931 1318 70450 1-2
PD-AAG-686-B1

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS PART I

1. TRANSACTION CODE: A - ADD, C - CHANGE, D - DELETE

PAF

2. DOCUMENT CODE: 5

3. COUNTRY/ENTITY

4. DOCUMENT REVISION NUMBER

5. PROJECT NUMBER (7 digits): 931-1318

6. BUREAU/OFFICE: A. SYMBOL / B. CODE

7. PROJECT TITLE (Maximum 40 characters): Control of Barley Diseases for [illegible]

8. PROJECT APPROVAL DECISION — ACTION TAKEN: A - APPROVED, D - DISAPPROVED, DE - DEAUTHORIZED

9. EST. PERIOD OF IMPLEMENTATION: YRS. 2 QTRS.

10. APPROVED BUDGET AID APPROPRIATED FUNDS $000.

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	D. LOAN	E. 1ST FY [illegible] F. GRANT	G. LOAN	H. 2ND FY [illegible] GRANT	J. LOAN	K. 3RD FY [illegible] L. GRANT	M. LOAN
(1)	111E	963		[illegible]		230		[illegible]	
(2)									
(3)									
(4)									
			TOTALS	[illegible]		[illegible]		[illegible]	

A. APPROPRIATION	N. 4TH FY ___ O. GRANT	P. LOAN	Q. 5TH FY ___ R. GRANT	S. LOAN	LIFE OF PROJECT T. GRANT	U. LOAN
(1)					[illegible]	
(2)						
(3)						
(4)						
TOTALS					[illegible]	

PROJECT FUNDING AUTHORIZED — GRANT / LOAN

ENTER APPROPRIATE CODE: 1 - LIFE OF PROJECT, 2 - INCREMENTAL, LIFE OF PROJECT

C. PROJECT FUNDING AUTHORIZED THRU FY

12. INITIAL PROJECT FUNDING ALLOTMENT REQUESTED $000

A. APPROPRIATION	B. ALLOTMENT REQUEST NO. ___ C. GRANT	D. LOAN
(1)		
(2)		
(3)		
(4)		
TOTALS		

13. FUNDS RESERVED FOR ALLOTMENT

TYPED NAME (Chief, SER/FM/FSD)

SIGNATURE

DATE

14. SOURCE/ORIGIN OF GOODS AND SERVICES: 000 / 941 / LOCAL / OTHER ___

15. FOR AMENDMENTS, NATURE OF CHANGE PROPOSED

New project pursuant to Project # 931-0500.11 "Inheritance Improvement of Protein Quality and Content in Barley".

BEST AVAILABLE DOCUMENT

CONTRACT AID/DSAID-C-0024 723 [illegible]

FOR PPC/PIAS USE ONLY	16. AUTHORIZING OFFICE SYMBOL	17. ACTION DATE MM DD YY	18. ACTION REFERENCE (Optional)	ACTION REFERENCE DATE MM DD YY

AID 1330-4 (7-73)

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS

PART II

ENTITY : DS Bureau

PROJECT : Control of Barley Diseases for LDCs

PROJECT NUMBER : 931-1312

1. I hereby authorize a new project activity in the "Control of Barley Diseases for the Lesser Developed Countries of the World" to be implemented by Montana State University, Bozeman, Montana.

2. This three year project was recommended for approval by RAC at its March 31, 1978 meeting at a total funding level of $724,000.

3. This project is based on an unsolicited proposal from Montana State University. I hereby determine that this unsolicited proposal is the product of original thinking, has significant scientific or technical merit, and will contribute to AID's research program objectives. On this basis, consistent with the provisions of AIDPR 7-4.5301(e), a negotiated contract with the subject contractor without consideration of other competitive sources is considered appropriate.

/s/ Sander Levin
Sander Levin
Assistant Administrator
for Development Support

6/2/78

Enclosures:
1. Research Project Statement
2. Memo, Hesser-AA/DS, dated 4/26/78
3. RAC Recommendations
4. Memo, Byergo-Darvin, dated 5/18/78

Clearances:
DS/AGR, LHesser by DFP Date: 5/18/78
DS/AGR, MMozynski MCM Date: 5/18/78
DS/PO, RSimpson RCS Date: 5/19

931-1318

DATE: November 15, 1977

TO : Act. AA/TA, Ms. Marjorie S. Belcher

(2)

FROM: TA/PPU, John N. Gunning

PROBLEM: Your Approval is Requested of the Project Identification Document (P.I.D.) for Control of Barley Diseases for the Developing World.
Proposed Project Begins: FY'78 Proposing Office: TA/AGR

A. TA/PPU Review:

1. Does PID adequately Describe and Justify Project?

Yes.

2. Funding Adequate? In FY 77/78 Budget? How Compares to FY 77b C.P.?

Yes. (See memorandum Gunning to Belcher dated 11/15/77)

3. Are Plans for PP Development, Approval and Project Initiation Realistic?

Yes.

B. This PID has been in TA/PPU; staff work is incomplete because of:
_____ TA/PPU work pressure; _____ Tech. Office work pressure.
Recommend you return the PID for further work prior to your final decision.

C. TA/PPU recommends the following action:

X Approval.
_____ Approval subject to _____

_____ Return for further work prior to AA/TA decision.
_____ Disapproval.

D. AA/TA Action:

✓ Approved.
_____ Approved subject to _____

_____ Disapproved.

Signature

NOV 23 1977
Date

Attachment:
Recommendation for Environmental Threshold Decision

Proposal to the Agency for International Development

1. Statistical

Project Title:	Control of Barley Diseases for the Lesser Developed Countries of the World
New of Extension:	New
Proposed Contractor:	Montana State University Bozeman, Montana
Principal Investigator:	Dr. Eugene L. Sharp
Duration:	Three years beginning with contracting date estimated to be April 1, 1978
Estimated Total Cost:	$723,000 (3 years)
Budget by Years:	$223,124 (Year 1) $230,076 (Year 2) $269,800 (Year 3)
Project Manager:	John M. Yohe

2. Abstract and Narrative Summary:

The basic goal of this project is to improve the control of barley diseases for the lesser developed 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 germ plasm including both 2 row and 6 row types. The barley male sterilies 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 seedling and mature plants (field) and, in both bases, 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. This project should lead to broad based resistances to the major diseases of barley which will be effective in the barley growing areas of the world.

Barley (*Hordeum vulgare*) is grown for food in many areas, especially where the growing season is too short or the rainfall is not adequate for other cereal crops. Substantial populations in the Mediterranean

region, the Near East, India, Ecuador, Peru, and Eastern and Northern Europe eat barley.

The MSU-AID barley proposal and program has recently focused on the needs of barley eating people. The program was designed to produce populations that were adapted, disease resistant, and high yielding, and that had satisfactory quantity and quality of protein. These characteristics coupled with hulless grain would benefit 200 million of the world's most impoverished people.

Within the developing countries of the world, barley is grown within all regions, the Middle East, Africa, Latin America and Asia. The production of barley in the LDCs is tabulated in Table 1. It is difficult to obtain estimates on the amount of barley directly consumed as a human food but Table 1 lists the best estimates available for direct food consumption based upon information available from the USDA Foreign Agricultural Service.

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 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 will 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 to utilize the superior material in its barley breeding program. 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.

TABLE 1
Production of Barley in LDCs[a]

	Area Under Production (1000 ha)	Quantity Produced (1000 MT)	Quantity Directly Consumed by Humans (1000 MT)
AFRICA			
Algeria	800	600	450
Egypt	44	123	-
Ethiopia	991	800	1,500
Morocco	2,130	2,862	1,475
Tunisia	350	230	265
SOUTH AMERICA			
Argentina	500	760	-
Bolivia	110	80	80
Brazil	49	56	-
Chile	56	78	-
Colombia	46	71	-
Equador	65	57	-
Peru	185	165	175
Uruguay	44	47	-
ASIA			
Afghanistan	390	400	375
China [b]	13,501	21,000	-[c]
India	2,941	3,196	3,025
Iran	1,480	1,487	210
Iraq	576	579	-
Korea	711	1,759	1,529
Pakistan	186	130	92
Syria	1,172	1,059	125 [c]
Turkey	2,700	5,100	750 [c]
Yemen AR	180	235	-

a. Data taken from FAO Production Yearbook, Vo. 30, 1976.
b. People's Republic of China
c. Quoted as non-animal feed utilization
d. Source - USDA Foreign Agri. Ser. Aug. figures for 1975-77

TABLE OF CONTENTS

			Page
I.	A.	Proposal to the Agency for International Development	1
		1. Statistical	
		2. Abstract and Narrative Summary	
	B.	Research Purpose and Objectives	4
		1. Purpose	
		2. Objectives of the proposed program	
	C.	Significance and Rationale for the Research	4
		1. The Development Problem	
		2. State-of-Art	7
	D.	Plans to Develop Linkages and to Facilitate Utilization of Research Results	9
		1. CIMMYT	9
		2. ICARDA	9
		3. Other U. S. Institutions	10
		4. Other	10
		5. Dissemination and Application of Results	11
	E.	Management Considerations	11
	F.	Project Background Description	12
	G.	Project Design and Methods	15
		1. General Methods	15
		2. Germ Plasm Bank for Resistance Sources and Virulence Pool	17
		3. Disease in Relation to RSP Development	18
		4. Special Procedures	21
		5. Selection Pressures	25
		6. Screening Nurseries	26
		7. Training	26
		8. Linkages	27
	H.	Proposed Barley Workshop	27
	I.	Time Phased Work Plan	28
	J.	Contractor Internal Management and Facilities	35
	K.	Key Project Personnel	36
	L.	General Project Appraisal	43
	M.	Environmental Considerations	44
	N.	Women in Development	44
	O.	Contract Considerations	44
	P.	Contract Budget and Life-of-Project Cost	46
	Q.	Literature Cited	49
	R.	The Logical Framework	51

II. Tables, Figures

Table 1	2a
Table 2	30
Table 3	32
Table 4	33
Figure 1	16
Figure 2	34

B. Research Purpose and Objectives:

1. Purpose:

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

2. Objectives of the Proposed Program:

a. Different sources of resistance to the major diseases of barley and linkage relationships will be determined.

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

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

d. Assistance will be given in establishment of serodiagnosis programs for detection of barley stripe mosaic virus (BSMV) in barley stocks at the International Centers for barley improvement - CIMMYT and ICARDA.

e. All efforts will be made to develop a simple toxin screening procedure for use with the scald disease caused by *Rhynchosporium secalis* and with other barley diseases.

C. Significance and Rationale for the Research:

1. The Development Problem:

Diseases are often the most limiting factor in barley production and seriously affect production wherever the crop is grown. The losses incurred through both reduced quantity and quality are particularly important in the lesser developed countries (LDC's) since barley often constitutes the main crop that can be grown in the drier areas. Furthermore, it is one of the main staples for feed and food in these areas. 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 1968. Ag. Handbook #338, ARS, USDA). Among 25 countries from the Middle East & 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. Barley sown in these countries totalled over 22 million hectares. The amount of barley used as human food varied from less than 5% to 100% and averaged about 40%.

It is difficult to obtain quantitative data on the amount of loss in barley attributable to specific diseases because of lack of detailed experimentation in this regard. In fact, FAO has recently proposed a Plant Protection Program (1977) to obtain such quantitative data. 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. In this regard, it should be mentioned that 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 of 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 input for a viable program.

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. In diseases such as the smuts, there is generally a one for one relationship between per cent infection and per cent yield loss. The amount of actual 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 and Eslick as well as ARS, 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 attention by the local barley breeders. A better appraisal of the problems with barley in the Middle East has been made via disease surveys and collections, contacts with people working with barley and especially during the workshop and tours held in Jordan and Syria in April, 1977. This resulted in a much better idea where barley disease nurseries for specific diseases should be located to achieve suitable natural infection. This will, of course, lead to a better sampling of the virulence pool for the specific diseases and will in turn lead to development of broad based resistances in the barley stock populations

Virus diseases such as barley stripe mosaic and barley yellow dwarf have received very little attention in the Middle East to date. Visits

in the area revealed that these diseases were limiting barley production to a significant degree. Moreover, recent observations by Dubin (CIMMYT-Personal Communication) in South America strongly suggest that barley yellow dwarf is a very serious disease on that continent.

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 would fill definite niches in barley improvement programs in the developing countries. An additional budget for training is thus proposed.

2. 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, where ever barley is grown, as important diseases on this crop. Scald, smuts and rusts are also worldwide in distribution 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 relationship 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 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 useable 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 germ plasm 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. (1963).

Suneson (1956) described his use of composite crosses and implied that natural selection should be relied upon for development of superior barley types. He (Suneson 1963) later 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. Subsequent forced, outcrossing 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 agronomic types 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 essentially 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.

D. Plans to Develop Linkages and to Facilitate Utilization of Research Results.

1. CIMMYT:

Close sooperation with CIMMYT is planned in developing barley stocks with broad-based resistance to specific diseases. Stocks developed at MSU 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 in setting up their own serodiagnosis laboratory for detection of seed-borne BSMV in their various barley stocks.

2. ICARDA:

Similar to the cooperation with CIMMYT barley crossing block parents and advanced lines coming from ICARDA will be evaluated to a wide array of virulence types within the major diseases. Barley stocks with broadbased 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 barley 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.

3. Other U. S. Institutions:

Barley recurrent selection populations for the various major diseases would be distributed to locations where a high probability exists for natural infection with the diseases involved. Locations presently involved are in Georgia, Florida, California and Arizona. Other tentative locations would be in North Dakota and Minnesota. Dr. Ramage, USDA-ARS, (University of Arizona) is currently working with RSP's for resistance to powdery mildew. Assistance would be given him in assuring adequate infection and dissemination. Winter field plots in Arizona would also be utilized to obtain two barley generations per year, and thus accelerate development of the desired barley populations. This cooperation will be at no additional expense to the project.

4. Other:

It is proposed to cooperate with other national and international organizations (e.g. FAO) in furnishing resistant barley stocks and in training of personnel in both plant pathology and plant breeding methods.

Additionally several field locations will be utilized in Montana for growing the various RSP's. Some of the locations involve the various research centers of the Montana Agricultural Experiment Station while other locations involve individual grower's fields. This will detect, as far as possible, the various virulence genes to the different diseases and serve to broaden the resistance bases.

5. Dissemination and Application of Results:

As technical information becomes available from the project it will be published in the form of reports to A.I.D. in recognized technical journals, etc; copies and reprints of these will be distributed to a mailing list of barley workers in developing countries. Additionally, as mentioned in previous sections, barley stocks will be supplied to the international centers each year with descriptive information on their relative disease resistance against the virulence pools evaluated. In visiting and evaluations of the RSP nurseries each year, methods and results to date will also be discussed with the local barley co-operators involved. Barley stocks from these nurseries may be utilized at any time by the cooperating LDCs but it is important that the RSPs be continued for selection of better disease resistances and improved agronomic types. As the project advances trainees and graduate research assistants will become available for continuing barley improvement programs in their own respective countries. Professional staff on the program will also be available for short term consultation insofar as time and funding permit.

E. Management Considerations.

No unusual management problems are expected to arise in connection with this project. It will be similar in concept and design to other centrally funded crop improvement research projects of DS/AGR.

Noncontract funded inputs will be substantial. These include time of four MSU investigators spending a total of 12 man/months per year on the project. Also there will be cooperation by other staff members, office, and laboratory facilities, as well as use of equipment and extensive field facilities.

The project will be evaluated by a review and evaluation team visit to the campus during the first year of the project, probably during the growing season of 1979. In addition, management evaluations will be conducted each year and technical and managerial considerations will be under constant monitoring by the A.I.D. project manager.

Contractor will clear all manuscripts proposed for publication with the project manager, and will submit an annual report within 45 days of the close of each contract year.

F. Project Background Description:

Determination of and utilization of resistance to specific diseases of barley was formerly part of an overall project on improving barley for the semi-arid areas of the world which also included nutrition and drought studies. From the disease standpoint, one of the first approaches was to visit some areas of the Middle East and North Africa and obtain an indication of the major problem areas. Many isolates of specific disease organisms were collected at this time and these along with other isolates from the Montana areas were used in evaluation and screening for resistance sources. Potential resistance sources were evaluated from the world collection of barley. Search for resistance sources were also based on previous reports in the literature and from elite lines catalogued and stored by ARS-USDA. As the project developed a broader sample of the virulence pool for specific diseases was accumulated and further sources of resistance were evaluated.

In the earlier studies, the line of approach was to place a major resistance gene in an agronomically adapted population by the use of specially selected translocation. The translocation breakpoint must be distal to the resistance gene. This effectively prevents crossing-over in the interstitial segment and "locks-in" the resistance gene. In cases where gene location was not known, crosses to a series of primary trisomics was used. Aberrant segregation ratios indicate on which chromosome the gene is located. Once the correct translocation is found additional marker genes (e.g. male sterility, seedling markers) can be placed in the same interstitial segment. This allows the resistance gene, in combination with the translocation, to be added to a recurrent

selection population without having to screen for resistance in every cycle of selection. In this approach, one must bear in mind that the pathogen may overcome such resistance following mutation. Thus, the method finds it's best applicability with resistance genes that have had a history of stability (such as with the "T" gene in barley for resistance to stem rust).

The scald organism, Rhynchosporium secalis, is one of the major diseases of barley and resistance genes have been reported at 6 to 10 loci (Shipton, et. al. 1974). Several cultivars contain the Rh gene for scald resistance, thought to be a closely linked gene complex, located on chromosome 3. Other resistant cultivars contain genes whose locations in the barley genome have not been determined. Recently, (Bockelman et. al., 1977) using the Betzes primary trisomics showed that the barley cultivar Kitchin contained one dominant gene on chromosome #4 conditioning resistance to scald and that the barley cultivar Jet contained 2 recessive genes on chromosomes 3 and 4 conditioning resistance to scald. It is well established that the scald organism, R secalis, is represented by many different virulence genes or races (Jackson & Webster, 1976). Recurrent selection populations in which both major and minor gene resistances are being separately accumulated are underway by the barley research group at MSU. Male sterility is being utilized to facilitate recombinations and pyramiding of the resistance genes.

Net blotch caused by Pyrenophora teres is another major disease of barley throughout many areas of the world. Inheritance of resistance to net blotch has been attributed to at least three genes, Pt-1, Pt-2 and Pt-3. Pt-1 and Pt-2 are reported to be closely linked, while Pt-3 is inherited independently (Khan and Boyd, 1969). The placement of these

genes on linkage maps has not been reported. Bockelman et al (1977) using Betzes primary trisomics recently reported that Tifang contains one major dominant gene for resistance on chromosome 3, Barley C.I. 7548 contains one major dominant resistance gene on chromosome 2, and C.I. 9819 contains 2 dominant genes on chromosomes 2 and 5. The relationship between the two resistance genes found on chromosome 3 is currently being investigated. As with the scald disease, male sterile facilitated RSP's are being developed for both major and minor genes for resistance.

In leaf rust, (Puccinia recondita) Alameddine (1965) and Roane and Starling (1970) reported three resistance genes to be located on chromosomes 2,4 and 5 respectively. Location of other resistance genes has not been reported. A number of resistance sources have been determined in our laboratory and we are in the process of determining their relationships to each other. Additionally, both major and minor gene RSP's are being established.

The "T" gene for stem rust resistance in barley (chromosome 1) has been notable for its stability. Attempts are currently underway to find a break point translocation which will bracket this gene. Pyramiding of genes for stem rust resistance is also being developed via male-sterile facilitated RSP's.

Other diseases of barley are being studied. This presently involves mainly the determination of resistance sources and an evaluation of methods for large scale field inoculations.

Barley stripe mosaic virus (BSMV) and barley yellow dwarf virus (BYDV) cause important diseases of barley in many areas of the world. A serodiagnostic test, developed at MSU, is being used for testing either embryos or leaves of barley for the presence of BSMV. It can easily

detect significant levels of the virus. Evaluation of the CIMMYT crossing block materials has shown that several of the barley lines contained the virus.

Greenhouse, laboratory and field methods have been developed for screening oats, barley and wheat for tolerance to BYDV. Similar methods will be used for this project.

G. Project Design and Methods:

1. General Methods:

In this work male sterility will be used to obtain multiple crossings and to pyramid genes for resistance without the necessity of making laborious hand pollinations. Initially the investigation will involve detection of resistance genes within the world collection and other sources by evaluation against a wide range of virulences within the specific pathogens. The isolates of the pathogens will include many cultures from North Africa, the Middle East and from more local sources. Seedling trials will be conducted in controlled environment chambers or in the greenhouse. Field plots will be established at semi-arid sites - both in Montana and in the Middle East and will serve to identify resistant sources under natural infection conditions. After a number of resistant sources have been identified, they will be pyramided into selected barley stocks containing germ plasm from widely diverse but adapted cultivars. The more resistant selections will be saved in each generation and recycled to further pyramid resistance genes and selections will also be made to improve the general agronomic base. (See Figure 1 for the general procedure for development of RSP's with disease resistance).

The RSP's will include separate populations for both 2 row and 6 row

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 discarded

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.

barley and will also include separate populations for major and minor gene resistances.

The methods used for determining major gene resistances have been given previously. The parents for populations concerned with minor gene resistances will be selected from cultivars which have little resistance effect when non-combined with similar reacting cultivars. These parental materials will be selected from barley cultivars showing an intermediate or near susceptible reaction. It is expected that many of these selections will show an additive reaction for greater resistance when combined. This method has resulted in a useful resistance to stripe rust of wheat Puccinia striiformis (Sharp et. al. 1976) and appears to be feasible for some barley diseases.

2. Germ plasm bank for resistance sources and virulence pool:

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. The project is so designed 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.

3. Diseases in relation to RSP development.

Research on several barley diseases has advanced to the point where development of the RSP's is well underway. (See time table given in Table 2). In other cases, more fundamental information is required on such items as inoculum increase, large scale inoculation methods and on determination of resistance sources. Broad based resistance is first being developed for specific diseases. These resistances to specific diseases will later become combined within RSP's to give a wide spectrum of disease resistances. The status of development of resistance for the specific diseases follows.

Scald caused by *Rhynchosporium secalis*.

Data in Table 2 shows that development on this disease in regard to RSP's is in cycle 2 (1978) for 6 row barley containing accumulated major genes. To reiterate the complete development (Figure 1), a male sterile line was first crossed with 15 widely adapted 6 row types and the F_1 was grown during the winter in Arizona. The F_2 seed was then bulked to form the RSP. The RSP F_2 was then crossed to a number of cultivars containing several major genes (Rh genes) for scald resistance. The resistance sources were determined by methods outlined in Section F. The F_1 of this latter cross was again grown in Arizona and the F_2 seed was again bulked to form RSP n___ actually RSP Rrs in this case. That is, a recurrent selection population for resistance (first R) to *Rhynchosporium secalis* (next two letters = rs). In the succeeding step,

the population was planted in a disease nursery at Bozeman, Mt and susceptible plants were discarded. The seed arising from the resistant plants in this nursery was split into two groups. One group of seed was distributed to world wide nurseries where it was screened for resistance to natural infection with scald. The seed harvested from the resistant plants in the world wide nurseries is rebulked for another cycle of recombination in Arizona and so the process continues. The second group of seed is sent directly to Arizona for further recombination and seed is harvested from male sterile plants and planted once again in the disease nursery at Bozeman where resistant plants are saved for further recycling. Any number of cycles can be conducted as desired or until broad based resistance types of acceptable agronomic traits are obtained. Development on the other three RSP's for this disease are as shown in Table 2

Net Blotch - caused by Pyrenophora teres.

Development of the four RSP's is proceeding as shown in Table 2.

Stem rust, and Leaf rust caused by Puccinia graminis, Puccinia recondita, respectively.

RSP's have been initiated for both of these rust diseases and are developed to various stages as shown in Table 2.

Covered smut caused by Ustilago hordei.

Techniques have been established for working with the major gene RSP's but no suitable method is yet available pyramiding of minor genes

for resistance. Various methods are being investigated that might increase infection on susceptible controls to near 100%. If successful, minor gene RSP's could then be initiated. Where feasible, chemical seed treatment compounds can also be used for effective control.

Barley Yellow dwarf virus -

Some sources of resistance or tolerance have been identified but further fundamental work is required on aphid transmission studies using different strains of the virus. Preliminary RSP's will be initiated in 1978.

Spot Blotch - caused by Helminthosporium sativum.

This is one of the three diseases of barley caused by Helminthosporium species. It often occurs on the same leaves with net blotch (Pyrenophora teres = Helminthosporium teres) and the symptoms may be easily confused with the latter, particularly with the spot type symptom of the net blotch organism (Smedegard - Petersen 1976). Major genes for resistance are being identified and RSP's will be initiated in 1978. It is estimated that minor gene RSP's can be started the following year.

Bacterial streak, Bacterial blight, Helminthosporium stripe and Dryland root rot are caused by Xanthomonas translucens, Pseudomonas syringae, Helminthosporium gramineum = Pyrenophora graminea and a complex of Helminthosporium sativum and Fusaruim roseum, respectively.

These diseases have come under investigation quite recently and considerable more fundamental information is required before RSP's can be initiated. More screening with difference virulence groups are required to identify resistance sources and suitable techniques for large scale inoculum production, and inoculation need to be established. Once

these techniques have been established RSP's may be initiated as estimated in Table 2.

It should also be emphasized that additions to the agronomic base or resistance base may be added at any time during the recycling of any of the RSP's.

Special Procedures:

Under this category, screening for resistance to specific toxins, the BSMV serodiagnosis program, the single gene transfer system and allele testing will be considered.

It has been shown by Auriol, et al. (1977) that resistance to the Rhynchosporium toxin is linked to resistance to R. secalis, but that two separate genetic entities regulate these two phenomena. Even though the resistance to the toxin is not 100% correlated with resistance to the fungus, it would be ultimately desirable to eliminate toxin susceptibility from commercial barley cultivars in order to reduce crop loss. Since the two genes are linked, it is conceivable that a simple toxin screening procedure may be successful in acquiring lines that are also resistant to the fungus. Ideally, the toxin screening procedure would involve the use of the synthetic toxin (prepared by organic chemical means) and its application to either seed, young plants, or separate young leaves in test tubes. Workable methods have been developed to synthesize such compounds. We would ultimately select the best method for toxin and toxin analogue synthesis, and develop the most effective screening technique. Such procedures could then be compared with scald inoculation tests in the greenhouse.

The serodiagnostic technique for BSMV is a double diffusion technique in agar gel using sodium dodecyl sulfate as a degrading agent for the virus. This test could be used for detection of BSMV in embryos or leaves. The technique was developed at Montana State University and a manuscript in which it and its application are described, will soon be submitted to the journal "Phytopathology" for possible publication. It is envisioned that barley workers at the international centers would be provided with the necessary reactants, including antisera, for the serodiagnosis of BSMV in barley. Training workers in this technique could be done at either Montana State University or at the centers.

Briefly, the technique is a simple modification of an immunodiffusion method developed by Hamilton (1965) in which sodium dodecyl sulfate is substituted for leonil SA detergent. Paper disks - 6 mm in diameter - are placed on the medium comprised of 0.6% Noble agar, 0.1% SDS and 0.1% sodium azide (all w/v) in 0.05 M sodium borate buffer, pH 8.0. About 1.0 ml of medium is dispensed per plate.

When testing barley seed lots, embryos are separated from the endosperms rather easily. Seeds are covered with water, dehulled in a Waring blendor, and soaked in water overnight. Embryos are separated from the swollen, dehulled endosperms by a metal rolling pin. Embryos are recovered through a sieve having round hole perforations 1/8 of an inch in diameter. Embryos are transferred to a Petri dish containing distilled water. Next, embryos are placed on filter paper disks lying in an embryo press, wetted with distilled water, and then crushed. Subsequently, the supporting disks and crushed embryos are transferred to the test plate. Reactions can be read 24 hrs. later. Infected embryos produce precipitation lines in the agar medium between the embryo and antiserum disks.

Similarly, this technique can be applied to testing barley plants in all growth stages, except fully mature. In this case, leaf sap, obtained by the vise-grip pliers method, is substituted for embryos.

When selecting for a multitude of traits in segregating populations, each additional gene to be selected for requires doubling the population size, conversely each desired gene present in a homozygous condition halves the necessary population size.

Certain genes require an undue amount of labor, expertise, and risk to establish in the homozygous condition in a population. Genes for disease resistance in barley are a good example. For effective selection an epiphytotic must be developed in the growth chamber, greenhouse, or field. Seedling reaction may not be the same as mature plant response. The virulence necessary for selection may not be present and must be introduced to an area representing some degree of hazard. The pathogen may have to be cultured, sometimes representing a problem. Inoculum in large quantities may be necessary. Dependence on natural infections, and artificial inoculations for field infections can frequently result in disappointment and slow a program.

Considerable progress has been made in genetic systems that will permit gene transfers that establish a population homozygous for a selected gene without evaluating for the presence of the desired alleles.

The system basically involves the transfer of a chromosome segment with the desired gene, through the use of translocations having an induced marker gene in an interstitial segment.

To establish the system one needs to know on what chromosome it is located (accomplished with primary trisomics), have available a translocation

that does not cross-over with the translocation breakpoint (determined in translocation crosses, susceptible x resistant), and induce a marker gene, preferably a lethal, in the interstitial segment of the translocation. The system also requires (preferably) several "donor" parents homozygous for the gene to be transferred.

A translocation heterozygote as established above (recognized by semi-sterility) is crossed to a homozygous "donor" and the semi-sterile F_1's continued into F_2 where only completely fertile plants are selected. These plants will be normal cytologically and homozygous for the gene or genes transferred.

Once the system is established it is good for all time: and can be used by anyone that can make a cross and distinguish between fertile and semi-sterile plants.

The general procedures are listed below:

1. Determine sources of resistance
2. Allele test, to avoid duplication
3. Assign non-allelic genes to chromosomes with primary trisomics
4. Determine suitable identified translocation (some 500 are available)
5. If necessary induce lethal gene in interstitial segment (We have done this with about 20 translocations)
6. Develop a suitable "donor".
7. Check the system to see that it is working properly.
8. Release the stocks for general use throughout the world.

It is proposed to do this with net-blotch, scald, stem rust, leaf rust and other diseases as time permits. It is now possible to manipulate several of the disease resistant genes in this manner.

5. Selection Pressures

Throughout the disease work the emphasis is on accumulation of genes for resistance in an outcrossing population. The second step is to get these genes well distributed in the population and the third step is then to apply rather severe selection pressure for resistance to increase the frequency of all resistant genes in the population. For example, a minimum of three cycles of selection and recombination are required to pyramid eight (8) resistant loci into one plant.

Once this is accomplished then one can turn to improvement of the population for general agronomic type with less risk of losing some of the genes for resistance.

Probably the most obvious improvement would be to eliminate colored lemma and smooth awn types. A second improvement could be the establishment of definite maturity groups (perhaps 3). When introducing the resistant genes into the population both vvII (6-row) and VVii genotypes were introduced simultaneously. The populations should be purified to these two row types, particularly the vvii genotype should be eliminated from the 6-row population. Shattering resistance can be improved by delayed harvests in Arizona. Sieving on a 6½ or 7/64" sieve can assure that the seed weight component of yield is adequate. Other population improvements can be made. It should be emphasized that improvements of agronomic potential of the population should at no time put the population through a "bottle-neck" that would restrict the underlying genetic base and diversity of the population.

It should be recognized that the underlying 15 parental varieties for the 2-row population and the 15 for the 6-row population were selected for wide adaptation, particularly in the mideast.

If in the selection for disease resistance in the target countries it is also possible to select for desirable plant types then adaptation should be improved.

Much of the final population improvement, particularly in the final stages, should be done under the conditions, i.e., in the country, where the varieties are to be selected.

6. 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 RSPs will be grown in several locations within the United States and at foreign sites. A tentative listing of nursery locations for the RSPs is given in Table 3. 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.

7. 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 semiarid areas of the world.

In the other approach the trainees would not work toward an advanced degree but would participate in a six month training period. They would receive training in laboratory and field work primarily with barley diseases. They would spend the bulk of the time at MSU - Bozeman, but would also be involved with the winter plots in Arizona. The trainees would receive training in laboratory and field 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 RSPs 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 virus. Training would also involve various methods of hybridization and techniques and materials required for serodiagnosis for BSMV.

8. Linkages:

The linkages involved in this project have been previously described (Section D) and include CIMMYT, ICARDA, FAO, and other national and state organizations.

II. Proposed Barley Workshop.

The Barley Workshop held at Amman, Jordan, April 24-28, 1977 and the related field tours served a very worthwhile purpose. It was a useful educational experience for all countries involved and resulted in a much better understanding

of the importance of barley for the LDCs and of the problems involved in increasing barley production.

It is proposed that another Barley Workshop be held in the spring of 1980 in a Middle East location, to be selected later. Similar to the previous workshop, it is proposed that it be sponsored cooperatively with the international centers such as CIMMYT and ICARDA.

The financial assistance required for such an undertaking is given 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.

I. 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 RSPs is given in Table 2 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 2, 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 RSPs.

The SDS serodiagnostic test can be used, along with roguing, to develop a control program for BSMV at ICARDA and/or CIMMYT. Initially, the program would be confined to a limited number of breeder stocks. Later, however, the program could be expanded to include all important stocks. Roguing symptomatic plants from breeding stock in field plots would eliminate all severe and moderate strains, and some mild strains of BSMV, but no latent strains of the virus. Serodiagnosis, on the other hand, would detect all strains, including those strains which would not cause readily visible symptoms. The anticipated time sequence development for the establishment of an effective control program for BSMV is given in Table 4 and the different steps and substeps are explained in Figure 2.

Table 2. Time phased work plans.

Scald	1978	1979	1980
2-row major		Cycle 1 ---------->	
2-row minor		Cycle 1 ---------->	
6-row major	Cycle 2 ---------->		Cycle 3
6-row minor	Cycle 1 ---------->		Cycle 2
Net blotch			
2- row major		Cycle 1 ---------->	
2-row minor		Cycle 1 ---------->	
6-row major	Cycle 1 ---------->		Cycle 2
6-row minor	Cycle 1 ---------->		Cycle 2
Stem rust			
2-row major		Cycle 1 ---------->	
2-row minor		Cycle 1 ---------->	
6-row major	Cycle 1	Cycle 2 ---------->	
6-row minor		Cycle 1 ---------->	
Leaf rust			
2-row major		Cycle 1 ---------->	
2-row minor		Cycle 1 ---------->	
6-row major	Cycle 1 ---------->		Cycle 2
6-row minor		Cycle 1 ---------->	
Covered Smut			
2-row major		Cycle 1 ---------->	
2-row minor	--	--	
6-row major	Cycle 1	Cycle 2 ---------->	
6-row minor	--	--	

Table 2 (con't)

	1978	1979	1980
Yellow dwarf			
2-row major		Cycle 1 ---------->	
2-row minor	--		Cycle 1
6-row major		Cycle 1 ---------->	
6-row minor	--		Cycle 1
Xanthomonas			
2-row major			Cycle 1
2-row minor			Step 2
6-row major			Cycle 1
6-row minor			Step 2
Spot Blotch			
2-row major		Cycle 1 ---------->	
2-row minor			Cycle 1
6-row major		Cycle 1 ---------->	
6-row minor			Cycle 1
Pseudomonas			
2-row major			Cycle 1
2-row minor		--	Step 2
6-row major			Cycle 1
6-row minor		--	Step 2
Stripe			
2-row major			Cycle 1
2-row minor		--	Step 2
6-row major			Cycle 1
6-row minor		--	Step 2
Dryland Root Rot			
2-row major			Cycle 1
2-row minor		--	Step 2
6-row major			Cycle 1
6-row minor		--	Step 2

Table 3. Tentative List of Disease Screening Nurseries for 1978

	Contacts	Scald	Net blotch	Leaf rust	Stem rust
Bozeman, MT	Bockelman, Sharp	✓	✓	✓	✓
Ft. Benton, MT	H. Hanford	✓	✓		
Sidney, MT	Glenn Hartman	✓	✓		
Conrad, MT	Supervisor, Sattelite Res. Sta.	✓	✓		
Experiment, GA	B. Cunfer	✓			
Quincy, FL	R. D. Barnett	✓			
Stockton, CA	NK, Western P.B.	✓			
Izmir, Turkey	F. Demirkan	✓	✓		
Nicoller, Tunisia	Djerbi, H. Stoetzer	✓	✓	✓	
Aleppo, Syria	J. Srivastava	✓	✓		
Nakura, Kenya	G. Kingma	✓	✓	✓	✓
Sacha, Egypt	Ali Mansoor		✓	✓	✓
, France (Cargill Seed Co., Ft. Collins)	Mike Gleason	✓	✓		✓
Rabat, Morocco	G. de Smet	✓	✓	✓	

Table 4. Time phased work plan.

BSMV	1978	1979
	Step 1	Step 2

Fig. 2. Procedure for development of a BSMV Control Program.

Step 1. Initiate the program.

a. Eliminate the virus from breeding stocks.

1. Rogue symptomatic plants from field plots.

a. Train foreign barley workers to recognize disease symptoms.

b. Serologically verify presence of BSMV in some plants of key breeding stocks.

2. Establish a central clearing laboratory for serodiagnosis of all seed lots moving among breeding programs for freedom of BSMV.

a. Train foreign barley workers to use the serodiagnostic test developed at MSU for the detection of BSMV in embryos or seedling leaves.

b. Supply essential reactants (antisera, known antigen preparations, etc.) to the foreign barley workers.

Step 2. Review the program.

a. Inspect breeding stocks in field plots for occurrence or nonoccurrence of symptoms caused by BSMV.

b. Spot check by serodiagnosis randomly selected seed lots of breeding stocks for the presence of BSMV.

c. Report findings, including possible recommendations for improvement in the control program.

J. Contractor Internal Management and Facilities:

1. Local Research Organizations Involved

a. 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
Dr. Gary A. Strobel

b. Dept. of Plant & Soil Sciences

Department Head: Dr. K. C. Feltner

Key Project Personnel: Professor R. F. Eslick

Key Project Cooperator: Dr. E. A. Hockett
ARS, USDA Barley breeder Genticist

c. Montana Agricultural Experiment Station

Dean & Director: Dr. Johan A. Asleson

d. Research Centers - Montana

Agricultural Experiment Station
Eastern Montana Research Center
Sidney, Montana
Director: Mr. Glenn P. Hartman

e. Grants and Contracts Office
Montana State University - Bozeman

Director: Prof. Theodore Williams

2. 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.

K. Key Project Personnel:

Eugene L. Sharp (Principal Investigator)

a. Education:

B.S. Major:	Botany	University of Idaho, Moscow	1949
M.S. Major:	Plant Pathology	Iowa State University, Ames	1951
Minor:	Crop Breeding		
PhD. Major:	Plant Pathology	Iowa State University, Ames	1953
Minor:	Crop Breeding		

b. Experience:

Research Plant Pathologist, Fort Detrick, Frederick, Md. - 1953-1957
(2 years with U.S. Army Chemical Corps. Biological Lab.)
(2 years as civilian employee)
Ass't Professor of Plant Pathology, Mont. State Univ. - 1957-1962
Assoc. Professor of Plant Pathology, Mont. State Univ. - 1962-1967
Professor of Plant Pathology, Montana State University - 1967-present
Professor & Head, Plant Path., Montana State Univ. - 1973-present
Von Humbolt Senior Scientist Awardee
Braunschweig, Federal Republic of Germany - Oct. 1975-Oct. 1976

c. Principal Publications:

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. 55:2142-2148.

Sharp, E. L. and H. E. Bockelman. 1977. Utilizing recurrent selection populations for disease resistance in barley. Proceedings of Barley Workshop, Amman, Jordan. Apr. 24-28. (In Press).

Robbelen, G. P. and E. L. Sharp. 1977. Mode of inheritance, interaction and application of genes conditioning resistance to yellow rust. Advances in Plant Breeding. Supplement 9 to Journal of Plant Breeding. Paul Parey Berlin and Hamburg. 150 pp. (In Press).

Sharp, E. L. 1976. Broad based resistance to stripe rust in wheat. Fourth European and Mediterranean Cereal Rusts Conference. Interlaken, Switzerland. 5-10 Sept. 159-161.

Sharp, E. L., B. K. Sally and G. A. Taylor. 1976. Incorporation of additive genes for stripe rust resistance in winter wheat. Phytopath. 66:794-797.

Sharp, E. L. 1973. Wheat. Chapter in Breeding plants for disease resistance - concepts and application. Editor R. R. Nelson.

The Pennsylvania State University Press, University Park and London. 110-131.

Amount of time on project - 25%

K. Key Project Personnel:

Thomas W. Carroll

a. Education:

B.S.	Horticulture	Calif. State Polytechnic Coll.	- 1954
M.S.	Plant Pathology	Univ. of Calif., Davis	- 1962
PhD.	Plant Pathology	Univ. of Calif., Davis	- 1965

b. Experience:

Postdoctoral Research Plant Pathologist, Univ. of Calif., Davis	- 1965-1966
Asst. Prof. of Botany, Montana State Univ.	- 1966-1969
Assoc. Professor of Botany, Montana State Univ.	- 1969-1974
Professor of Plant Pathology, Montana State Univ.	- 1974-present

c. Principal Publications:

McNeal, F. H., M. A. Berg, and T. W. Carroll. 1976. Barley stripe mosaic virus data from six infected spring wheat cultivars. Plant Dis. Reptr. 60:730-733.

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.

Carroll, T. W., and D. E. Mayhew. 1975. Barley stripe mosaic virions associated with spindle microtubules in barley cells undergoing microsporogenesis. Proc. of Third International Barley Genetics Symposium. p. 525.

Mayhew, D. E., and T. W. Carroll. 1974. Barley stripe mosaic virus associated with spindle microtubules. Science 185:957-958.

Carroll, T. W. 1969. Electron microscopic evidence for the presence of barley stripe mosaic virus in cells of barley embryos. Virology 37:649-657.

• McNeal, F. M., and T. W. Carroll. 1968. Wheat streak mosaic in twelve varieties of spring wheat. Plant Dis. Reptr. 52:201-203.

Amount of time on project - 20%.

K. Key Project Personnel:

Robert F. Eslick

a. Education:

B.S.	Washington State University	- 1939
M.S.	University of Wyoming	- 1942
	University of Wisconsin	- 1948
	Oregon State University	- 1956

b. Experience:

Student Asst.	Washington State University	1935-1939
Grad. Asst.	University of Wyoming	1939
Instructor	University of Wyoming	1940-1942
Asst. Prof.	Colorado State University	1942-1946
Assoc. Prof.	Montana State University	1946-1956
Professor	Montana State University	1956-present

c. Principal Publications:

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:66-73.

Jarvi, A. J. and R. F. Eslick. 1975. Shrunken endosperm mutants in barley. Crop Science 15:363-366.

Ramage, R. T. and R. F. Eslick. 1975. Translocation Linkage test - T2-Ta x male sterile genes. BGN5:46-48.

Eslick, R. F. and E. A. Hockett. 1974. Genetic Engineering as a key to water-use efficiency. Agric. Meteor. 14:13-23.

Ferguson, Hayden, R. F. Eslick and J. K. Aase. 1973. Canopy temperatures of barley as influenced by morphological characteristics. Agron. J. 65:425-428.

Pomeranz, Y., R. F. Eslick and F. S. Robbins. 1972. Amino acid composition and malting and brewing performance of high-amylose and hiproly barleys. Cereal Chem. 49:620.

d. Amount of time on project - 20%.

K. Key Project Personnel:

Donald E. Mathre

a. Education:

B.S. Botany	Iowa State University	- 1960
PhD. Plant Pathology	University of Calif., Davis	- 1964

b. Experience:

Asst. Prof. of Plant Pathology, Univ. of Calif., Davis Responsible for soil-borne diseases of cotton.	- 1964-1967
Asst. Prof. of Plant Pathology	- 1967-1969
Assoc. Prof. of Plant Pathology	- 1969-1972
Professor of Plant Pathology, Mont. State Univ. Responsible for soil borne diseases of wheat and barley	- 1972-present

c. Principle publications:

Mathre, D. E., R. H. Johnston, and C. G. McGuire. 1977. Cephalosporium stripe of winter wheat: Pathogen virulence, sources of resistance, and effect on grain quality. Phytopathology 67:1142-1148.

Darlington, L. C., T. W. Carroll, and D. E. Mathre. 1976. Enhanced susceptibility of barley to ergot as influenced by barley stripe mosaic virus infection. Plant Disease Reporter. 60:584-587.

Mathre, D. E., and R. H. Johnston. 1976. Presence of dwarf and common smut in Montana wheat. Plant Disease Reporter 60:580-583.

Mathre, D. E., and R. H. Johnston. 1975. Dispersion of loose smut in foundation barley seed fields in a semiarid climate. Plant Disease Reporter 59:979-981.

Mathre, D. E., and R. H. Johnston. 1975. Cephalosporium stripe of winter wheat: Infection processes and host response. Phytopathology 65:1244-1249.

Cunfer, B., D. E. Mathre, and E. A. Hockett. 1974. Factors influencing the susceptibility of male-sterile barley to ergot. Crop Science 15:194-196.

Amount of time on project - 15%.

K. Key Project Personnel:

David C. Sands

a. Education:

A.B.	Botany	Pomona College	- 1963
PhD.	Plant Pathology	Univ. of Calif., Berkley	- 1969

b. Experience:

N.S.F. Postdoctoral fellow to C.S.I.R.O., Div. of Soils, Adelaide, Australia.	- 1969-1970
Asst. Plant Pathologist, Connecticut Agr. Expt. Stn., New Haven, Ct.	- 1970-1976
Asst. Professor of Plant Pathology, Mont. State Univ.	- 1976-

c. Principle Publications:

Sands, D. C. and L. Hankin. 1976. Fortification of foods by fermentation with lysine-excreting mutants and lactobacilli. J. Agric. Food Chem. 24:1104-1106.

Sands, D. C. and L. Hankin. 1975. Ecology and physiology of fluorescent pectolytic pseudomonads. Phytopathology 65:921-924.

Sands, D. C. and L. Hankin. 1974. Selecting lysine-excreting mutants of lactobacilli for use in food and feed enrichment. Applied Microbiol 28:523-524.

Sands, D. C. and A. D. Rovira. 1971. Modifying the virulence and host range of weed pathogens. IN Proceedings of the Third International Conference on Plant Pathogenic Bacteria, Wageningen.

Sands, D. C., M. N. Schroth and D. C. Hildebrand. 1970. Taxonomy of phytopathogenic pseudomonads. J. Bacteriology 101"9-23.

Sands, D. C. and A. D. Rovira. 1970. Isolation of fluorescent pseudomonads with a selective medium. Applied Microbiol. 20:513-514.

Amount of time on project - 20%.

X. Key Project Personnel:

Albert L. Scharen

a. Education:

B.S.	Agronomy	Univ. of Wyoming, Laramie	- 1952
M.S.	Plant Pathology	Univ. of Nebraska, Lincoln	- 1956
PhD.	Plant Pathology	Univ. of Nebraska, Lincoln	- 1960

b. Experience

Research Plant Pathologist ARS-USDA, Beltsville, Md. - 1960-1972
Research Plant Pathologist, Mont. State Univ., Bozeman - 1972-present

c. Principle Publications:

Scharen, A. L., and J. M. Krupinsky. 1977. Detection and accumulation of resistance to Septoria nodorum in wheat. Phytopathology. (In press).

Krupinsky, J. M., J. C. Craddock and A. L. Scharen. 1977. Septoria resistance in wheat. Pl. Dis Reptr 61:632-636.

Eyal, A. and A. L. Scharen. 1977. A quantitative method for the inoculation of wheat seedlings with pycnidiospores of Septoria nodorum. Phytopath. 67:712-714.

Scharen, A. L., J. W. Bergman and E. E. Burns. 1976. Leaf diseases of winter wheat in Montana and losses from them in 1975. Plant Dis Reptr. 60:686-690.

Scharen, A. L., and J. M. Krupinsky. 1973. The effect of age on virulence of Septoria nodorum spores on wheat. Plant. Dis. Reptr 57. 363-366.

Krupinsky, J. M., J. A. Schillinger and A. L. Scharen. 1972. Resistance in wheats to Septoria nodorum. Crop Science 12:528-530.

Amount of time on project - 15%.

K. Key Project Personnel:

Gary A. Strobel

a. Education:

B.S. Botany	Colorado State University (with honors)	- 1960
PhD. Plant Pathology	Univ. of California, Davis	- 1963

b. Experience:

Assist. Prof. of Plant Pathology, Mont. State Univ. - 1963-1967
Assoc. Prof. of Plant Pathology, Mont. State Univ. - 1967-1971
Professor of Plant Pathology, Mont. State Univ. - 1971-present
A.A.A.S., American Society of Plant Physiologists, American Society of Biological Chemists, American Phytopathological Society. Has served on editorial boards and various committees for these organizations.

c. Principal Publications:

Kenfield, D. S., and Gary A. Strobel. 1977. Biochemical aspects of plant disease resistance and susceptibility. American Chemical Society (in press).

Nachmias, A., I. Barash, Ā. Solel, and Gary A. Strobel. 1977. Purification and characterization of a phytotoxin produced by Phoma tracheiphila, the causal agent of Mal-secco disease of citrus. Physiol. Plant Pathol. 10:147-157.

Strobel, Gary A. 1976. Phytotoxins as tools in studying plant disease resistance. Trends in Biochemical Sciences 1:247-250.

Strobel, Gary A. 1977. Bacterial phytotoxins. Ann. Rev. Microbiol. 31:205-224.

Strobel, Gary A. 1976. Toxins of Plant Pathogenic Bacteria and Fungi. Plant Biochemistry Series, Phytochemical Society. Academic Press, 135-159.

Strobel, Gary A. 1974. Phytotoxins from plant parasites. Ann. Rev. of Plant Physiol. 25:541-566.

Amount of time on project - 15%.

L. General Project Appraisal.

This project has been given high priority by the Crop Production Division and Office of Agriculture. In addition to the need for developing barley populations carrying broad levels of resistance to specific diseases which will be useful to LDCs, the strong support to be provided CIMMYT's and ICARDA's barley disease breeding program is considered essential.

Internationally, less research and breeding work have been conducted with barley than with any of the other major cereal crops. In the United States, only two universities have any significant research in progress on population improvement on this crop and only one (Montana State University) is devoting more than one full-time equivalent research scientist's time to the crop.

The proposing institution has a strong staff with excellent experience in most of the developing countries with whom they will be working. Equipment needed for the proposed project is available with the exception of expendable supplies, etc. Facilities available include several controlled environment chambers, dew chambers, inoculation towers, isolation greenhouses, lyophilization apparatus and standard laboratory facilities for virus, bacterial and fungal cultural studies. Field facilities and equipment for breeding nurseries, screening lines and introduced germ plasm, and conducting agronomic trials are available at the Agricultural Experiment Station field research farm located a few kilometers from the campus.

The proposal is sound in design and cost estimates are appropriate in the level of effort intended. The project is not a high risk activity. Sources of genetic resistance to the diseases in question are known and ready for inclusion into the recurrent selection populations. The technical knowledge and capability is available and this in turn assures rapid,

specific outputs which can be achieved for each of the objectives. The probability for success within the three year contract period is almost one hundred per cent.

A detailed review of the project should be conducted at the end of the second project year to assess progress and to determine the need for possible extension.

M. Environmental Considerations.

Since this project involves only controlled experimentation on small plots, and is therefore of limited scope and under strictly controlled conditions, it has been determined that it will not result in a major federal action which will have a significant effect on the human environment.

Therefore, an Environmental Impact Statement or an Environmental Assessment will not be required.

N. Women In Development.

This project will provide equal opportunity for women, both for women participants from the LDCs and for potential women professional staff.

O. Contract Considerations.

1. Identification of the contracts or grants that will be needed to implement the program: N.A.
2. Description of services and supporting goods to be included in the proposed scope of work of each contract or grant: See Work Plan.

3. The proposed procurement agent: A.I.D. Washington.

4. Proposed method of procurement: Noncompetitive procurement based on predominant capability.

5. Independent government cost or price estimates: Subject to negotiation by SER/CM.

6. Special Terms, required waivers, etc.: None.

7. Scheduled dates for award and contractor start up: N/A.

P. 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	87,658	102	96,595	108	102,331	108	286,584	318
2. Fringe Benefits (13.5%)	11,834		13,040		13,815		38,689	
3. Indirect Costs (52.0%)	51,736		57,010		60,396		169,142	
4. Travel & Per Diem								
(a) Domestic	2,400		3,000		3,000		8,400	
(b) International	13,000		15,500		16,000		44,500	
5. Equipment	8,000		2,000		3,000		13,000	
6. Materials & Supplies	4,400		3,400		3,700		11,500	
7. Publications	800		800		1,000		2,600	
8. Other Direct Costs (Repairs, Maintenance & Comm)	1,300		1,300				3,900	
9. Training	41,996	24	37,579	24	65,258	24	144,833	72
10. Totals	223,124	126	230,224	132	269,800	132	723,148	
Outputs								
Project Design & Method G-1 = General Methods (includes fundamental studies)	36,769		27,741		14,318		78,828	

P. Contract Budget and Life-of-Project Cost (Cont'd)

Inputs	Year 1	Work Months	Year 2	Work Months	Year 3	Work Months	TOTAL	Work Months
G2-Germplasm Bank for resistance sources and virulence pool	42,384		41,611		30,477		114,472	
G3-Diseases in relation to RSP development	44,920		59,142		105,339		209,401	
G4-Special procedures (toxins, serodiagnosis gene transfers)	57,055		64,151		54,408		175,614	
Training of young RDC scientists (Barley Research)	41,996		37,579		65,258		144,833	

Training Portion

	Inputs	1 Year 1	Man mos.	2 Year 2	Man mos.	3 Year 3	Man mos	4	5 Totals	Man mos
1	Salaries	15,300	24	16,218	24	17,191	24		48,709	72
2	Fringe benefits	2,066		2,189		2,321			6,576	
3	Indirect costs	9,030		9,572		10,146			28,748	
4	Travel & Per Diem									
	(a) Domestic	1,600		1,600		1,600			4,800	
	(b) International	6,000		3,000		6,000			15,000	
5	Equipment									
6	Materials & Supplies	1,000		1,000		1,000			3,000	
7	Publications									
8	Other Direct Costs Dep. allow.	7,000		4,000		7,000			18,000	
9	Barley Workshop Spring 1980					*20,000				
10	Totals	41,996	24	37,579	24	65,258	24		144,833	72
	Outputs									
	Training of young scientists (Barley research)	41,996		37,579		65,258			144,833	

* To furnish travel assistance funds for foreign and national scientists with expertise in barley diseases.

Literature Cited

Alemeddine, M. A. 1965. Location of genes for resistance to Puccinia hordei in the barley varieties Sudan and Reka I as determined by means of translocation stocks. Magon, Tel-Amara: Sci Ser. No. 3:32-43.

ARS-USDA 1968. Barley: Botany, Culture, Winter hardiness, Genetics, Utilization, Pests. Agr. Handbook #338.

Auriol, P., G. A. Strobel, J. P. Beltran and G. Gray. 1977. Rhychosporoside - a host selective toxin produced by Rhynchosporum secalis, the causal agent of scald disease in barley. Proc. Natl. Acad. Sci. (USA) submitted.

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. Jour. Bot. 55:2142-2148.

Eslick, R. F. 1977. Personal Communication.

Hamilton, R. I. 1965. An embryo test for detecting seed-borne barley stripe mosaic virus in barley. Phytopathology 55:798-799.

Harlan, H. V. and M. L. Martini. 1929. A composite hybrid mixture. Jour. Amer. Soc. Agron. 21:487-490.

Hockett, E. A., R. F. Eslick, D. A. Reid and G. A. Wiebe. 1968. Genetic male sterility in barley. II Available srping and winter stocks. Crop Science 8:754-755.

Jackson, L. F. and R. K. Webster. 1976. Race differentiation, distribution and frequency of Rhynchosporium secalis in California. Phytopathology 66:719-725.

James, W. C. 1977. Crop production constraints - plant protection programme. 16th Session of the FAO/ICP working Group on Pesticides. FAO Headquarters, Rome.

Khan, T. N., and W. J. R. Boyd. 1969. Inheritance of resistance to net blotch in barley II. Genes conditioning resistance against rac- W. A. -2. Can. Jour. Gen. Cyt. 11:592-597.

Piening, L. and M. L. Kaufmann. 1969. Comparison of the effects of net blotch and leaf removal on yield of barley. Can. J. Plant Sci. 49:731-735.

Roane, C. W., and T. M. Starling. 1970. Inheritance of reaction to Puccinia hordei in barley III. Genes in the cultivars Cebada Capa and Franger, Phytopathology 60:788-790.

Sharp, E. L., B. K. Sally and G. A. Taylor. 1976. Incorporation of additive genes for stripe rust resistance in winter wheat. Phytopathology 66:794-797.

Shipton. W. A., W. J. R. Boyd and S. M. Ali. 1974. Scald of barley. Review of Plant Pathology 53:839-861.

Singh, S. P. 1977. Use of genetic male sterility for simultaneous conversion and improvement of alien sorghums. Crop Science 17:482-484.

Smedegard-Petersen, V. 1976. Pathogenesis and genetics of net-spot blotch and leaf stripe of barley caused by Pyrenophora teres and Pyrenophora graminea. Royal Agricultural and Veterinary College publication. Copenhagen, Denmark.

Srivastava, J. P. 1977. Barley production, utilization and research in the Afro-Asian region. Fourth Regional Cereal Workshop - Barley. Amman, Jordan 24-28, April.

Suneson, C. A. 1940. A male sterile character in barley. Jour. Hered. 31:213-214.

Suneson, C. A. 1956. An evolutionary plant breeding method. Agron. Jour. 48:188-191.

Suneson, C. A. 1963. Breeding techniques - composite crosses and hybrid barley. Barley Genetics I, centre for Agricultural Publications and Documentation, Wageningen, Netherlands. 303-309.

LOGICAL FRAMEWORK

Project Title & Number: 931-1312 Control of Barley Diseases for the Lesser Developed Countries of the World

Total U. S. Funding
Date Prepared: ____

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: Improving quality of life of the poorest of the poor in dry areas where barley can be most advantageously grown. Control of barley diseases	Measures of Goal Achievement: Increased productivity of barley and well-being of people involved in the LDC's	Country statistics from Ministeries of Agriculture USAID reports On-site observations	Assumptions for achieving goal target: Recipient Countries give priority to food production.
Project Purpose: Pyramid genes for resistance to barley diseases in agronomically suitable genetic backgrounds. Establish serodiagnostic test for BSMV at ICARDA & CIMMIT.	Conditions that will indicate purpose has been achieved: End of project status. Barley stocks incorporated into barley breeding programs of target areas resulting in better disease protection and improved barley production. Serodiagnosis routinely used for testing seed lots for BSMV.	LDC reports Contractor reports On site evaluations	Assumptions for achieving purpose: Selection procedures are adequate Diversity of germ plasm is present in starting materials
Outputs: 1. populations with broad-based resistance 2. populations homozygous for resistance but heterozygous for other characters. 3. Germ plasm bank - both resistance sources and pathogen virulence types. 4. Data on reaction of entries in uniform tests to several diseases.	Magnitude of Outputs: Four populations for each disease Virus-free barley seed stocks Catalog of resistance gene combinations Catalog of virulences represented in the various diseases.	Contractor reports and on-site observations	Assumptions for achieving outputs: Genetical assumptions are correct. Selection procedures or successful entries are available for testing. Cooperators complete sowing of experimental materials.
Inputs: AID financial support; technical help & facilities provided by MSU, AID & LDC's provide logistical support in LDC's.	Implementation Target (Type and Quantity)	AID reports, on-site observations & contractor reports correspondence with LDC cooperators.	Assumptions for providing inputs: Approval of proposal. Adequate personnel available for contractor and Int'l Center linkages.