ISN-30899

PD-AAN-034

RESEARCH PROJECT STATEMENT

CONTROL OF BARLEY DISEASES FOR THE LESSER DEVELOPED COUNTRIES OF THE WORLD

PROJECT NUMBER: 931-1318.11 /49

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RESEARCH PROJECT STATEMENT

I. PROJECT SUMMARY

Project Title	Control of Barley Diseases for the Lesser Developed Countries of the World
New or Extension:	Extension
Contractor:	Montana State University
Principal Investigator:	Dr. Eugene L. Sharp
Duration:	August 1, 1981 - July 31, 1984
Total Estimated Cost:	$859,179
Funding by Fiscal Years:	FY 1981 - 1982 $275,872 FY 1982 - 1983 $269,151 FY 1983 - 1984 $314,156
Project Manager:	Dr. Robert I. Jackson
Prior Funding:	Funding from August 1, 1978 - May 31, 1981 - $724,000

SUMMARY NARRATIVE STATEMENT

The basic goal of this project is to improve the control of barley diseases for the lesser develcped countries (LDCs) with particular emphasis on the semi-arid areas of the world. Wherever possible and feasible, this will be done by accumulation of resistance genes into acceptable barley stocks. After the various different sources of resistance have been determined, crosses will be made to incorporate these resistance genes into a base of widely adapted but diverse barley germplasm includeing both 2 row and 6 row types. The barley male steriles will be utilized to facilitate various crossings for pyramiding genes for resistance and to establish recurrent selection populations (RSPs) for the various diseases. Evaluations will be made on both seedlings and mature plants (field) and, in both cases, the barley stocks will be exposed to a wide range of virulences. Selections of the most resistant and agronomically acceptable barley types will be repeated in several cycles of recombination. Separate RSPs for the various diseases will be established where selections will be made for both major and minor effect genes. When resistance is adequately established for specific diseases, combinations will be made to combine resistances to 2 or more diseases. This project should lead to broad based resistances to major diseases of barley which will be effective in the barley growing areas of the world.

Barley diseases are often the most limiting factor in barley production. The research proposal in this project is intended to augment and assist the efforts of CIMMYT and ICARDA as well as LDCs' regional and country programs. Emphasis will be on improving the control of barley diseases for the semi-arid areas of the world but the findings should be applicable to all barley growing areas. Additional cooperative nurseries may be established in Asia as desired and future potential areas for inclusion would be the countries of Peru and Brazil in South America.

This project has been developed through working level coordination with CIMMYT and ICARDA. The diseases listed for study are important throughout most of the barley growing areas of the world. The approach of producing resistant stocks rather than varieties is geared to enable CIMMYT and ICARDA to utilize the superior material in their barley breeding programs. The methodical assembling and pyramiding of major and minor genes for resistance cannot be done easily at CIMMYT or ICARDA but fits well into the developed expertise of the barley program at Montana State University thus resulting in a very desirable and worthwhile relationship.

During the past two years, considerable progress has been made in development of barley stocks with broad-based resistance to specific diseases. Emphasis has been placed on barley scald and net blotch caused by *Rhynchosporium secalis* and *Pyrenophora teres*, respectively. Resistant stocks are also being developed via RSP's for leaf rust caused by *Puccinia hordei*, bacterial streak caused by *Xanthomonas translucens*, and barley yellow dwarf virus (BYDV). Leaf rust has received major input during the past year. Basic preliminary work has involved such diseases as root rots and powdery mildew. Good working relationships not only have been established with representatives of ICARDA and CIMMYT, but also with various scientists stationed in target areas of the LDC's. Furthermore, the training program has been attractive and the number of applicants has exceeded financial and space limitations.

II. Background and Accomplishments:

A. General information

Determination of and utilization of resistance to specific diseases of barley was formerly a part of an overall project on improving barley for the semi-arid areas of the world which also included nutrition and drought studies. During the past two years the main thrust has been disease resistance with associated plant breeding. The major diseases of North Africa and the Middle East have been identified and specific nursery sites have been located where a high probability for natural infections exists. Many isolates of fungal and bacteria pathogens and a few isolates of barley stripe mosaic virus have been collected from the target areas and these have served to give information on the virulence pool and at the same time have been used for determining different sources of resistance. Since barley yellow dwarf virus (BYDV) does not lend itsself readily to such type of isolation, there is little known about its virulence pool. Diagnostic antisera is required for the determination of virulence pools of this virus.

Potential resistance sources were evaluated from the world collections of barley and from literature reports on resistant sources. Reportedly elite resistant barley lines, catalogued and stored by SEA-USDA were also evaluated. As the project developed, a broader sample of the virulence pool for specific diseases was accumulated and further sources of resistance were evaluated.

The basic breeding method used was recurrent selection facilitated by male sterility. A base population of barley was established using barley lines of diverse origin but of wide adaptation. In case of the six row barley population for scald resistance, for example, 14 barley cultivars were crossed on to a male sterile line and equal amounts of seed for each cross constituted the base population (Table 5). As new and different resistant sources were identified these were crossed into the population. Each cycle consisted of selection in disease nurseries for resistant types, followed by a recombination nursery where seed was harvested only from the male sterile plants thus assuring recombination and pyramiding of disease resistance genes. Two generations were obtained each year by growing the selection nurseries at a number of locations and the recombination nurseries in Arizona. The populations contained about 25% male sterile plants so there was no problem in obtaining plentiful seed and tedious hand-crossing was not required. By recycling only those resistant plants in the recurrent selection populations (RSP's) broad-based resistant barley stocks are developed. Resistant seed for these populations is derived each year from RSP nurseries both in the USA and from several RSP nurseries overseas. The resistances incorporated should thus be broad-based. The base varieties for 2-row barley RSP's are shown in Table 6.

In the case of RSP's with minor gene resistance, the method is similar except the base population contains only susceptible or near susceptible entries. Thus recombinations showing transgressive segregation for resistance can be readily identified. It is also believed that this type of resistance should be of greater duration.

B. Specific diseases

The status for each of the major diseases being investigated is described below. The resistant sources crossed into the various RSP's for specific barley diseases are shown in Tables 7-13.

Scald - caused by *Rhynchosporium secalis*.

A number of races of *R. secalis* are known and several resistance genes (Rh genes) have also been described and some have been located on specific chromosomes (Shipton et al. 1974, Jackson and Webster 1976, and Bockelman et al. 1977). A 6 row RSP for scald resistance was first established in 1975 and is the most advanced. Four complete cycles of recurrent selection have been completed and many sources of resistance have been incorporated (Table 7) and the population presently consists of components selected at twelve locations around the world.

Two row populations with major gene resistance to scald and for minor gene resistance are in the second cycle.

Net Blotch - caused by *Pyrenophora teres*

In examination of more than 50 isolates of *P. teres* using 12 or 15 barley cultivars as host differentials, nine virulence types were recognized, (Bjarko M.S. thesis 1979). Isolates from Montana formed four virulence groups and those from the Middle East, five (Tables 14 and 15). Evaluation of more than 170 barley cultivars from the USDA world collection and reported resistant sources, revealed nine barley lines which were resistant to all nine virulence groups (Table 16). Genetic analysis showed that several barley lines contained more than one gene for resistance (Table 17). At least 6 different genes conditioning reaction to net blotch were indicated in these studies.

Particularly interesting were some studies in which susceptible barley plants were crossed with each other and some resistant progeny appeared in the F_2 (Table 18). This strengthens our belief that minor gene resistance can be obtained by recombination within a base population containing only susceptible plants.

The various different net blotch resistant sources identified in this study are being crossed into the base recurrent selection population for net blotch to broaden the resistance base. The six-row major gene RSP has undergone three cycles of selection and also contains components (seed from resistant plants) selected at eleven locations around the world. Under conditions of natural infection in Montana 95% of the plants in this population are resistant to *P. teres*. A greater percentage of plants was susceptible in a nursery grown at Woodland, California under severe infection conditions. A two row barley major gene RSP has completed one cycle of selection and minor gene RSP's are currently being assembled using basic information obtained in greenhouse and field studies.

Leaf Rust - caused by Puccinia hordei

The leaf rust organism Puccinia hordei together with scald Rhynchosporium secalis and net blotch Pyrenophora terres is considered a major disease of barley in the Mediterranean area and has received major attention this past year in the barley project. A number of barley varieties or lines reportedly contain one or more resistance genes for leaf rust. The genes Pa - Pa_9 have been described. The Pa_3 gene in Aim and Estate as well as the Pa_7 gene in Cebada Capa and several other varieties are considered to be the most effective resistance sources. However virulence against Pa_3 and Pa_7 has been reported from Great Britain and Israel, respectively (Clifford and Udeogalanga, 1976: Golan et al., 1978). Over the past few years researchers from Montana State University collected leaf rust samples representing different virulence types at many sites in the Mediterranean area. Some 120 barley varieties or lines which have been reported to express a certain degree of resistance at some time or place were evaluated against 8 isolates out of the Mediterranean collection as well as against two isolates from widely separated locations in Montana. Several good sources of resistance against Puccinia hordei not identical with the known Pa genes were collected. Two of the most promising lines Ford 1203 (resistant to 8/10 isolates and CCIM-13 (resistant to 9/10) interestingly were selected in a field nursery at Sakha (Egypt) under very heavy infection pressure. Only 23/7000 lines showed some degree of resistance under those conditions. The barley line 386-16-2 reacted similar to all varieties containing the genes Pa_3 or Pa_7 and was resistant to all isolates. Differences in the infection types however, indicate a different genotype - (Table 19, Reinhold and Sharp, 1980).

A six row major gene RSP for leaf rust resistance is in the second cycle and newly discovered resistance sources are being crossed into the population. A two row RSP for major gene resistance has been established and will be selected for resistance in the near future. Resistance sources already incorporated for resistance to leaf rust are given in Tables 11 and 12.

Bacterial Streak - caused by Xanthomonas translucens

Fundamental work with this disease shows that there are a number of sources of resistance within barley and that different biotypes or races of the organism are present. It can become a major disease problem of barley following extended moist periods. In the Middle East it was most prevalent in nurseries at Izmir, Turkey and Allepo, Syria. It occurs regularly in Mexico and is probably present throughout many areas of South America. It is also widespread throughout Montana and has been a dominant disease in some areas of Arizona.

A major gene RSP in 6 row barley has been selected for 2 cycles and shows some plants with moderate levels of resistance.

Virus diseases of Barley

Barley yellow dwarf and barley stripe mosaic.

Investigations on virus diseases of barley have involved methods of detection, improvement of serodiagnosis techniques evaluation of barley lines tolerant to BYDV, development of a barley type resistant to the seed transmission of BSMV, and selection within composite cross populations.

Materials and assistance for the use of serodiagnosis for detection of BSMV have been furnished to scientists in Tunisia and Lebanon.

Composite crosses XXXIII A and XXXIII B developed by Dr. Rex Thompson, Arizona for BYDV tolerance were evaluated at Bozeman, MT. and Pullman, WA. using artificial inoculation with a given strain of the virus and a known aphid vector species. At Pullman 40-50% of the plants were rogued and at Bozeman 10-20% of the plants exhibited symptoms. Seed derived from these tests were bulked and sent to Mexico, Morocco, and Syria for further evaluation to prevalent strains of BYDV. These composite cross populations in addition to the yd2 gene for tolerance to BYDV contain components for short stiff straw and rapid early growth. They also contain male sterile genes msg1 and msg2.

The crossing block nurseries from ICARDA and CIMMYT have been evaluated each year for seedborne barley stripe mosaic virus. Additionally, several selections of Betzes X Modjo barley have also been found to contain resistance to seed transmission of BSMV. Seed from these selections is being increased and will be available for interested parties next year.

Other diseases of barley

The diseases discussed to this point have received major emphasis in this investigation. Considerable basic information has been obtained and this is being applied in resource or RSP development. Other diseases are being considered but the input has been somewhat less and further basic information is required before they can be completely utilized. Also, due to space and personnel limitations it has not been possible or desirable to consider all possible disease problems of barley. Since diseases are dynamic, the ones considered as less important at one time may later become the most dominant. It is thus important that all diseases be considered in these terms.

Investigations with powdery mildew caused by *Erysiphe graminis* has involved basic methods for increasing inoculum, uniform inoculations and methods of preservation. Composite cross populations are now being

inoculated to determine the extent of resistance to various cultures that existed in parents and early generations after the composite was made.

Three experimental chemicals were tested for control of Helminthosporium stripe (H. gramineum) in field plots. These were compared with registered chemicals, Vitavax 200 and Nusan 30 as well as the former standard, Ceresan. Only one of the experimental materials, Sisthane, appears to have promise of efficacy, but at rates used, it is also somewhat phytotoxic. Stand counts and symptomatology will be supplemented by yield data to be collected later in the year.

Juglone, an antibiotic derived from walnut, also evaluated, was phytotoxic and resulted in more infection in treated plots than in the non-treated, infected control. Experiments are presently being done with a strain of Pseudomonas syringae that has been shown to produce a product that is toxic to H. gramineum in culture. The bacterial culture and a cell-free filtrate of the culture both reduce seedling emergence significantly, but whether surviving plants are disease free is not yet known.

In Morocco, a survey in 1975 conducted by Mr. M. Boulif showed that 50% of the inspected fields had from 1 to 20% stripe-infected plants. In 1977 Rolli (personal communication) inspected 177 commercial fields around Morocco and found stripe infections from a minimum of 0.4% to a maximum of 26%, with an overall average of 2%. Field studies involving fungicidal seed treatments of 8 varieties showed that yield losses from natural infection may be as high as 55%. Components of yield affected were number of tillers per unit field area, and numbers of kernels per spike.

Basic information is being obtained on the root rot diseases of barley. Identification of the pathogens involved in root rot, effects of root rots on yield components in barley and development of a method for screening and scoring plants for relative resistance have been investigated. Preliminary findings indicate three fungi are incitants of root rot in North Africa - Fusarium culmorm, Fusarium gramineum and Helminthosporium sativum. In naturally infested fields in Montana losses from 10-20% were obtained following inoculation with Fusa.. The main effects were reduced tillering with some reduction in seed weight. Among the various inoculation methods evaluated, the best inoculum source for the two Fusaria was macroconidia added to the seed, while for H. sativum infested oat kernels produced the most disease.

C. Summary of accomplishments

1. Release of recurrent selection populations with a high percentage of broad-based resistance to net blotch and scald of barley - available to any interested party.

2. Improved barley lines developed for resistance to specific diseases supplied as germ plasm to cooperators in several LDC's.

3. Plant pathology graduate under barley project at Montana State University employed by ICARDA at Aleppo to establish a Plant Pathology laboratory and assist the barley breeder in development of better barley.

4. Three MSU plant pathology faculty (T. W. Carroll, A. L. Scharen, E. L. Sharp) invited participants to a brainstorming session on control of diseases of barley and wheat funded and sponsored by ICARDA in London.

5. E. L. Sharp was invited to a regional cereal conference with emphasis on yellow rust and yellow dwarf virus of barley. This was funded and sponsored by CIMMYT, INIAP, CIDA at Quito, Ecuador.

6. T. W. Carroll was invited to a special work shop on barley yellow dwarf funded and sponsored by CIMMYT at Mexico City, Mexico.

7. Production of tolerant selections of barley to BYDV in the field. Seed available to anyone on request and supplied to several cooperators.

8. Two composite crosses of barley containing tolerance to BYDV received from Rex Thompson, Mesa, Arizona reevaluated and reselected at two locations and sent to ICARDA, CIMMYT and Morocco for further use in breeding programs.

9. Materials and methods for laboratory diagnosis of barley stripe mosaic virus were supplied to several LDC's including cooperators in Syria, Tunisia, Lebanon and South Korea.

10. Advised and furnished information on controlled environment equipment for selecting for disease resistances in seedling plants.

III. Research Purpose and Objectives:

A. Purpose:

To decrease losses caused by the major diseases of barley, particularly in the developing countries of semi-arid areas.

B. Objectives of the proposed program:

1. Different sources of resistance and different virulence types involving the major diseases of barley will be determined.

2. Barley populations, both 2 row and 6 row, with broad based major gene resistance and minor gene resistance to specific diseases will be developed.

3. Special populations with specific agronomic traits combined with disease resistance will be selected.

4. Resistances to different specific diseases will be combined into barley stocks.

5. Assistance will be given to ICARDA and CIMMYT in evaluation of their elite barley lines for specific disease resistances.

6. Utilize and advocate other control measures such as cultural practices and chemical seed treatments where appropriate.

IV. Significance and Rationale for the Research:

A. The development problem:

Barley is grown in many lesser developed countries (LDCs) in particular in areas with an extremely short growing season or inadequate rainfall for other cereal crops. Barley grown in these countries (the million hectares(Table 1 and Table 2). Diseases are often the most limiting factors in barley production. The losses incurred through both reduced quantity and quality are particularly important in the LDCs since the average yield compared with other barley growing areas is considerably lower (table 3). Furthermore barley often constitutes the main crop that can be grown in the drier areas and therefore is one of the main staples for feed and food in these countries. The amount of barley used as human food varied from less than 5% to 100% and averaged about 40% (Table 4).

Yield reductions resulting from diseases are often not obvious because the symptoms may be readily apparent only during specific growth stages or even lacking. For the period from 1951-1960, it has been estimated that diseases of barley caused losses equal to 13.5% of

the total barley production (from Barley: Botany, Culture, Winterhardiness, Genetics, Utilization, Pests 1979. Ag. Handbook #338, SEA, USDA). Among 25 countries from the Middle East and Far East reporting on barley at the recent Barley Workshop in Amman, Jordan (April 1977) the Helminthosporium diseases, rusts, smuts, scald and powdery mildew were in the forefront as the most important diseases recognized throughout this area. More recent surveys indicate that barley yellow dwarf virus and bacterial streak can also be important.

It is difficult to obtain quantitative data on the amount of loss in barley attributable to specific diseases because of lack of detailed research in this regard. It is generally conceded that the losses from plant diseases are greater in the LDC's than in the more developed countries and may be devastating in some cases. Srivastava (1977) has pointed out that very few of the LDC's have independent programs on barley. Most of the work with barley is included along with a more rigorous program on wheat and there is therefore a serious gap in discovery and application of principles and methods for improving barley production. The approaches proposed in this project should help to alleviate this situation and furnish the inputs for viable national programs. Implementation will be facilitated as more scientists from the LDC's become available.

Even though quantitative information on losses caused by specific diseases of barley is largely lacking for the LDC's, extrapolation can be made from findings for other areas. Net Blotch, caused by H. teres, for example may result in losses as high as 30% as found by Piening and Kaufman (1969) in western Canada. The greatest losses were also noted under low fertility and other stress conditions. In the virus diseases, barley stripe mosaic virus (BSMV) and barley yellow dwarf virus (BYDV) infection levels of 10% e.g. may result in 3-5% loss in yield and losses as high as 50% may occur. BYDV, depending on strain, barley cultivar, stage of plant development at time of infection, may cause severe losses (>50% yield red.). In diseases such as the smuts and Helminthosporium stripe there is generally a one for one relationship between percent infection and percent yield loss. The amount of loss for many diseases may be influenced by many factors such as initial onset. In the rusts early infection may result in devastating losses but a high severity of infection first developing after the soft dough stage may be of minor consequence.

In the past few years, investigators Sharp, Carroll, Eslick, Sands and Scharen, as well as SEA, USDA cooperator Hockett have had the opportunity to visit the Middle East area and survey some of the major barley growing areas. They found that barley diseases were widely prevalent and that they received little, if any attention by the local barley breeders. A better appraisal of the problems with barley in the Middle East has been made through disease surveys and collections, contacts with people working with barley during the workshop and tours held in Jordan and Syria in April, 1977 and especially in annual evaluations of nurseries in the Middle East. This has resulted in a much better idea where barley disease nurseries for specific diseases should be located to achieve suitable natural infection. This is leading to a better sampling of the virulence pool for the specific

diseases and in turn should lead to development of broad based resistances in the barley stock populations.

Virus diseases such as barley stripe mosaic and barley yellow dwarf (BYDV) have received very little attention in the Middle East to date. Visits in the area revealed that these diseases, particularly BYDV, often limited barley production to a significant degree. Moreover, recent observations by Dubin (CIMMYT-Personal Communication) in South America strongly suggest that barley yellow dwarf virus is a very serious disease on that continent and a special CIMMYT sponsored workshop on this disease was conducted in Mexico this past year.

Contacts with scientists representing the various international organizations concerned with barley improvement also have been most enlightening. It has become quite clear that Montana pathologists involved in the AID program for improving barley will be expected to take an active role in the disease ratings and selections within the various nurseries in the LDC's. This aspect is reflected in the travel portion of the budget.

There has been much interest and several inquiries from foreign students regarding the possibility of receiving training with barley diseases at MSU. This category of agricultural scientist is in short supply and participants can fill definite niches in barley improvement programs in the developing countries. A continuing budget for training is thus proposed.

B. State-of-the-art

The diseases of barley are pretty much the same all over the world although the incidence of any one specific disease may vary in time and space depending largely on local environmental conditions. The three Helminthosporium species attacking barley, for example, are world-wide in distribution and have been noted all over the globe, as important diseases on this crop. Wherever barley is grown, scald, smuts and rusts are also widely distributed although the races or strains may vary at different locations. Sources of resistance have been detected at a number of locations but usually these resistances are not broad-based and their relationships to other resistance sources are generally unknown. Furthermore, the resistant cultivars are often unsuitable for direct utilization because of other poor agronomic traits. There has not been a concerted effort, particularly in the LDC's, to combine different sources of resistance to give broad-based resistances in suitable barley stocks. As stated by personnel at CIMMYT, they have been using all resistant material available, but much more is needed, particularly material that has been checked for resistance and integrated with other genes into a usable genetic background. CIMMYT is not in a position to methodically identify, assemble and pyramid major and minor genes for resistance to barley diseases. The proposed program should greatly aid CIMMYT, ICARDA and other international organizations in their programs for barley improvement in their outreach programs but it certainly does not involve a duplication of effort.

Once a number of resistance sources have been identified as being different the problem becomes one of combining these sources of resistance by an effective method into usable barley stocks.

Over the years composite crosses within barley have been used along with natural selection to combine favorable genes to advance superior barley (Harlan & Martini, 1929). Somewhat more recently, a series of "bridge-crosses" consisting of crossing F1's was utilized to further combine germplasm from desirable types. Establishment of this type of composite cross without male sterility in the population was very time consuming, required several generations and limited the number of recombinants. Suneson (1940) first described male sterility in barley-msg 1. Subsequently, some 28 separate loci for male sterility have been identified and many have been assigned to chromosomes (Hockett et. al. 1968).

Suneson (1956) described the use of composite crosses and implied that natural selection should be relied upon for development of superior barley types. In 1963 he summarized his work and advocated that development of barley resource materials should be emphasized. The assumption was made that yields of composite crosses would increase over a period of time due to accumulation of disease resistance and other desirable genes. However, Eslick (personal communication), monitored composite crosses grown under dryland conditions in Montana for as long as 30 consecutive generations and yield increases during this period were essentially nil. Perhaps yield increases with natural selection can only be realized in some environments or when natural selection is effective for certain traits.

It would thus appear more fruitful not to rely alone on natural selection but to make the maximum use of male sterility in facilitating and directing recurrent selection populations of barley. Forced out-crossing using male sterility should result in a great amount of genetic diversity and with continued crossing result in the breakup of long established linkage blocks. Although the frequency of good recombinants may initially be low, this can be directed in a more favorable outcome by limiting the number or kinds of parents entered into the population. Parents can be chosen, both from the standpoint of resistances to diseases and diverse but wide adaptation. At the same time undesirable types can be rogued from the population and the better genotypes can be recycled for further selection and improvement. From the disease standpoint, it is important that the barley RSP's be challenged by a wide range of virulences for specific pathogens. The proposed research is basically designed to do just this and more details are presented in the following sections.

It is interesting that a similar approach is being utilized by Singh (1977) for development of cold tolerant sorghum cultivars with early maturity and short stature and by Fujimaki (1979) for rice improvement.

V. Cooperation to Facilitate Utilization of Research

A. CIMMYT:

There is close cooperation with CIMMYT in developing barley stocks with broad-based resistance to specific diseases. Stocks developed at MSU have will be channeled into their program and will be used in their crossing blocks. At the same time parents from their crossing block will be evaluated to MSU's specific cultures of barley disease organisms. The results of these tests should indicate which cultivars have best potential for resistance to specific diseases. CIMMYT elite advanced barley lines will also be evaluated to the various major diseases of barley. Advise and assistance will also be given to CIMMYT personnel on serodiagnosis for detection of seedborne BSMV in their var'ous barley stocks.

B. Similar to the cooperation with CIMMYT barley crossing block parents and advanced lines coming from ICARDA will continue to be evaluated to a wide array of virulence types within the major diseases. Barley stockds with broad based disease resistance will also be shunted into their program as developed. Recurrent selection populations for specific disease resistance to diseases will be grown at Aleppo, Syria and at other locations within the area of ICARDA's responsibility and key personnel on the Montana AID project will assist in the disease readings and selections within these key parley populations. It is anticipated that trainees and graduate students associated with the ICARDA program will receive training at Montana State University related to cooperative barley programs.

VI. Contractor Internal Management and Facilities:

A. Local research organizations involved

1. Dept. of Plant Pathology
   Montana State University
   Bozeman, Montana 59717

   Principal Investigator: Dr. Eugene L. Sharp

   Key Project Personnel: Dr. Thomas W. Carroll
   Dr. Donald E. Mathre
   Dr. David C. Sands
   Dr. Albert L. Scharen

2. Dept. of Plant & Soil Sciences

   Department Head: Dr. A. H. Ferguson

   Key Project Personnel: Professor R. F. Eslick

   Key Project Cooperator: Dr. E. A. Hockett
   SEA, USDA Barley breeder Geneticist

3. Montana Agricultural Experiment Station

   Dean & Director: Dr. Johan A. Asleson

4. Research Centers - Montana

   Agricultural Experiment Station
   Eastern Montana Research Center
   Sidney, Montana
   Director: Mr. Jerry Bergman

5. Grants and Contracts Office
   Montana State University - Bozeman

   Director: Dr. J. W. Jutilla

B. Available facilities:

Facilities for the proposed investigation include several controlled environment chambers, dew chambers, inoculation towers, isolation greenhouses, lyophilization apparatus and standard laboratory facilities for virus, bacterial and fungal cultural studies. Adequate space for local field plot work is available at the Agricultural Experiment Station field research farm located a few kilometers from the campus.

VII. Proposed Design and Methods for Further Investigations.

A. General methods

The basic method utilized for developing broad-based resistance to the major diseases of barley has been and will continue to be recurrent selection facilitated by male sterility. The basic steps were outlined in section E and will not be reiterated.

B. Design for specific barley diseases.

Scald - caused by *Rhynchosporium secalis*

As new virulence types are identified they will be used for determining new sources of resistance. New sources of resistance will be crossed into the RSP's as soon as possible. Disease nurseries will be continued in areas with a high probability of natural infection thus allowing selection for resistant types and pyramiding of genes for resistance. The 6 row barley RSP with major gene resistance to scald will be combined with a similar population having major resistance to net blotch. The six-row major gene RSP is being registered as Composite Cross XXXVI by the Crop Science Society of America and is available for all interested parties.

Net Blotch caused by *Pyrenophora teres*

As with the populations for scald resistance, new sources of resistance will be added as identified. The 6-row major gene population will be combined with its counterpart scald resistant population. Scald and net blotch resistance are the furthest advanced in our study and many resistant types are present in good agronomic backgrounds. Several of the target countries have selected individual plants from these populations for further evaluations. Additional work will concentrate on accumulating minor genes for suitable plant protection.

Leaf Rust - caused by *Puccinia hordei*

During the past year a number of promising sources for leaf rust resistance have been identified using many isolates from the Mediterranean area and Montana. These resistance sources will be crossed into the RSP's to broaden the resistance base. Additional isolates have been collected and these will be evaluated on the reported resistance sources to determine the efficacy of the resistance genes. Finally there is increasing evidence that many barley lines escape damage from leaf rust by being slow-rusters. These plants develop a high infection type but the latent period is longer thus slowing epidemic development and reducing losses. These slow-rusting types will be crossed into RSP's to develop a slow-rusting population. Slow rusting is polygenic in nature and should effectively constitute minor gene or additive gene protection against disease losses. Some of the slow-rusters appear to be non-specific in reaction so should furnish long lasting resistance to leaf rust.

Bacterial Streak - caused by Xanthomonas translucens

Further trials are required on recombination and selection for disease resistance. This will be implemented by placing the populations where the disease is worst. This includes present plot locations in 1980 in Izmir, Turkey; Saltello, Mexico; Fairfield, Bozeman and Sidney, Montana. Future additional locations should include certain sites in Syria and in Mexico. The possibility of placing RSP's in South America is being investigated.

Barley yellow dwarf and barley stripe mosaic virus.

Development and improvement of serodiagnostic techniques for detecting BYDV and BSMV will continue. These techniques will be used to assist concerned people in regional, national or international organizations for years to come. ICARDA and CIMMYT crossing block nurseries will continually be evaluated for the presence of BSMV and the effect of various levels of BYDV infection on grain yield will be determined. Work will also continue on the identification of virus strains. Knowing what virus strains occur in the LDC's permits one to develop a control strategy based on virulence pool information.

The Betzes x Modjo selections resistant to the seed transmission of BSMV will be registered in Crop Science and desirable lines will be increased and seed will be made available to interested parties. The male sterile facilitated RSP's for tolerance to BYDV will be grown in several locations for high probability for natural infection and tolerant or resistant types (BYDV) will be selected and recombined for broader plant protection. The yd2 major gene for resistance in a proper genetic background has generally given adequate protection against BYDV.

Other barley diseases

Several other diseases of barley are being considered but on a less intensive scale and more fundamental information is required before application in RSP's is possible.

In regard to Helminthosporium stripe caused by Helminthosporium gramineum more efficaceous but low mammalian-toxic seed treatments will be sought, efforts will continue to develop a more efficient screening technique for resistance, virulence types from various parts of the world will be determined and effective sources of resistance, once determined will be advanced for variety development.

Powdery mildew resistance in composite cross populations will be evaluated to determine the extent of resistance to various cultures that existed in parents and in the early intermediate and late generations of the composite cross population grown in both the presence and absence of the disease.

In a recent review of this project the importance of doing basic work on some diseases was advanced even if the present technology does not allow immediate incorporation of resistance into RSP's. The root rot

diseases are an example of this category.

In terms of barley root rots the following studies are contemplated.

a. Continue development of a greenhouse-field screening technique. In particular, it is necessary to know the effect of inoculum dosage on reaction of various lines with known degrees of resistance to either the two species of Fusarium or to H. sativum. Most of the effort would be on the field aspects of this work.

b. Using the best techniques, the known reported sources of resistance to the two Fusaria and to H. sativum would be evaluated. There are 10 such lines reported in the literature which we have obtained from the U.S.D.A. small grain cereals collection. Ten g quantities of these lines were recently planted on the Agronomy Farm for seed increase. Thus sufficient seed will be present for testing by the summer of 1981.

c. Using F. culmorum and F. graminearum, the existing RSP's would be evaluated for their reaction to root rot. Even though these RSP's were put together for other pathogens, some may have some resistance to root rot. At least, the most susceptible plants in a population could be eliminated.

d. Establish a composite cross using known sources of resistance to either the two Fusaria, to H. sativum, or to both groups of pathogens.

e. Utilize the root rot plots to provide material for use in the Trainee program such that they would learn to recognize the symptoms of root rot, the procedures for isolation of the respective pathogens plus their identification, the methods used to score infected plants, and methods used to inoculate root rot plots. If needed, some training in the testing and use of seed treatments for control of smuts and/or Helminthosporium stripe could also be provided.

C. Exploitation of germ plasm developed

Male Sterile-Facilitated Recurrent Selection Populations are designed as a source of germplasm that can be continually exploited and continually improved. The local plant breeder is encouraged to grow the population and improve it agronomically for local conditions. Additional locally-adapted germplasm can be added to the population as the cycles of selection and recombination continue. Individual plant selections can be removed from the population at any time and handled in the same manner as segregating material in a pedigree breeding scheme. A proportion of plant selections will be male sterile or segregate for male sterility. The male sterile gene can be removed from the segregating lines by progeny testing. Since plant selections from the population will contain multiple genes for resistance, a cross to other susceptible breeding material will result in a break-up and loss of part of this resistance and, thus, is not recommended.

The local breeder is not necessarily limited to the populations produced by this project. A new population containing specific lines adapted to local conditions can be started. Recurrent selection, as a breeding method, is quite flexible and is useful for improvement of almost any heritable character.

D. Germ plasm bank for major and minor gene resistance.

Various resistance sources to a number of specific diseases will be determined throughout this project. These will include entries from the world collection of barley as well as from other sources evaluated in the program. Appropriate crosses will be made to determine which sources of resistance belong to the same linkage groups and which are truly different. These resistance sources will be catalogued regarding their effective areas and the specific pathogen cultures they are effective against. They can also be placed in a national storage facility for future reference.

At the same time, many cultures of specific disease organisms will be classified for virulence genes or at least the virulence groups to which they belong. Effective/ineffective formulas will be determined for standard sets of host differentials. At present, all cultures are being lyophilized for long term storage and future reference. These cultures along with identifying formulas and other pertinent data on area of collection will be deposited with the American Type Culture Collection where they will be readily available for other scientists working with diseases of barley.

E. Agronomic improvement of disease resistant recurrent selection populations

One of the objectives of this project is to improve the agronomic characteristics of the disease resistant male sterile facilitated recurrent selection populations. The purpose is to increase the probability of a plant breeder selecting successful lines from these populations.

This improvement should not begin until the disease resistant genes are well established throughout the population in order to not eliminate any disease resistant genes through genetic drift.

A second chance for elimination of desirable, or included genotypes can occur if the number of plants selected to continue a population is too small. We have used "500 gr. of seed" as our minimum population size to move from one generation to the next. This amount should vary in number from 12,000-15,000 seed or genotypes.

The recurrent selection populations under this program were typically established with 15 selected parental varieties. To incorporate the disease resistant genes it was necessary to introduce a number of undesirable genes. Introduction of the disease resistant sources also introduced the two row gene into basically a six-row genetic background. We have shown, in our isogenic work, that a six-row genetic background is not a desirable background for the two row gene. Also that the 6-row

genotype vvii is much inferior to the 6-row vvII genotype. The former is recognized by pedicelled lateral kernels and the latter by the sessile lateral kernels. The sessile condition is recessive and thus one accurate classification can eliminate the vvii genotypes from the population. Our work with isogenics also confirms the work of others that the smooth awn rr gene is not desirable from the standpoint of yield.

Tolerance to drought is one of the more important requirements. Highly technical physiological stress indicators have been useful in classifying specific varieties but these techniques are not desirable for large populations. Several techniques were investigated and isogenic lines were utilized in considering the association of heading dates, kernel weight, kernels per spike and rooting pattern with drought escaping mechanisms. Early heading varieties escape drought and are easily selected. Kernel weights are a good measure of late season stresses and selection for plump kernels served to identify on a mass scale those less affected by these stresses. Increased kernels per spike in early heading cultivars should be of value for semi-arid environments. Rooting pattern studies further delineated stress responses but root assay is too complex to be useful in a large scale selection program.

An association between plant internal water stress and free proline accumulation has been postulated. A bioassay using the auxotrophic bacterium Pediococcus mesenteroides was developed for determination of free proline in 1 gram quantities of ground barley. The sensitivity of the new assay was sufficient to delineate significant varietal and environmental differences in proline. Correlations, although significant, were not as strong as expected. Additional research is still needed to refine this technique.

A single simple method for evaluating drought tolerance was not found but multiple correlated indices as described above were useful for making more accurate selections.

Investigations are currently underway to improve the suitability of the RSP's for target areas involve a number of considerations.

Early maturity is being selected for which is essential for dryland areas, and is being combined with day-length insensitivity by alternating selection in Arizona and Montana.

Selection for large seed and increased number of seed per spike have been used to increase yield potential. In adding various disease resistance sources to the RSP's some undesirable features such as black lemma and blue aleurone are introduced. These dominant traits are readily removed from the populations on the other hand the hulless trait, controlled by a single recessive gene can be readily selected.

Research on these populations will be concerned with evaluation of the efficacy of selection as compared to the original population, and the effectiveness of selection for each additional trait. Comparison

of each generation should establish trend lines (heritability). Random 100 plant samples of the populations will be evaluated in hill plots for the selected trait, disease resistance, yield, etc.

F. Screening nurseries

Most of the screening for disease resistance will be done in controlled environment chambers using seedling barley plants and a wide array of virulences for the different disease organisms.

The RSP's will be grown in several locations within the United States and at foreign sites. A tentative listing of nursery locations for the RSP's is given in Table 20. These nurseries are a very important part of the overall proposed program as they will serve to expose the barley populations to a wide range of virulences and the seed from the resistant plants will be used for recycling in the RSP flow sheet illustrated in Figure 1. Investigators associated with the Montana A.I.D. project would visit many of these nurseries, as required or requested, and assist in the selection of the desirable barley types.

G. Training

It is deemed advisable to have a separately funded program for training and therefore a separate budget is submitted for this aspect. Such people are particularly in short supply in the developing countries. MSU has had many inquiries concerning the possibility of having training in developing resistance to barley diseases including the plant breeding aspects involved.

Two approaches are proposed. In one case graduate research assistants would be accepted from foreign countries on the same academic basis as required for resident students. They would be assigned thesis projects relating to the A.I.D. proposal for improving barley for the semi-arid areas of the world.

In the other approach the trainees would not work toward an advanced degree but would participate in a three month training period. They would receive training in laboratory and field work primarily with barley diseases including culturing and methods of increasing inoculum, inoculation techniques for both seedling tests in controlled environment chambers and for maturing plants in the field. They would also receive training in working with RSP's from the standpoint of plot techniques, disease ratings and selection of the better disease resistant and agronomic types. They would become familiar with the major barley diseases including those caused by fungi, bacteria, and viruses. Training would also involve various methods of hybridization and techniques and materials required for serodiagnosis for BSMV and BYDV.

During the first year of the current contract 2 graduate students from the target countries initiated work under the AID contract. One was from Morocco and one from South Korea. Five trainees were accommodated

the first year: One from India, one from South Korea, one from Turkey and two from Syria. Currently we have two trainees from Morocco and one from Syria. Two more trainees are expected for this year - one from Tunisia and one from S. Korea. The two trainees from Morocco are funded by FAO. We consider the training portion to be an important part of the overall program and have continually had more requests than we can accommodate.

Plans are currently underway for a barley workshop to be held in Rabat, Morocco in April, 1981. This will be jointly sponsored by INRA (National Institute for Agricultural Research), Rabat, MSU-AID, ICARDA and CIMMYT. This workshop will involve a total of about 40 people closely involved with barley improvement. This will include representatives from about 15 LDCs plus resource people from Montana and other locations. If this project is continued for another three years, it is proposed that another workshop on barely be held in the spring of 1984.

Figure 1. Procedure for development of RSP's with disease resistance

Step 1. Male sterile line x broadly adapted 2 or 6-row varieties (about 15)

F_1 grown in Arizona winter

F_2 seed bulked to form RSP

Step 2. RSP F_2 x cultivars containing desired resistance

F_1 grown in Arizona winter

F_2 seed bulked to form RSP R__(res)

Step 3 RSP R__(res) planted in disease nursery and susceptible plants dicarded

RSP R__ grown in Arizona for recombination (seed from m.s. plants is harvested)

RSP R__ planted in disease nursery and susceptible plants discarded

distributed to world wide nurseries for screening

-rebulked to begin another cycle

- sent to Arizona for recombination

Note: Additional germplasm can be added by returning to Step 1 or Step 2.

The financial assistance required for a 1984 workshop is estimated in the last year of the proposed budget. The amount requested would be required mainly for furnishing travel assistance to foreign and national scientists with primary interest and expertise in improvement of barley with emphasis on barley diseases.

VIII. Time-Phased Work Plan:

Once the necessary fundamental work has been completed on handling of the cultures for inoculum increase and methods of inoculation and disease rating, various sources of resistance to the specific diseases can be identified using cultures representing different genes for virulence. The expected time sequence development in terms of male sterile facilitated RSP's is given in Table 21 and the various steps and cycles are explained in Figure 1. Step 1, crossing of male sterile lines to broadly adapted barley cultivars, can be done at any time but the use of these stocks for introducing resistance germplasm can only be undertaken after completion of the initial fundamental studies. Therefore, the entry of "Step 2" in the time-phased work plan signals the initiation of effective RSP development. As illustrated in Table 21 several diseases are well along in RSP development. Other diseases, recently considered, are in the fundamental development stage and a time sequence is given for the estimated sequential development.

The work design is also open ended in that new sources of desirable agronomic types or new sources of resistance germplasm may be introduced at any stage in the development of the RSP's.

IX. Reporting Plans:

An annual substantive report covering the status of the work, indicating progress made during the year, and outlining plans for ensuing period will be submitted to the AID project manager. An annual review will be held if deemed necessary by the AID project manager

Scientific reports and manuscripts will be prepared and presented at various symposia, conferences professional meetings and workshops.

X. Initial Environmental Examination

The activities of this project fall into the area described in environmental procedure regulations paragraph 216.2(c) "Analysis, studies, academic or investigative research, workshops and meetings." These classes of activities will not normally require the filing of an Environmental Impact Statement or the preparation of an Environmental Assessment. It is possible that an output of this project will be a set of procedures, guidelines or research results which when used would require such an assessment. However, the project itself only proposes research and directly supportive activities. Under these guidelines, this activity clearly qualified for a Negative Determination at the time when a threshold decision is determined.

XI. Women in Development

It is the goal of this project to encourage the widest possible participation of barley workers, broadly defined, in the design and implementation of problem solving in barley production, protection and use. The current research contract, AID/DSAN-C-0024, employs women professionals in the Department of Plant Pathology actively supporting the research work. A continuation of these strategies under this proposed research project is assumed. Overall program requirements are to advance knowledge in control of barley diseases and thereby increase barley production for food and feed. Increased uses of barley as food in the LDCs offers potential for greater utilization of women in those areas.

Montana State University has an aggressive affirmative action program to assure opportunities of employment for qualified personnel including minorities and females, in compliance with Title IX. Montana State University has an officer repsonsible for program implementation

XII. Contract Budget and Life-of-Project Cost

Research Portion

Inputs	Year 1	Work Months	Year 2	Work Months	Year 3	Work Months	TOTAL	Work Months
1. Salaries	110,568.	135	117,202.	135	124,238.	135	352,008.	405
2. Fringe Benefits	13,360.		14,166.		15,009.		42,535.	
3. Indirect Costs	71,099.		75,365.		79,885.		226,349.	
4. Travel & Per Diem								
(a) Domestic	8,100.		8,100.		8,100.		24,300.	
(b) International	12,000.		12,000.		17,000.		41,000.	
5. Equipment	19,000.		--		--		19,000.	
6. Expendable Supplies	9,500.		9,500.		9,500.		28,500.	
7. Publications - Commun.	3,500.		3,500.		3,500.		10,500.	
8. Other Direct Costs Repair & Maintenance	2,200.		2,200.		2,200.		6,600.	
9. Other - Workshop 1984					30,000.		30,000.	
10. GRA Travel & Dependent allowance (Foreign)	6,000.		6,000.		3,000.		15,000.	
11. Trainees	20,545	12	21,118.	12	21,724.	12	63,387.	36
12. TOTALS	275,872.	147	269,151.	147	314,156	147	859,179.	441

TRAINING PROGRAM

INPUTS	1 Year 1	Man Mos.	2 Year 2	Man Mos.	3 Year 3	Man Mos	4	5 Totals	Man Mos.
(2) GRA									
Salary	*							*	
M.S. Candidates									
Dependents All.	2,000.		2,000.		2,000.			6,000.	
Benefits									
Indirect Costs									
Travel & Per diem									
To & from home base	3,000.		3,000.					6,000.	
Domestic	1,000.		1,000.		1,000.			3,000.	
Supplies	*							*	
TOTAL	6,000		6,000.		3,000.			15,000.	
(4) Trainees 3 mos.		12		12		12			36
Salary	6,000.		6,360		6,742.			19,102.	
Dependents All.	2,000.		2,000.		2,000.			6,000.	
Benefits	60.		64.		67.			191.	
Indirect costs	3,485.		3,694.		3,915.			11,094.	
Travel & Per diem									
To and from home base	6,000.		6,000.		6,000.			18,000.	
Domestic	2,000.		2,000.		2,000.			6,000.	
Supplies	1,000.		1,000.		1,000.			3,000.	
TOTAL	20,545		21,118		21,724.			63,387.	

* Salary & supplies estimated for 2 foreign graduate research assistants figured within the main budget.

XIII. Budget Justification

The overall budget reflects the scope of the proposal and attempts to allow for inflation. This is particularly true in the case of expendable equipment which has greatly increased in cost within the past few years. The capital equipment requests are briefly explained below.

Isco density-gradient fraction collector and recorder unit for the purification of barley yellow dwarf virus $ 8,000.

This equipment is necessary for the production of diagnostic antisera and is prerequisite for the virus investigation section within this proposal

Single row binder $2,000.

Needed for harvest of recombination plots in Arizona. An important part of this proposal.

Vogel thresher $6,000.

Much of the work we do involves an analysis of yield. The Dept. of Plant Pathology does not own a Vogel Thresher which is necessary for this type of plot work. At the current time we must use a thresher owned by the Plant and Soil Science Dept. With the current level of field plot activity on the Agronomy Farm, we sometimes must wait in line to use the thresher. With inclement weather always a possibility, it is imperative that our department get its own thresher. All other small plot equipment owned by the Plant Pathology department has been purchased by other funding sources, and none by AID, even though the AID project has utilized and benefited by its presence and availability.

Temperature, relative humidity and dew monitoring equipment $3,000.

Many of the major diseases of barley are investigated in the RSP nurseries at Bozeman. We inoculate with endemic cultures and need to be assured of adequate infection each year. These nurseries are also an important part of our training program. This equipment is needed to facilitate this operation and assure adequate infection for the different diseases of barley.

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TABLE 1. The Changes in the Pattern of Barley Production Over the Periods Between 1961/65, 1974/76, and 1976/78.

COUNTRY	1961-65			1974-76			1976-78		
	Area (1000 ha)	Yield (kg/ha)	Prod. (1000 Mt)	Area (1000 ha)	Yield (kg/ha)	Prod. (1000 Mt)	Area (1000 ha)	Yield (kg/ha)	Prod. (1000 Mt)
Mediterranian Europe									
Portugal	125	486	61	105	842	89	87	620	54
Spain	1420	1379	1959	3176	1814	5765	3238	2073	6713
Greece	184	1349	248	404	2360	953	383	2280	872
North Africa									
Morocco	1627	808	1316	1991	1134	2279	2249	1030	2316
Algeria	811	587	476	758	718	558	733	710	523
Tunisia	507	286	145	358	624	220	316	520	170
Libya	350	248	87	300	569	171	160	630	100
Egypt	52	2614	137	39	2798	110	42	2803	118
East Africa									
Ethiopia	1612	820	1323	1053	829	867	1775	850	1500
Kenya	12	1281	15	20	1557	31			
Middle East									
Cyprus	69	1243	86	64	1423	93			
Turkey	2791	1235	3447	2621	1640	4310	2635	1813	4778
Lebanon	13	968	13	7	1007	8	9	1250	11
Jordan	85	735	62	40	501	22	42	343	14
Saudi Arabia	9	1046	10	14	1571	22	16	1300	207
Yemen, AR.	141	1000	141	180	1268	228			
Yemen, DEM.	1	2255	3	1	1938	2			
Syria	740	877	649	960	812	770	840	750	630
Iraq	920	925	851	554	934	516	660	927	612
Iran	990	800	792	1431	873	1263	1350	803	1084
Afghanistan	350	1082	379	350	1114	388	350	1070	375
South and Far East									
Pakistan	186	632	118	195	697	137	180	690	124
India	2998	864	2590	2825	1023	2891	2345	1117	2619
Nepal	23	1077	25	28	869	24	26	920	24
Bangladesh	28	549	15	25	648	16	26	620	16
Korea, Rep.	726	1584	1150	709	2279	1616	594	2160	1283

Sources: FAO Production Yearbook, 1976
USDA Agricultural Statistics, 1979

TABLE 2. Barley: Area, Yield per Hectare, and Production in South America.

COUNTRY	Area (1000 ha)			Yield per hectare (kg/ha)			Production 1000 Mt		
	1976	1977	1978	1976	1977	1978	1976	1977	1978
ARGENTINA	476	310	300	1600	1140	1330	760	353	400
BOLIVIA	112	112	115	710	540	720	80	60	83
BRAZIL	83	100	95	1200	1030	1050	100	103	100
CHILE	63	64	65	2200	1950	2000	143	125	130
COLOMBIA	47	49	75	1110	1760	1960	63	86	147
EQUADOR	65	50	40	880	800	800	57	40	32
PERU	185	180	185	890	940	950	165	170	175
URUGUAY	44	43	45	910	880	1160	40	38	52
TOTAL	1085	908	920	--	--	--	1408	975	1119

Source: USDA, Agricultural Statistics, 1979.

TABLE 3. Average Yield of Barley in the Near East and North African Region in Comparison to the World and Other Regional Averages.

Region/Country	Average Yield (Kg/ha)
WORLD	1867
AFRICA	899
N. C. AMERICA	2165
S. AMERICA	1141
ASIA	1342
EUROPE	3125
OCEANIA	1240
U.S.S.R.	1672
CHINA	1476
FAR EAST REGION	1266
DEVELOPED REGION	2634
DEVELOPING REGION	1059
NEAR EAST & NORTH AFRICAN REGION	1062

Source: Proceedings: Fourth Regional Winter Cereal Workshop - Barley, Aman, Jordan, 1977.

TABLE 4. Barley Utilization in Lesser Developed Countries (Percentage of Production).

North Africa	Food	Feed	Malt	Others
Algeria	5	90	5	-
Egypt	50	35	15	-
Libya	90	10	-	-
Morocco	50	30	2	18
Tunisia	0	90	10	-
South and Far West				
Bangladesh	100	-	-	-
India	80	10	10	-
Korea	97	-	-	-
Nepal	80	10	10	-
Pakistan	50	40	10	-
Near & Middle East				
Afghanistan	-	95	-	-
Cyprus	-	100	-	-
Iran	10	80	10	-
Iraq	2	90	5	-
Jordan	-	100	-	-
Lebanon	-	60	40	-
Saudi Arabia	15	85	-	-
Syria	-	90	-	-
Turkey	-	70	30	-
Yemen, A.R.	80	20	-	-
Yemen, P.D.R.	90	10	-	-
East Africa				
Ethiopia	40	-	3	57 (home-made beverages)
Kenya	-	30	70	-
Sudan	1	1	97	1
Tanzania	-	-	99	-

Source: Proceedings: Fourth Regional Winter Cereal Workshop - Barley, Amman, Jordan, 1977.

Table 5. Base Varieties for RSP's - 6 row barley

RSP-5 Base Varieties

Manchuria msg 10	Galt
Gem	Steptoe
Unitan	Nude Vantage
Arimont	Nude Glacier
Waxy Titan	Minn. 21
Nordic	Athenais
Atlas 66	Atsel
Beecher	CM 67

Table 6. Base Varieties for RSP's - 2 row barley

RSP-4 Base Varieties

Compana msg 10	Waxy Compana
Herta	Union
Ingrid	Vireo
Bruens Wisa	Summit
Zephyr	Maris Mink
Erbet	Nude Compana
Dekap	Cumhuriyet 50
Hector	Toonucier

Table 7. Resistant Germplasm in RSP-5 Rrs - 6 row scald population

Trebi	C.I. 935	Bey
Jet	C.I. 1218	La Mesita
Kitchin	C.I. 1257	C.I. 8158
Steudelli	Osiris	C.I. 8159
Atlas 46	Ellis	C.I. 11577
Modoc	C.I. 3940	C.I. 11579
Nigrinudum	Atlas	McNair
Turk	C.I. 4354	C.I. 11628
C.I. 668	Little Ben	C.I. 11839

Table 8. Resistant Germplasm in RSP-4 Rrs - 2 row scald population

Jet	Modoc
Ellis	C.I. 8158
C.I. 4354	C.I. 8159
Steudelli	Nigrinudum
C.I. 3940	C.I. 11577
Atlas	C.I. 11628
Bey	Turk
La Mesita	

Table 9. Resistant Germplasm in RSP-5 Rpt - 6 row scald population

OAC 21	C.I. 9776	C.I. 5298
C.I. 2235	Tifang	C.I. 5401
C.I. 2750	C.I. 9819	C.I. 5822
C.I. 4544	Manker	C.I. 5845
Oderbrucker	C.I. 1197	C.I. 6388
Harbin	C.I. 1615	C.I. 6496
C.I. 5791	C.I. 4207	C.I. 7208
C.I. 7584	C.I. 5296	C.I. 7272
C.I. 7296	C.I. 9647	C.I. 9825
C.I. 7297	C.I. 9698	C.I. 10379
C.I. 7447	C.I. 9699	C.I. 12821
C.I. 7504	C.I. 9702	C.I. 12860
C.I. 8332	C.I. 9751	C.I. 13262
C.I. 9440	C.I. 9758	C.I. 14023
C.I. 9505	C.I. 9768	

selections from CC-30-F

Table 10. Resistant Germplasm in RSP-4 Rpt - 2 row net blotch population

Steptoe	C.I. 7272	C.I. 9776
Unitan	C.I. 7296	C.I. 9825
C.I. 1615	C.I. 7744	C.I. 9831
C.I. 4207	C.I. 7504	C.I. 11631
C.I. 5298	C.I. 9440	C.I. 12821
C.I. 5401	C.I. 9505	C.I. 13262
C.I. 5822	C.I. 9698	C.I. 13727
C.I. 5845	C.I. 9702	C.I. 14023
C.I. 6388	C.I. 9758	Tifang
C.I. 7208	C.I. 9768	

Table 11. Resistant Germplasm in RSP-5 Rph - 6 row leaf rust population

Horsford	Titan
Kwan	Rivale
Weider	Proctor
C.I. 4974	Julia
Reka I	Carre 180
Austral	Vada
Lechtaler	

Table 12. Resistant Germplasm in RSP-4 Rph - 2 row leaf rust population

Horsford	Reka I
Kwan	Austral
Carre 180	Lechtaler
C.I. 4974	Julia

Table 13. Resistant Germplasm in RSP-5 Rxt - 6 row *Xanthomonas* population

Nigrinudum	OAC 21
Wapana	Peatland
Summit	C.I. 5810
Nupana	Mars

selections from RSP-5 Rpg and RSP-5 Rrs

Table 14.
Virulence Groups of Montana Isolates in Relation to 15 Different Barley Varieties. (Net Blotch)

Virulence Group	Varieties 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group A	R	R													
Group B	R	R									R	R	R	R	
Group C	R	R		R							R	R	R	R	R
Group D	R	R									R				

1. Unitan R or I to all
2. Steptoe R or I to all
3. Shabet
4. Hypana
5. Dekap
6. Ingrid
7. Betzes
8. Firlbecks III
9. Mona-Arivat
10. Arimont
11. C.I. 7584
12. C.I. 9776
13. C.I. 9819
14. C.I. 5791
15. Tifang

Table 15:
Virulence Groups of Middle East Isolates in Relation to 15 Different Barley Varieties. (Net Blotch)

Virulence Groups	Varieties 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group A	R	R									R	R	R	R	R
Group B	R											R	R	R	
Group C	R	R	R			R							R	R	
Group D	R	R	R	R		R	R	R			R		R	R	R
Group E	R		R			R	R				R	R	R	R	R

1. Unitan
2. Steptoe
3. Shabet
4. Hypana
5. Dekap
6. Ingrid
7. Betzes
8. Firlbecks III
9. Mona-Arivat
10. Arimont
11. C.I. 7584
12. C.I. 9776
13. C.I. 9819
14. C.I. 5791
15. Tifang

Table 16.
Barley Lines Resistant to all 9 or 8 of 9 Virulence Groups. (Net Blotch).

Barley Lines with resistance to:

All nine virulence groups:

C.I. 1615	C.I. 5401	C.I. 9768
C.I. 4207	C.I. 5845	C.I. 10421
C.I. 5298	C.I. 7208	C.I. 13262

Eight of nine virulence groups:

C.I. 5404	C.I. 7272	C.I. 9698
C.I. 5822	C.I. 7296	C.I. 9699
C.I. 6388	C.I. 7297	C.I. 9831
C.I. 6475	C.I. 7504	C.I. 12860
C.I. 6496	C.I. 9440	C.I. 13727

Table 17.
Possible Numbers of Genes for Resistance in Each Barley Line (Net Blotch)

Steptoe	2(3)	C.I. 1197	2	Firlbecks III	1
Unitan	2(3)	C.I. 2230	1	C.I. 9776	1(2)
C.I. 5791	2(3)	C.I. 4544	1	C.I. 7584	1(2)
C.I. 9819	2(3)	Betzes	1	Georgie	1
Tifang	2	C.I. 2235	1		

Table 18. Evidence for Additive Resistance to *P. Teres*.

Cross	F_1 reaction	F_2 reaction type 1	2	3	4	Isolate
Tifang (4)[1] x Georgie (4)	4	1[2]	6	18	158	Mt 77-1
Betzes (4) x Georgie (3,4)	3,2	0	7	40	254	Mt 77-6
Georgie (3,4) x Firlbecks III (4,3)	3,2,4	25	65	126	155	Mt 77-6
Betzes (4) x Firlbecks III (4,3,2)	4,3	0	13	28	328	Mt 77-7
Tifang (4,3) x Firlbecks III (3,4)	3,2	4	69	136	182	Mt 77-51

[1]Parental Reaction Type in Parentheses.
[2]Indicates Number of F_2 Plants in Each Reaction Type.

TABLE 19. Promising Sources of Resistance to *Puccinia hordei*.

	VARIETY (LINE)	ISOLATE*
RESISTANT TO 5 ISOLATES OUT OF 10	FORRAJERA	1,4,5,6,9
	SUDAN	2,4,5,6,9
	RICARDO	4,5,6,8,10
	AMBER	4,6,7,8,9
RESISTANT TO 6 ISOLATES OUT OF 10	CI 4216	1,2,4,5,6,10
	WEIDER	1,5,6,8,9,10
	MENELIK	2,4,6,8,9,10
RESISTANT TO 7 ISOLATES OUT OF 10	BOLIVIA	1,2,3,5,6,7,9
	CI 11577	1,2,4,5,6,8,10
	MODJO	1,3,4,5,6,9,10
	CI 4974	1,4,5,6,7,8,10
RESISTANT TO 8 ISOLATES OUT OF 10	ARIANA	1,2,3,4,5,6,8,10
	BATNA	1,2,3,4,5,6,8,10
	SAN CARLOS	1,2,3,4,5,7,9,10
	CCIM-13	1,3,4,5,6,7,9,10
RESISTANT TO 9 ISOLATES OUT OF 10	FORD 1203	1,3,4,5,6,7,8,9,10

* 1-Creston, 2-Sidney, 3-Rabat I, 4-Merchouch, 5-Khemi Zemar, 6-Marrakech, 7-Sakha, 8-Tel Hadia, 9-Homs, 10-Izmir

RESISTANT TO ALL ISOLATES	CEBADA CAPA (PA_7)	AIM (PA_3)
	FORRAJERA KLEIN/REKA (PA_7)	ESTATE (PA_3)
	LA ESTANZUELA (PA_7)	386-16-2
	CI 11801 (PA_7)	

Table 20. List of Disease Screening Nurseries for 1980

	Scald	Net Blotch	Leaf Rust	Xanthomonas	Powdery Mildew
Bozeman, MT	✓	✓		✓	
Fairfield, MT Ross Peace	✓	✓		✓	
Sidney, MT Gerald Bergman		✓		✓	
Woodland, CA Robert Matchett	✓	✓			
San Antonio, TX Jack Malchoff			✓		
Experiment, GA Barry Cunfer	✓				
Rabat, Morocco Lynn Gallagher	✓	✓	✓		
El Kef, Tunisia A. Daaloul	✓	✓			
Sahka, Egypt E. Saari		✓	✓		
Izmir, Turkey C. Temiz	✓			✓	
Aleppo, Syria J. Srivastava	✓	✓			
Honam, Korea N.P. Park	✓	✓			
Suweon, Korea E. S. Lee	✓	✓			
Milyang, Korea P.R. Kyung	✓	✓			
Saltillo, Mexico A. Acosta-Carreon	✓	✓	✓	✓	✓
Annoeullin, France G. Thiebaut	✓				

Table 21. Time Phased Work Plans.

		1980	1981	1982	1983	1984
Xanthomonas	2-row major			Cycle 1-----		
	6-row major	Cycle 3-----				
Dryland Root Rot	2-row major			Cycle 1----		
	6-row major			Cycle 1----		
Scald	2-row major	Cycle 2-----				
	6-row major	Cycle 5-----				
	2-row minor	Cycle 1-----				
Net Blotch	2-row major	Cycle 2-----				
	6-row major	Cycle 4-----				
	2-row minor	Cycle 2-----				
Leaf Rust	2-row major	Cycle 1-----				
	6-row major	Cycle 2-----				
	slow-rusting		Cycle 1--------			