net blotch, (b) scald, (c) spot blotch, (d) loose smut, (e) covered smut, (f) mildew, (g) stem rust, (h) stripe rust, (i) leaf rust and certain other genes including (j) large seed (k) hullless, (l) waxy endosperm, (m) short straw, and (n) extreme earliness. (1)

F1. We have previously shown that the genetic background necessary for high yielding two-row barleys is quite different from that necessary for high yielding six-row barleys. (F) Accordingly it was deemed desirable to establish two-row and six-row populations separately to maintain a relative high frequency of good agronomic types in the RSP's. (1)

G1. Utilizing a single male sterile gene in one cultivar in the first crosses can lead to a bias of the germplasm toward the genotype of the donor. This may or may not be desirable. Utilizing only one male-sterile would mean only one cytoplasm (and possible genetic vulnerability) was involved. (G) This dictated that several donor varieties for the male sterile gene be included. (1)

H1. If a population could be homozygous for 1, 2, 3, or more genes that gave resistance to a disease before the recurrent selection process was started, progress could be much faster. This approach is essentially impossible in many instances without genetic manipulation of some type. (H) A method would be valuable that will effect a gene transfer resulting in rapid visual selection of mature plants homozygous for any selected gene even though the gene may not express the trait. (1).

This method requires (1) known genes (disease resistant genes in this instance) that have been assigned to positions on specific chromosomes. (2) a reciprocal translocation that has an allele of the gene located in the interstitial segment resulting in no recombination with the translocation the breakpoint (3) a lethal (or other recessive identifying gene) present in the interstitial segment to eliminate translocation homozygotes, (lethal translocation homozygotes) (4) Lethal translocation homozygotes of generally acceptable agronomic type, (5) a "donor" parent with a maximum number of coupled alleles for a disease, for the several disease resistances, amino acid level, maturity or whatever characteristics are to be transferred that may be on the specific interstitial segment (6) that the "donor" parent be in a generally acceptable agronomic type. (1)

I1. Certain diseases, particularly barley stripe mosaic virus (BSMV) do not fit the general pattern given in A-H above. In this instance the principal goals should be to prevent the spread of this seed borne virus through exchange of seed among researchers and to determine that new varieties released do not include the virus. Breeding for resistance may follow. (1)

From the beginning of the project work has been oriented around the reasoning set forth in items A through I above. Progress on each of these items is set forth below:

A2. Soon after initiation of the research project a survey was made in the barley growing areas of the developing countries in North Africa and the Middle East. Barley diseases were found to be widely prevalent and they were receiving little attention by the local barley breeders. Isolates of the various diseases were collected, returned to Montana and evaluated in controlled environment chambers on various barley cultivars. Many known resistance sources have been evaluated and a number of other sources have been detected within the world collection of barley. Thus a number of virulence genes and a number of different sources of resistance have been determined for the different diseases of barley. Surveys and visits in the Middle East area also gave a better idea where barley disease nurseries should be grown both from the standpoint of obtaining natural infection and the probability of receiving reciprocal cooperation. (4)

A comprehensive literature survey yielded a considerable list of varieties that were resistant to the various virulences of a pathogen. In many instances the genes for resistance had been determined to be non-allelic and in some instances the allele had been assigned to a chromosome. The number of selected resistances for a given disease are listed below:

stem rust-----4 sources  
leaf rust-----13 sources  
scald-----36 sources  
net blotch-----11 sources  
covered smut----- 9 sources

We were of the opinion that some good sources of resistance in the world collection might be overlooked, so CCXXXF (representing crosses of the world collection on male sterile plants followed by several generations of outcrossing) was screened for additional sources of resistance. Populations resistant to stem rust, net blotch, and covered smut have been isolated from CCXXXF. Seed of these are available as:

8. CCXXXF Ruh (covered smut resistance)  $F_1 S_7 F_2 S_1 F_1 S_1 F_2$   
Screened 9-10-11-12-13-14 generations
9. CCXXXF Rpt (net blotch resistance)  $F_1 S_7 F_3 S_1 F_2$   
Screened 11-13 generations
10. CCXXXF Rpg (stem rust resistance)  $F_1 S_7 F_2 S_1 F_1 S_1 F_2$   
Screened 10-12-14 generations (1)

B2 All of the above sources of resistance were crossed onto an out-crossing population of desirable agronomic type 6-row barleys (Rsp 5 - see E2 below). This has been followed with roguing susceptible types,

harvesting in bulk, recombination by harvesting male steriles only, and repeating the cycle. Seed for the following recurrently selected populations are available from this program:

11. RSP5 Rrs      scald resistance  $F_2 S_1 F_1 S_1 F_1 S_1 F_2$   
                  screened 4-6-8 generations
12. RSP5 Rrs      net blotch resistance  $F_2 S_1 F_3 S_1 F_2$   
                  screened 7-8 generations
13. RSP5 Rpg      stem rust resistance  $F_2 S_1 F_3 S_1 F_2$   
                  screened 5-6-8 generations
14. RSP5 Ruh      covered smut resistance  $F_2 S_1 F_3 S_1 F_2$   
                  screened 6-7-8 generations
15. RSP5 Rph      leaf rust resistance  $F_2 S_1 F_3$

In addition to these a 2-row RSP for mildew resistance is available from R. T. Ramage, Univ. of Ariz., Tucson, and a RSP for yellow dwarf resistance is available from R. K. Thompson, Univ. of Ariz. Mesa. We have cooperated in the development of these populations.

C2 Disease resistant RSP were first distributed for exposure to other virulences. The scald resistant population RSP5 Rrs has been grown in the following countries and states and seed from resistant plants returned: Turkey, Morocco, Tunisia, Maryland, Georgia, and California. These sources of resistance are in the processes of integration back into the base population of RSP5 Rrs.

D2 By incorporating male sterile in the populations and selecting for disease resistance in  $F_1$  and  $F_2$  plants populations in the north (Bozeman, MT) and selecting only male sterile plants in the south (Mesa, Ariz.) where we usually harvest 5-10 kilograms of seed. We accomplish 1 cycle of recurrent selection per year. (1)

E2 Cultivars selected for inclusion in the base population were:

6-row: Unitan, Arimont, Watan, Nordic, Atlas 68, Beecher, Galt, Steptoe, Nuvan, Nucier, Minn. 21, Athenais, Atsel, and CM67;

2-row: Herta, Ingrid, Bruens Wisa, Zephyr, Erbet, Dekap, Hector, Wapana, Union, Vireo, Summit, Maris Mink, Nupana, Cumhuziyet 50, and Toonucier. (1)

F2 The 6-row parents were crossed onto Manchuria msg10 msg10 to yield RSP5 and the 2-row parents onto Compana msg10 msg10 to yield RSP4. We have used these two populations most frequently as recipients of the disease resistant genes. Seed of the undiluted populations is available

as follows:

16. 2-row RSP4  $F_3 S_1 F_2 S_1 F_1$

17. 6-row RSP5  $F_2 S_1 F_2$  (1)

G2 We have produced the following populations (produced as for F2) with different genotypes cytoplasms, and male sterile genes. These are held in reserve for anyone wishing to use them or to be used in this program.

2-row:

18. RSP10 Shonupana (hulless) msg10 msg10  $F_2$  (chromo. 1)

19. RSP11 Compana msg2 msg2  $F_3$  (chromo 2)

20. RSP8 Carlsberg II msg5 msg5  $F_2$  (chromo 3)

21. RSP9 CI 4961 msg19 msg19  $F_2$  (chromo 7)

22. RSP6 Betzes msg23 msg23  $F_2$  (chromo 1)

6-row:

23. RSP7 Betzes msg23 msg23  $F_2$  (chromo 1) 2 x 6 row cross

24. RSP12 Carlsberg II (6-row) msg5 msg5  $F_2$  (chromo 3)

25. RSP13 Trebi msg2 msg2  $F_3$  (chromo 2)

26. RSP14 WS471 (smut resistant) msg1 msg1  $F_2$  (chromo 5)

H2. (Step 1) Utilizing a set of Betzes primary trisomics the two scald resistant genes in Jet, rrs1 and rrs6 were assigned to chromosome 3 and 4 and the scald resistant gene Rrs9 was assigned to chromosome 4. These scald resistant genes had not previously been assigned to chromosomes. No net blotch resistant genes had previously been assigned to chromosomes. Three dominant net blotch resistant genes, Rpt1, Rpt2, and Rpt3, were assigned to chromosomes 3, 5, and 2, respectively. Judging by seed requests for the Betzes trisomic series these results have stimulated much interest in the developed countries in using the method to locate disease resistant genes. This is the first time results from trisomic analysis for disease resistance have been reported. (Step 2) Progeny of forty-four crosses in  $F_2$  were examined for no recombination between 13, T-3 translocation breakpoints and the scald resistant genes, principally Rrs3 and Rrs3. T3-4d could be used to transfer the Rrs3 as found in Turk and the double translocation T3-7C = T3-7d could effectively transfer the Rrs4 gene as found in Osiris, Modoc and Trebi. These studies used non-lethal translocation homozygote stocks.

With current emphasis on the rust genes in wheat in target countries it was originally projected that stem rust would be one of the important diseases. This was subsequently shown not to be so. Initially we crossed 79 R-1 translocations onto a stock carrying the t gene for stem rust resistance. Six of the translocations were examined and the gene

was shown to be independent of the breakpoints. Some difficulties were encountered in obtaining reliable seedling readings and the material was stored for possible future work. (Step 3) Seed from interchange heterozygotes selected from the  $F_2$  crosses between male steriles and selected interchange homozygotes was treated with the chemical mutagen diethylsulphate. Interchanges were selected to represent breakpoints in the 14 barley chromosome arms, with the breakpoints as far from the centromere as possible. The male sterile genes selected are located near the centromere of one chromosome involved in the chromosomal interchange.  $M_2$  head rows were selected on the basis of aberrant ratios with respect to fertility. The expected ratio is 1 fertile:2 semisterile:1 male sterile; the aberrant ratio selected for was 0:2:1. To date we have obtained 19 interchange homozygote lethal stocks (0:2:1 ratio), representing all but 6 of the 21 possible chromosome interchange combinations. Among the 19 were T3-4d and the double translocation T3-7c + T3-7d thus establishing an easy transfer system for the scald genes Rrs3 and Rrs4. (Step 4) As the lethal translocation homozygote stocks have been isolated they have been backcrossed to the 2-row cultivar Shabet to improve the general agronomic type, and eliminate simultaneous mutations and place the nuclear system in an unaltered cytoplasm. (Steps 5 & 6) To date we have done little to assemble a desirable donor stock, other than to backcross some of the resistant genes into Shabet. (1)

12. The principal accomplishments in the general area of virus diseases are enumerated below.

1. Evaluated the barley plant virus disease situation and collected specific plant pathogens from areas not previously visited by scientists on this project. Special emphasis was placed on barley stripe mosaic virus (BSMV) and barley yellow dwarf virus and their diagnosis and control and made germ plasm and technical knowledge available to barley workers in the developing countries.
2. Developed a germ plasm resistant to the seed transmission of some BSMV strains. The germ plasm was derived from Betzes-Modjo hybrids and contained 7 doses of Betzes obtained by the backcross method.
3. Determined the inheritance of resistance to the seed transmission of BSMV in Modjo-Vantage hybrids.
4. Screened CIMMYT barleys for presence of seed-borne BSMV.
5. Screened germ plasm from the world collection of barleys shown previously to have some resistance to BSMV.
6. Tested international seed lots for BSMV presence. Ten seed lots from Tunisia, and 35 lines from the CIMMYT World collection of scald resistant barleys were all virus-free.
7. Began clean-up of BSMV in composite cross XXXI. Rogued 207 infected plants from the population.

8. Perfected a technique using sodium dodecyl sulfate (SDS) in the serodiagnosis of BSMV in barley embryos and leaves. The technique shows promise for field surveys and seed testing worldwide.
9. Gained expertise in the diagnosis and transmission of barley yellow dwarf virus (BYDV).
10. Established colonies of aphids that vector BYDV in preparation for screening barley germ plasms for resistance to BYDV.
11. Obtained several germ plasms purported to be resistant to BYDV, for evaluation.
12. Made cooperative arrangements with Dr. R. T. Ramage, USDA, SEA, Department of Agronomy, University of Arizona, Tucson, AR, and Dr. C. W. Schaller, Department of Agronomy, University of California, Davis, CA., to:
  - a. Exchange and evaluate germ plasms resistant to BYDV.
  - b. Identify the strain or strains of BYDV encountered in screening nurseries in Arizona, California, and Montana (5)

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Throughout the narrative portion of this report the authorship is indicated by the bracketed numbers following a paragraph, topic, or section.

- (1) R. F. Eslick - Principal investigator
- (2) J. H. Brown - crop physiologist
- (3) A. H. Ferguson - soil physicist
- (4) E. L. Sharp and H. E. Bockelman - Plant pathologists
- (5) T. W. Carroll - plant virologist
- (6) C. W. Newman - animal nutritionist
- (7) L. P. Carter - Co-principal investigator

DISSEMINATION OF RESEARCH FINDINGS

PUBLICATIONS

- Barr, E. L. 1976. Evaluation of barley cultivars for gibberellic activity. M.S. Thesis.
- Biggerstaff, D. R. and R. F. Eslick. 1978. Combining cytogenetic and mutagenesis to recover unusual genotypes. Abstr. of paper presented at 10th North Amer. Barley Workers Conf. 1978 BN. 22:
- Bjarko, M. E., E. L. Sharp, and H. E. Bockelman. 1977. Reactions of 141 barley lines to Montana and Middle East virulence groups of Pyrenophora teres. Barley Newsletter 21:21-23.
- Bjarko, M. R., E. L. Sharp, and H. E. Bockelman. 1978. Genetic relationships between several net blotch resistant cultivars. Barley Genetics Newsletter 8:15-17.
- Bockelman, H. E., R. F. Eslick and E. L. Sharp. 1976. Reaction of CC-XXX-F and an inbred bulk of the world collection to Montana and Middle East isolates of Scald. BGN 6:89-90.
- Bockelman, H. E., E. L. Sharp, and R. F. Eslick. 1977. Trisomic analysis of several scald and net blotch resistance genes. Barley Genetics Newsletter 7: (in press).
- Bockelman, H. E., E. L. Sharp, and R. F. Eslick. 1977. Trisomic analysis of genes for resistance to scald and net blotch in several barley cultivars. Can. J. Bot. 55:2142-8.
- Bockelman, H. E., E. L. Sharp, and R. F. Eslick. 1977. Reaction of CC-XXX-F and an inbred bulk of the world collection to Puccinia graminis sp. tritici. Barley Newsletter (1976) 20:28.
- Bockelman, H. E., R. F. Eslick and E. L. Sharp. 1977. A single gene transfer system for barley. Agron. Abstr. p. 49.
- Bockelman, H. E., and R. F. Eslick. 1977. Absence of crossing-over of ert-c in crosses involving T2-3a and additional information on the linkage of uz and msg5. Barley Genetics Newsletter 7:15.
- Bockelman, H. E., E. L. Sharp, and R. F. Eslick. 1978. Observed recombination between T3 translocation stocks and scald resistant loci. Barley Genetics Newsletter 1:17-20.
- Calvert, C. C., C. W. Newman, B. Moss and R. F. Eslick. 1975. The nutritional significance of varying combinations of amylose and amylopectin in Barley. BN 18:33-34.
- Calvert, C. C., C. W. Newman, Robert Eslick and K. G. Goering. 1975. Waxy vs. normal barley in rat and pig diets. Vol. 26: Proceedings, Western Section, American Society of Animal Science.

- Calvert, C. C., C. W. Newman, R. F. Eslick and K. G. Goering. 1976. Comparison of waxy, high-amylose and normal barley starches in purified rat diets. *Nutrition Reports International* 14:155.
- Calvert, C. C., C. W. Newman, B. R. Moss, A. M. El-Negoumy and R. F. Eslick. 1976. High-amylose barley in rat and pig diets. *Proc. WS Am. Soc. Animal Sci.* 27:119.
- Calvert, C. C., C. W. Newman, Robert Eslick, K. G. Goering, B. R. Moss and A. M. El-Negoumy. 1977. Waxy vs. normal barley in rat and pig diets. *Nutrition Reports International* 15:157.
- Carroll, T. W. and D. E. Mayhew. 1975. Electron microscopy of barley stripe mosaic virus in barley during anther and pollen development. In *Proceedings of the American Phytopathological Society*. 2:112. (Abst.)
- Carroll, T. W. and D. E. Mayhew. 1975. Barley stripe mosaic virions associated with spindle microtubules in barley cells undergoing microsporogenesis. *Proceedings of Third International Barley Genetics Symposium*. (In press). (Abst.)
- Carroll, T. W., and D. E. Mayhew. 1976. Anther and pollen infection in relation to the pollen and seed transmissibility of two strains of barley stripe mosaic virus in barley. *Can. J. Bot.* 54:1604-1621.
- Carroll, T. W., and D. E. Mayhew. 1976. Occurrence of virions in developing ovules and embryo sacs of barley in relation to the seed transmissibility of barley stripe mosaic virus. *Can. J. Bot.* 54:2497-2512.
- Carter, L. P. 1978. Montana State University/AID Barley Research Program. 4th Regional Winter Cereal Workshop-Barley. Vo. II 145-148.
- Cunfer, B., D. E. Mathre and E. A. Hockett. 1975. Factors influencing the susceptibility of male - sterile barley to Ergot. *Crop Science*. 15:194-196.
- Darlington, L. C., T. W. Carroll, and D. E. Mathre. 1976. Enhanced susceptibility of barley to ergot as a result of barley stripe mosaic virus infection. *Plant Dis. Repr.* 60:584-587.
- Eslick, R. F. 1974. Allele tests of gs and cer mutants. *BGN*. 4:9-10.
- Eslick, R. F. and W. L. McProud. 1974. Positioning of genetic male sterile (msg5) on chromosome 3. *BGN*. 4:16-22.
- Eslick, R. F., R. T. Ramage and D. R. Clark. 1974. Two genetic male steriles, msg6 and msg,,bk, assigned to chromosome 6. *EGN*. 4:11-15.

- Eslick, R. F. and E. A. Hockett. 1974. Genetic Engineering as a key to water-use efficiency. *Agric. Meteor.* 14:13-23.
- Eslick, R. F. 1976. Approximate position of the chlorina mutants f4f4 and f8f8 on chromosome 1. *BGN* 6:10-13.
- Eslick, R. F. 1976. Male sterile genes on chromosome 1. *BGN* 6:14-20.
- Eslick, R. F. and E. A. Hockett. 1976. A second locus for high lysine barley. *Barley Genetics* III:634.
- Eslick, R. F. and E. A. Hockett. 1976. Suggestions for gene symbol symbolization, g, m, x. *BGN* 6:115.
- Eslick, R. F., and M. N. Ries. 1976. Positioning sex1 on chromosome 6. *BGN* 6:21-22.
- Eslick, R. F. and S. E. Ullrich. 1977. Genetic and breeding considerations of the high lysine mutant Bomi, Riso 1508. *Agron. Abstr.* p. 55.
- Eslick, R. F. 1977. Breeding for a short time from planting to harvest. Asian and South Pacific Association of Countries, Food and Fertilizer Technology Center. *Ext. Bul.* 98:1-8.
- Eslick, R. F. and E. A. Hockett. 1977. Regression analysis applied to two Betzes Erectoides mutants. *BN.* 20:33-38.
- Eslick, R. F. and S. E. Ullrich. 1977. Regression analysis applied to two Betzes Erectoides mutants. *BN.* 20:39-45.
- Eslick, R. F. 1978. Barley improvement around the world. 4th Regional Winter Cereal Workshop-Barley. II:26-31.
- Eslick, R. F. 1978. Male sterile facilitated recurrent selection--advantages and disadvantages. 4th Regional Winter Cereal Workshop - Barley. II:84-91.
- El-Negoumy, A. M., C. W. Newman and B. R. Moss. Chromatographic fractionation and composition of the salt soluble proteins from Hiproly and Hiproly Normal barleys. Accepted for publication in "*Cereal Chemistry*". 54 (2) 333-344.
- El-Negoumy, A. M., C. W. Newman and B. R. Moss. 1977. Extractability of barley protein in pH7 phosphate buffer. *Barley Newsletter.* 1977.
- El-Negoumy, A. M. and C. W. Newman. 1977. Composition of protein recovered from various barleys obtained from various sources. *Barley Newsletter* 1977.
- Ferguson, H., J. Brown and R. F. Eslick. The influence of morphological features of barley on genotype - environment interactions - some examples. *BN* 18:56.

- Goering, K. J. and R. F. Eslick. 1976. Barley starch VI, a self-liquifying waxy barley starch. *Cereal Chemistry* 53:174-180.
- Heilmann, R. H. The influence of barley leaf width isotypes (Hordeum distichum L.) and associated characteristics on water-use efficiency. Ph.D. thesis.
- Hockett, E. A. 1975. The genetic male sterile barley collection. *BGN* 5:84-86.
- Hockett, E. A., J. A. Benson, and R. F. Eslick. 1975. Registration of Purcell barley. *Crop Sci.* 15:603.
- Hockett, E. A. and J. G. Moseman. 1975. Cooperative state - USDA regional barley nurseries. *BN* 18:140-142.
- Hockett, E. A. and K. C. Feltner. 1975. Sterility induced in barley by a chemical gametocide. *Agron. Absts.* 67:55.
- Jarvi, A. J. and R. F. Eslick. 1975. Shrunken endosperm mutants in barley. *Crop Science* 15:363-366.
- McNeal, F. H., M. A. Berg and T. W. Carroll. 1976. Barley stripe mosaic virus data from six infected spring wheat cultivars. *Plant Dis. Repr.* 60:730-733.
- Moss, B. R., C. W. Newman and A. Beekler, Waxy Compana as a dietary ingredient for poultry. *BN* 18:32-33.
- Newman, C. W., R. F. Eslick and R. C. Rasmusson. 1974. Effect of barley variety on protein quality and nutritional value for rats. *J. Anim. Sci.* 18:71.
- Newman, C. W., R. F. Eslick and R. C. Rasmuson. 1974. Effect of barley variety of protein quality and nutritional value for rats. *J. Anim. Sci.* 38:61.
- Newman, C. W., B. R. Moss and R. F. Eslick. 1975. Nutritional value of Hiproly barley for rats and pigs. *BN* 18:36-38.
- Newman, C. W., R. F. Eslick, B. R. Moss, and A. M. El-Negoumy. 1977. Hiproly barley as a source of protein and amino acids for growing finishing pigs. *Nutr. Rep. Internal.* 15:383.
- Newman, C. W., A. M. El-Negoumy and R. F. Eslick. 1978. Replacing soy protein with high-protein barley and amino acids. *J. Anim. Sci.* 46:161.
- Newman, C. W., R. F. Eslick, C. C. Calvert and A. M. El-Negoumy. 1978. Comparative nutritive value of Glacier and High Amylose Glacier barleys. *J. Anim. Sci.* 47:448.

- Newman, C. E., R. F. Eslick, G. J. Killen, J. E. T. Stobard, and S. E. Ullrich. 1979. Genetic and environmental effects on the nutritional quality of barley protein. Abstr. of paper presented at 10th North Amer. Barley Workers Conf. 1978 BN. 22:
- Rahman, M. M. and R. F. Eslick. 1975. Linkage of male sterile genes with seedling lethal genes. BGN 5:42-44.
- Rahman, M. M., and R. F. Eslick. 1976. Linkage of spontaneous mutant seedling lethal genes with genetic male sterile genes. BGN 6:53-58.
- Ramage, R. T., M. Paluska and R. F. Eslick. 1975. Cytological and breeding behavior of a large fragment of chromosome 6. BGN 5:51-53.
- Ramage, R. T. and R. F. Eslick. 1975. Translocation Linkage tests-T2-7a x male sterile genes. BGN 5:46-48.
- Ramage, R. T. and R. F. Eslick. 1976. Registration of Arimont Barley Germplasm. Crop Science 16:313-314.
- Ramage, R. T., R. K. Thompson, R. F. Eslick, D. M. Wesenberg, G. A. Wiebe, and J. C. Craddock. 1976. Registration of barley composite crosses XXX-A to G. Crop Science 16:314.
- Ries, M. N. and R. F. Eslick. 1976. Methods of evaluating genetic seed size differences in barley. Western Soc. Crop Sci. Abstracts PP. 12.
- Shaw, W. F., E. A. Hockett and M. J. Jackson. 1975. Malting barley production. Mont. State Univ. Bull. 1131:1-12.
- Smail, V. W. and R. F. Eslick. 1979. Pleiotropic effects of genetic differences in maturity in two and six row isotypes. Abstr. of paper presented at 10th North Amer. Barley Workers Conf. 1978 BN. 22:
- Sorum, Donald L. A Study Adapting Soft Wheat Evaluation Procedures to Barley. M.S. Thesis. Montana State University. Dec. 1977.
- Ullrich, W. E. and R. F. Eslick. 1976. Environmental response of the lysine gene associated with the shrunken endosperm mutant, seg1, of barley. Western Soc. Crop Sci. abst. pp. 13.
- Ullrich, S. E. and R. F. Eslick. 1977. Lysine and protein characterization of eight barley shrunken endosperm mutants. Agron. Abstr. p. 74.
- Ullrich, S. E. and R. F. Eslick. 1977. Inheritance of the shrunken endosperm character, sex3c, of Bomi Riso Mutant 1508 and its association with lysine content. BGN. 7:66-73.

- Ullrich, S. E. and R. F. Eslick. 1977. The establishment of barley high lysine male sterile facilitated recurrent selection populations. BN. 20:47-51.
- Ullrich, S. E. and R. F. Eslick. 1978. Protein and lysine characterization of spontaneous shrunken endosperm mutants of barley. Crop Sci. 18:809-812.
- Ullrich, S. E. and R. F. Eslick. 1978. Inheritance of the associated kernel characters--high lysine and shrunken endosperm-- of the barley mutant Bomi Risø 1508. Crop Sci. 18:828-831.
- Ullrich, S. E. and R. F. Eslick. 1978. Lysine and protein characterization of induced shrunken endosperm mutants of barley. Crop Sci. 18:963-966.
- Ullrich, S. E. and R. F. Eslick. 1978. Protein and lysine maternal inheritance effects in the high protein and high lysine barley mutant Hiproly. BGN. 8:108-109.
- Ullrich, S. E. and R. F. Eslick. 1978. Allelism evidence for barley high lysine shrunken endosperm xenia (sex) mutants. BGN. 8:109-112.
- Ullrich, S. E. and R. F. Eslick. 1978. Chromosome location for Risø induced high lysine shrunken endosperm mutants of barley. BGN. 8:114-125.
- Ullrich, S. E. and R. F. Eslick. 1978. Evidence for assigning the high amylose locus amol of Glacier barley to chromosome 2. BGN. 8:112-113.
- Ullrich, S. E. and R. F. Eslick. 1979. Effect of environment on protein and lysine content in 17 barley shrunken endosperm mutants. Abstr. of paper presented at 10th North Amer. Barley Workers Conf. 1978 BN. 22:
- Ullrich, S. E. and R. F. Eslick. 1977. High lysine, male sterile stocks of barley available. BGN. 7:120-121.
- Waters, R. F. 1975. Microbiological Assay of high lysine mutants in Hordeum sp. BN 18:40.
- Wiebe, G. A., R. T. Ramage and R. F. Eslick. 1974. Eight paired barley lines. BGN. 4:93-95.

Papers presented

- Barr, E. L. and L. E. Wiesner. Evaluation of Barley Cultivars for Gibberellic acid activity. American Society of Agronomy. Nov. 1976.
- Bockelman, H. E. Presented paper at American Society of Agronomy meeting, Los Angeles. A single gene transfer system for barley. Nov. 16, 1977.
- Brown, J. H. Presented paper on the influence of barley leaf color on photosynthesis, yield and water use at the North American Barley Research Workers Conference. Saskatoon, Saskatchewan. Aug. 16, 1978.
- Calvert, C. C., C. W. Newman, Robert Eslick and K. G. Goering. 1975. Waxy vs. normal barley in rat and pig diets. Proc. WS Am. Soc. Animal Sci. 26:108.
- Calvert, C. C., C. W. Newman, B. R. Moss, A. M. El-Negoumy and R. F. Eslick. 1976. High-amylose barley in rat and pig diets. Proc. WS Am. Soc. Animal Sci. 27:119.
- Carroll, T. W. Presented paper at American Phytopathological Society meeting, Davis, California. Electron microscopy of barley stripe mosaic virus in barley during anther and pollen development. June 17, 1975.
- Carroll, T. W. "Serodiagnosis of viral diseases in the field". For Extension Committee Discussion Session on New Techniques in Diagnosing Plant Diseases. Sixty-eighth Annual Meeting of the American Phytopathological Society, Kansas City, Missouri. 1976.
- Carter, L. P. Montana State University/AID BARley Research Program 4th Regional Winter Cereal Workshop-Barley. Amman, Jordan. April 25, 1977.
- Ferguson, Hayden. Possible characteristics of drought tolerant barley. Fourth Regional Winter Cereal Workshop-Barley, Amman, Jordan. April 1977.
- Ferguson, H. and Tom Fink. Drought Resistance - Varietal differentiation in barley. Western Regional Research Project, W-67. Riverside California. January 1977.
- Fink, Tom. Color as drought resistant trait. Western Society of Crop Science, Bozeman, Mt. July 1978.
- Killen, G. J., C. W. Newman, R. F. Eslick and A. M. El-Negoumy. 1978. The effect of nitrogen fertilizer on the nutritional quality of barley. Proc. West. Sec. Am. Soc. Anim. Sci. 29:169.
- McGuire, C. F. A pilot study using soft wheat evaluation procedures to evaluate barley flour. Sixth International Cereal & Bread Congress. Winnipeg. Sept. 16-22, 1978.

- McGuire, C. F. Microbiological Assay technique to screen barley populations for lysine. W-132 Committee Meeting. Riverside, CA. Nov. 19, 1977.
- Newman, C. W. and D. O. Elliott. 1975. L-lysine and DL-methionine supplements in barley-soy pig diets. Proc. WS Am. Soc. of Animal Sci. 26-105.
- Newman, C. W. Nutritional value of Hiproly barley for rats and pigs-- Presented at the American Barley Workers Conference, Milwaukee, Wisc., October 1974.
- Newman, C. W. The nutritional significance of varying combinations of amylose and amylopectin in barley--Presented at the American Barley Workers Conference, Milwaukee, Wisc., October 1974.
- Newman, C. W. Gene sources for high-lysine barley breeding --Presented at the Second Workshop on Breeding and Fortification of Cereals, September 1976, Boulder, Colo. In Improving the Nutrient Quality of Cereals II, Report of Second Workshop on Breeding and Fortification, US AID, Washington, D. C. 20523. Ed by H. L. Wilcke.
- Newman, C. W. Implications of barley breeding for food and feed quality-- Presented at the Fourth Regional Winter Cereal Workshop-- Barley, Amman, Jordan. April 1977. Sponsored by US AID, ICARDA, CYMMIT and the University of Jordan.
- Newman, C. W., R. F. Eslick, G. J. Killen, J. E. T. Stobart and S. E. Ullrich. Genetic and environmental effects on the nutritional quality of barley protein. Presented at the American Barley Workers Conference, Saskatoon, Saskatchewan, Canada, August 1978.
- Sharp, W. L. Presented paper on use of MSF RSP's for obtaining broad based resistance to barley diseases. Proceedings barley workshop, Amman, Jordan. April 1977.
- Sharp, E. L. Additive genetic resistance for barley and wheat diseases. May 31, 1978. In Summary of seminars delivered by Wheat and Barley Consultants. Wheat and Barley Research Institute. Suwon, S. Korea.
- Sharp, E. L. Stripe rust of wheat and barley. May 15-19, 1978. Invitational Cereals Conference sponsored by CIMMYT/CIDA and the Andean Region cereals team. Quito, Ecuador.
- Stobart, J. E., C. W. Newman, B. R. Moss, A. M. El-Negoumy and R. F. Eslick. Nutritional comparison of high-lysine barleys. J. Anim. Sci. Amer. Soc. Anim. Sci. 1977 Annual Meeting, Madison.
- Stutz, D. K., C. W. Newman, B. R. Moss, A. M. El-Negoumy and R. F. Eslick. A study of 2-row barleys selected for high-lysine. J. Animal Science 43:260. (abstr.).
- Wiesner, L. E. Evaluation of barley cultivars for rapid growth. Association of official seed analysts meeting. June 1976.

Out of Country Visits

- Carroll, T. W. Visits in the Middle East regarding improvement of the nutritive quality and productivity of barley. Feb. 25-Mar. 24, 1977.
- Carter, L. P. Planning meeting for the Fourth Regional Cereal Workshop on Barley being arranged for April of 1977. El Bataan, Mexico. CIMMYT. September 23-24, 1976.
- Carter, L. P. Amman, Jordan - April 24-28, 1977. Participated in barley workshop conducted at Amman, Jordan.
- Eslick, R. F. Amman, Jordan - April 24-28, 1977. Participated in barley workshop conducted at Amman, Jordan.
- Eslick, R. F. Cairo, Egypt - April 20-22, 1977. Visited barley growing areas and experiment stations doing barley work in Egypt.
- Eslick, R. F. Korea - May 15-29. Toured barley growing areas and visited experiment stations to evaluate Korean barley breeding program. 1977.
- Eslick, R. F. Suweon, Korea May 29-June 3. Participated in winter cereal improvement seminar sponsored by Food and Fertilizer Technology Center of the Asian and Pacific Council. 1977.
- Eslick, R. F. Korea. May 22-June 4. Member of task force reviewing production problems and barley breeding activities in Korea. Report prepared on observations and recommendations. 1978.
- Ferguson, A. H. Amman, Jordan - April 24-28, 1977. Participated in barley workshop conducted at Amman, Jordan.
- Ferguson, A. H. Barley growing areas of Jordan, Morocco, Syria, and Egypt. April and May of 1977.
- McGuire, Charles. Visit to CIMMYT, Mexico. To confer on microbiological assay of barley for lysine content. June 11-17, 1976.
- Newman, C. W. Amman, Jordan - April 24-28, 1977. Participated in barley workshop conducted at Amman, Jordan.
- Newman, C. W. Visit to CIMMYT, Mexico. To confer on microbiological assay of barley for lysine content. June 11-17, 1976.
- Sharp, E. L. Participated in barley workshop conducted at Amman, Jordan and surveyed barley growing areas in Morocco, Syria, Jordan and Egypt. April 24-28, 1977.
- Sharp, E. L. Cereals Conference with CIMMYT-CIDA. Quito, Ecuador, May 14-19. 1978.
- Sharp, E. L. Member of task force studying production problems of barley and wheat in Korea. Report prepared on observations and recommendations. Seminar on additive genes for resistance. Korea May 22- June 4, 1978.

Meetings Attended

- Brown, J. H. Attended the national American Society of Agronomy Meetings at Knoxville, Tennessee including a symposium on Measurements of Soil and Plant Water Status. Aug. 24-30, 1975.
- Brown, J. H. American Society of Agronomy National Meetings, Los Angeles, California. November 13-18, 1977.
- Bockelman, H. E. American Society of Agronomy meeting, Los Angeles, California. November 16, 1977.
- Carroll, T. W. Attended cereal virology workshop at Brookings, South Dakota, and presented a report on viral diseases of barley in Montana. December 16-17, 1975.
- Ferguson, A. H. and J. H. Brown consulted with CIMMYT staff and other barley workers from the USA, Canada and Australia at Ciudad De Obregon, Mexico about isogenic analysis, varietal adaptation, and water-use efficiency. March 25-28, 1976.
- Ferguson, A. H. and J. H. Brown consulted with faculty and observed plant materials and laboratory techniques at the University of Arizona, Tucson, Arizona relative to drought tolerance and genetic diversity for various traits in barley. March 29-30, 1976.
- McGuire, C. F. Sixth International Cereal and Bread Congress, Winnepeg, Manitoba, CANADA. September 16-22, 1978.
- McGuire, C. F. W-132 Regional Committee "Genotype - Environment Interactions Related to End-Product Uses in Small Grains", Tucson, Arizona. January 18, 1979.
- McGuire, C. F. American Society of Agronomy meeting, Los Angeles, Calif. November 14-17, 1977.
- McGuire, C. F. Western Society of Crop Science, Bozeman, MT. July 17-21, 1978.
- McGuire, C. F. W-132 Regional Committee "Genotype-Environment Interactions Related to End-Product Uses in Small Grains", Riverside, Calif. November 19, 1977.
- Sharp, E. L. Attended barley tour - Phoenix & Tucson, Arizona. April 21-25, 1978.
- Wiesner, L. E. Attended the American Society of Agronomy meeting in Houston, Texas. November 1976.

Visitors

- Beard, B. H. University of California, Davis, USDA. July 19, 1978.  
Discussed MSU-USAID barley project.
- Black, Clanton, University of Georgia. MSU-AID Project review team  
member. February 16-17, 1977.
- Boyd, W. J. R., Western Australia. Discussed barley breeding and  
pathology. June 11, 1976.
- Browning, J. A. Iowa State University. Discussed barley leaf diseases.  
May 12, 1976.
- Caraganal, A. R. Jr., San Miguel Corporation, Manila, Philippines.  
Discussed barley breeding with E. A. Hockett and R. F. Eslick.
- Carleton, A. E., Research Director, Montana Seeds, Conrad, Montana  
Discussed Barley breeding with R. F. Eslick and E. A. Hockett.  
1976.
- Carleton, Albert, Western Wheat Associates. July 1978. Discussed barley  
research.
- Chiarappa, L., U.N. FAO Chief Plant Pathologist, Rome. Visited and  
discussed barley diseases in the Middle East. March 31, 1976.
- Craddock, J. C., Crops Research Division, USDA. Beltsville, Maryland.  
Consulted on cooperative work on winter-spring determination  
on World Collection Barleys conducted at Bozeman.
- Duecker, Kurt C., Schreier Malting Co., Sheboygan, Wisconsin. Discussed  
barley breeding with R. F. Eslick and E. A. Hockett.
- Dutlu, C. Turkish Ministry of Agriculture. Aegian Regional Research  
Station, Izmir, Turkey. Discussed barley production and  
diseases in Turkey. October 18, 1976.
- Escuro, P. B., University of Philippines, Laguna, Philippines. Discussed  
barley breeding with E. A. Hockett and R. F. Eslick.
- Eyal, A. Tel Aviv University. Visiting Professor in Plant Pathology  
Dept., August, 1975 to June, 1976.
- Finlay, Keith. CIMMYT, Mexico. MSU-AID Project review team member.  
February 16-17, 1977.
- Frey, Kenneth. Iowa State University. MSU-AID Project review team  
member. February 16-17, 1977.
- Ghodbane, A. I.N.R.A.T., Ariana, Tunis, Tunisia. Discussed barley  
production and diseases in Tunisia.
- Ghodbane, A. Tunis, Tunisia. Discussed barley diseases. May 10, 1976.

- Gleason, L., Barley breeder, Cargill Inc., Ft. Collins, Colorado.  
Discussed barley breeding with R. F. Eslick and E. A. Hockett.
- Haus, T. E., Colorado State University, Ft. Collins, Colorado. Attended  
an Editorial Committee meeting of Barley Genetics Newsletter.
- Helms, J. H., University of Alberta, Edmonton, Alberta. Discussed  
barley breeding problems and diseases of common interest to  
Alberta and Montana. Nov. 14, 1975.
- Jarvi, A. J., Barley Breeder, Cargill Inc. Ft. Collins, Colorado.  
Discussed barley breeding with R. F. Eslick and E. A. Hockett.
- Klatzbuecker, R. A., Jos. Schlitz Brewing Company, Milwaukee, Wisconsin.  
Discussed barley breeding with R. F. Eslick and E. A. Hockett.
- Knowles, P. G. University of California, Davis. July 19, 1978.  
Discussed MSU-USAID barley project
- Lang, Earl. AID Washington D. C. MSU-AID Project review team member.  
February 16-17, 1977.
- Lee, Dr. Eun Sup (S. Korea) Wheat & Barley Research Institute.  
Discussed barley research.
- Matchett, R. W., Barley breeder, Northrup King and Co. Discussed  
barley breeding with R. F. Eslick and E. A. Hockett.
- McProud, W. L., Office of Rural Development, Seoul Korea. Discussed  
barley breeding with R. F. Eslick and E. A. Hockett.
- Moseman, J. G., Crops Research Division, SUDA, Beltsville, Maryland.  
Consulted on barley breeding and disease resistance work in  
progress.
- Knudsen, J. and L. Munk. Royal Agricultural University - Copenhagen.  
Study tour in Plant Pathology Dept. Sept. 1 - Dec. 1, 1976.
- Ramage, R. T., ARS, USDA, University of Arizona, Tucson, Arizona.  
Harvested summer barley crop and participated in various  
project connected activities.
- Reid, D. A., ARS, USDA, University of Arizona, Tucson, Arizona.  
Consulted on winter barley breeding.
- Rodriguez, Enrique. CIMMYT. Mexico. MSU-AID Project review team  
member. February 16-17, 1977.
- Rohwer, R. G., Grain Processing Corporation, Muscatine, Iowa. Discussed  
progress on work with barley starch processing and breeding  
with K. J. Goering and R. F. Eslick.
- Shaner, G., Purdue University Plant Pathologist. Visited and discussed  
leaf diseases of wheat and barley. April 10, 1976.

- Srivastava, J. P. (ICARDA). September 20-21, 1977. Discussed barley research.
- Thompson, R. K., Branch Experiment Station, University of Arizona, Mesa, Arizona. Harvested summer barley and wheat crop and participated in various project connected activities.
- Tsuchiya, T., Colorado State University, Ft. Collins, Colorado. Attended an Editorial Committee meeting of Barley Genetics Newsletter.
- Webster, R. K., University of California, Davis. July 19, 1978. Discussed barley diseases.
- Wooding, Frank. Extension Agronomist, University of Alaska. Discussed barley germination and establishment.
- Wright, Dr. Bill. Rockefeller Foundation, Turkey. Discussed barley and wheat research problems. September 14, 1976.
- Weinberger, Dr., In charge of the barley laboratory at the University of Wisconsin. Visited with A. M. El-Negoumy in May and discussed common work interests and the possibility of doing cooperative work together.
- Wood, V., Barley Breeder, North American Plant Breeders, Berthoud, Colorado. Discussed barley breeding with R. F. Eslick and E. A. Hockett.
- Yohe, Dr. John (AID - Washington D.C.) Review of old contract and of new proposal. Tour of laboratory and field plots. July 26-28, 1978.
- Zialcita, L. P., Jr., San Miguel Corporation, Manila, Philippines. Discussed barley breeding with E. A. Hockett and R. F. Eslick.

Appendix A:

FOURTH REGIONAL WINTER CEREAL WORKSHOP - BARLEY

AMMAN, JORDAN

APRIL 24 - 28, 1977

PROGRAM ABSTRACT

Sunday, April 24th

- 08.00 - 09.00 - Registration - Gymnasium
- 09.30 - 10.30 - Opening Session - Samir Raifai Auditorium
- 11.00 - 13.00 - Session 2
- 14.30 - 16.30 - Session 3
- 17.00 - 18.30 - Session 4
- 20.00 - Dinner at Mojamaa Al-Naqabat.

Monday, April 25th

- 08.30 - 13.00 - Session 5
- 14.30 - 18.30 - Session 6
- 20.00 - Dinner at the University Campus

Tuesday, April 26th

- 06.30 - 18.30 - Field Trip

Wednesday, April 27th

- 08.30 - 10.30 - Session 7
- 11.00 - 13.00 - Session 8
- 14.30 - 17.00 - Session 9
- 17.30 - 18.30 - Sunset Concert

Thursday, April 28th

- 08.30 - 10.30 - Session 10
- 11.00 - 13.00 - Closing Session.

FOURTH REGIONAL WINTER CEREAL WORKSHOP - BARLEY  
AMMAN, JORDAN  
APRIL 24 - 28, 19  
PROGRAM

<u>Sunday, April 24th</u>	Location - University of Jordan
08 00 - 09 00	Registration - Gymnasium
09 30 - 10 30	OPENING SESSION - Samir Raffai Auditorium Chairman - R D Havener Introduction - S Qasem Welcome Address and Conference Opening. His Excellency The Crown Prince Keynote Address - World Food Situation N. E Borlaug Vote of Thanks
10 30 - 11 00	C o f f e e B r e a k SESSION 2 - Gymnasium Chairman - R D Havener Reporters - M Duwayri R Gray
11 00 - 11 30	Status of Barley Improvement Around the World. R F Eslick
11 30 - 12 00	Barley Production, Utilization & Research In The Afro-Asian Region J. P. Srivastava
12 00 - 12 30	Status of Barley Improvement In The European Mediterranean Climate. J Comenge Ensenat
12 00 - 13 00	Barley Improvement In Australia and Its Potential Contribution to the Mediterranean Region. D H B Sparrow
13 00 - 14 30	L u n c h B r e a k

SESSION 3

Chairman - Z. Ghosheh

Reporters - L. Hachemi  
A. Klatt

- 14.30 - 15.00 The Agronomic Uniqueness of Barley.  
B. C. Wright
- 15.00 - 15.30 Agro-Climatological Environments and  
Barley Production.  
P. Bronzi
- 15.30 - 16.00 Farmers and Markets: Is Barley The Answer?  
D. Winkelmann
- 16.00 - 16.30 Factors Affecting Farmers' Adoption of New  
Production Technology.  
C. K. Mann
- 16.30 - 17.00 C o f f e e B r e a k

SESSION 4

Chairman - E. E. Saari

Reporters - E. Ghobrial  
R. Little

- 17.00 - 18.30 Brief Country Reports:
- |                |                      |
|----------------|----------------------|
| 1. Afghanistan | M. Osmanzai          |
| 2. Algeria     | L. Hachemi           |
| 3. Bangladesh  | A. Razzaque          |
| 4. Cyprus      | A. Hadjichristodoul. |
| 5. Egypt       | A. A. Mansour        |
| 6. Ethiopia    | H. Gebre             |
| 7. Greece      | E. A. Skorda         |
| 8. India       | M. Ram               |

- 20.00 Dinner - Hosted By The Ministry of Agriculture  
At Mojamaa Al-Naqabat.

Monday, April 25th

SESSION 5

Chairman - E. E. Saari

Reporters - M. H. El-Shater  
G. Varughese

08.00 - 10.30

Brief Country Reports (Cont'd)

- |                         |   |
|-------------------------|---|
| 1. Iran                 | B. Sadri                                    |
| 2. Iraq                 | S. Bekou/A. K. Al-Fakhry                    |
| 3. Jordan               | Z. Ghosheli and M. Duwayri                  |
| 4. Kenya                | M. W. Oggema                                |
| 5. Korea                | C. H. Cho and D. J. Maeng                   |
| 6. Lebanon              | A. Chaaban                                  |
| 7. Libyan Arab Republic | S. M. Sebai, M. R. Omar/<br>M. H. El-Shater |
| 8. Morocco              |   |
| 9. Nepal                | B. M. Mathema                               |
| 10. Pakistan            | M. Tahir/I. Hussein/<br>M. A. S. Kirmani    |
| 11. Portugal            | M. T. Barradas                              |

10.30 - 11.00

C o f f e e B r e a k

SESSION 5 (Cont'd)

11.00 - 13.00

- |  |                                   |
|--|-----------------------------------|
| 1. Saudi Arabia                              | M. S. Jowanna and I. Baghdadi     |
| 2. Somalia Dem. Republic                     | A. Guled                          |
| 3. Spain                                     | J. Comenge Ensenat.               |
| 4. Sri Lanka                                 | D. Murugesan                      |
| 5. Sudan                                     | A. G. I. Imam                     |
| 6. Sultanate of Oman'                        | M. H. Al-Tai and M. Akhtar        |
| 7. Syrian Arab Republic                      | W. El-Malek and<br>A. K. Koueidar |
| 8. Tunisia                                   | A. Daaloul and M. Djerbi          |
| 9. Turkey                                    | F. Demirkan                       |
| 10. Yemen Arab Republic                      | M. Mohamed El-Gouri               |
| 11. Peoples' Democratic<br>Republic of Yemen | S. Mohsin Atta                    |

13.00 - 14.30

L u n c h B r e a k

SESSION 6

Chairman - N. E. Borlaug

Reporters - M. W. Oggema  
G. McLean

International Barley Programs and Nursery  
Systems.

- 14.30 - 14.50 The Arab Center For The Studies of Arid Zones  
and Dry Lands (ACSAD).  
L. R. Morsi and J. A. Quhaiwi
- 14.50 - 15.10 International Maize and Wheat Improvement  
Center. (CIMMYT)  
R. G. Anderson
- 15.10 - 15.30 Food and Agricultural Organization of the  
United Nations. (FAO)  
Y. Y. Klaimi
- 15.30 - 15.50 The International Center For Agricultural  
Research In The Dry Areas. (ICARDA)  
H. S. Darling
- 15.50 - 16.10 Oregon State University, International Nursery  
Program.  
W. L. McCuistion
- 16.10 - 16.30 International Winter Wheat Performance Nursery.  
K. D. Wilhelmi and V. A. Johnson
- 16.30 - 17.00 C o f f e e B r e a k

SESSION 6 (Cont'd)

- 17.00 - 17.20 Montana State University/AID - Barley Research  
Program.  
L. P. Carter
- 17.20 - 17.50 Identifying and Cataloguing of Disease Resistant  
Barley Germplasm and The International Rust  
Nursery  
J. G. Moseman
- 17.50 - 18.10 The Svalof Barley Breeding Program.  
A. Hagberg
- 18.10 - 18.30 Off-Season Winter Cereal Nursery Facilities  
In Kenya.  
G. Kingma
- 20.00 Dinner - Hosted By The University of Jordan  
At The University Campus.

<u>Tuesday, April 26th</u>	Field Trip - Z. Ghosheh and M. Duwayri
06.30 - 18.30	Amman - Jarash - Ramtha - Irbid - Deir Allah - Dead Sea - Amman.
<u>Wednesday, April 27th</u>	SESSION 7
	Chairman - G. Hariri
	Reporters - I. Baghdadi R. Habgood
08.30 - 09.00	Obtaining Greater Progress in Barley Breeding. D. C. Rasmusson
09.00 - 09.30	Male Sterile Facilitated Recurrent Selection Advantages and Disadvantages. R. F. Eslick
09.30 - 10.00	Male Sterile Facilitated Recurrent Selection and Happy Homes. R. T. Ramage
10.00 - 10.30	Breeding For Wide Adaptability and Superior Agronomic Types. E. Rodriguez Campos
10.30 - 11.00	C o f f e e   B r e a k
	SESSION 8
	Chairman - A. K. Al-Fakhry
	Reporters - M. Akhtar A. Bozzini
11.00 - 11.30	Winter Barley Breeding and The Exploration of Spring x Winter Hybrids. G. Jenkins
11.30 - 12.00	Breeding For Short Duration Barley. E. I. Kivi
12.00 - 12.30	Implications of Barley Breeding For Food and Feed Quality C. W. Newman
12.30 - 13.00	The Potential of Utilizing Genes For Improved Quality in Barley For Food and Feed. L. Munck
13.00 - 14.30	L u n c h   B r e a k

SESSION 9

Chairman - F. Khoury

Reporters - M. R. Omar  
H. Nasr

14.30 - 15.00

Aspects of Improving Agronomic Practices to  
Maximise Barley Yields in the Region.

A. Hadjichristodoulou

15.00 - 15.30

Possible Characteristics of Drought Tolerant  
Barley.

H. Ferguson

15.30 - 16.00

Weed Control In Wheat and Barley in The Middle  
East.

A. R. Saghir

Cultural and Weed Control Practices for Barley  
Production in North Africa.

W. L. Nelson

16.00 - 16.30

Barley in The Ley Farming System.

J. B. Doolittle

Effect of Clipping on Forage, Hay and Grain  
Production from Barley, Wheat and Triticale.

E. A. Skorda

16.30 - 17.00

Seed Quality and Production - A Vital Link To  
National Barley Production Programs.

J. E. Douglas

17.00 - 17.30

C o f f e e B r e a k

17.30 - 18.30

Sunset Concert - The Royal Jordanian Army  
Band.

Thursday, April 28th

SESSION 10

Chairman - N. Kadra

Reporters - R. M. Djerbi  
A. H. Kamel

08.30 - 09.00

Barley Diseases in the Near East.

T. A. Hak and E. Ghobeial

09.00 - 09.30

Barley Diseases and Their Surveillance  
in The Region.

J. M. Prescott and E. E. Saari

- 09.30 - 10.00 Utilizing Recurrent Selection Populations  
For Disease Resistance in Barley.  
E. L. Sharp and H. E. Bockelman
- 10.00 - 10.30 USDA Barley Germplasm Collection Program -  
Classification and Availability to the National  
Programs.  
J. G. Moseman and J. C. Craddock
- 10.30 - 11.00 C o f f e e B r e a k
- 11.00 - 13.00 SESSION 11  
Chairman - O. L. Brough  
Reporters - S. A. Qureshi  
W. L. McCuisition
- 11.00 - 13.00 1. Sub-Committee Reports:
- a) Crop Improvement.  
J. M. Poehlman
  - b) Cultural Practices.  
R. J. Nilan
  - c) Plant Protection.  
E. E. Saari
  - d) International and Regional Nurseries.  
J. P. Srivastava
  - e) Economic Policies, Seed Production  
and Transfer of Technology.  
S. Barghouti
  - f) General Conclusions of the Workshop.  
R. G. Anderson
2. Closing Remarks.  
S. Qasem
3. Appreciation.  
L. P. Carter