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ANNUAL REPORT on Control of Barley Diseases for Lesser Developed Countries of the World

August 1, 1980-December 31, 1981
Report No. 3 - Annual Report
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on

CONTROL OF BARLEY DISEASES

FOR LESSER DEVELOPED COUNTRIES OF THE WORLD

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Report No. 3

NOT FOR PUBLICATION

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A. Narrative Summary

This report covers the 3rd year of a current 3 year contract with the U. S. Agency for International Development and Montana State University to decrease losses caused by the major diseases of barley particularly in the developing countries. Development under this contract includes a number of facets. First, it was necessary to know the major diseases of barley in the target areas. This information was obtained largely by onsite visits, workshops and discussions with plant pathologists in the area. Several of our people have visited the Middle East area and have become familiar with problems of barley cultivation. It is also necessary to know the races or strains of pathogens in the target areas and to this end a number of disease isolates have been collected and are used in our evaluation programs in the Plant Pathology Department. These isolates of the different pathogens have been used for identifying genes for resistance in the barley cultivars. Different resistant sources to specific diseases have been sought among the world barley collection and based upon reports in the literature where a specific barley cultivar has been reported to be resistant at some time or place to a specific disease organism.

Other fundamental information is necessary before the resistant sources can be effectively utilized. This includes determining best artificial medium for spore production, best mass inoculation methods and criteria for disease evaluations.

After the fundamental studies have been completed it is possible to effectively utilize the information for developing germ plasm and the plant breeding phase becomes operational. Although recurrent selection populations have been assembled for seven different diseases of barley, five (scald, net blotch, leaf rust, xanthomonas streak and barley yellow dwarf virus) are receiving major emphasis. We have close working relations with CIMMYT and ICARDA and evaluate their crossing block materials each year for several diseases as well as furnishing resistant stocks for their programs.

In addition to development of resistant germ plasm in barley a training program in barley diseases and associated breeding is being conducted. This past year 2 trainees from two different LDC's participated and 5 foreign graduate students are also being supported by the barley-AID program. One of our graduates (M.S. degree) recently served as a plant pathologist in cereal diseases with ICARDA at Aleppo, Syria. Details on the various aspects mentioned in this summary are presented in the following sections.

Plant breeding can be divided into two phases:
(1) collection and development of germplasm resources, and
(2) exploitation or variety development.

Collection and development of germplasm resources are often given a low priority by the urgent need to develop varieties. However, adequate attention to germplasm resources, which are the parental materials for variety development, is essential for the long-term success of a breeding program. The Montana-USAID barley project is concerned, in large part, with the modification and improvement of germplasm with disease resistance represented in collections.

Most barley varieties contain only one to a few genes for resistance to a particular disease. In fact, only a single major-effect gene controls resistance in many varieties. Single (and even two or three) genes are easy to transfer. However, varieties with this type of resistance are frequently rendered susceptible by a changing pathogen. A single resistance gene employed in a widely-grown variety gives a selective advantage to mutants of the pathogen that are virulent. The usual procedure has been to replace such a variety with one resistant to the new race, once again forcing the pathogen to mutate.

Stability of resistance can be increased by utilizing numerous genes for resistance simultaneously. This can be accomplished by varieties with multi-line or multi-genic resistance. A multi-line variety consists of several agronomically-similar components that differ in one or more genes for resistance. They are most useful in controlling "compound interest" diseases, such as the rusts. Although one or two components may be susceptible to a particular race of the pathogen, the remaining resistant components will reduce the spread and severity of the disease by reducing the quantity of inoculum available for reinfection.

A variety with multi-genic resistance contains numerous genes for resistance in every plant. The usefulness of this type of resistance is based on the premise that many genes present a formidable obstacle to the pathogen. While a typical pathogen reproduces in such large numbers that multiple mutations for virulence to overcome any number of resistance genes can occur, this often upsets the homeostatic balance in the pathogen population, thus preventing such multiple mutations from becoming widespread (Parlevliet and Zadoks, 1977). There is, also, evidence that multi-genic resistance often has a horizontal component, resulting in resistance broader than the individual genes (Nelson et al. 1970). The major disadvantage of using multi-genic resistance has been the difficulty in transferring it.

Recurrent selection populations can be used to develop multi-genic resistance. A method commonly employed in cross-pollinated crops, recurrent selection utilizes populations of plants to intensify characters through cycles of selection and recombination. In order to use this method with a self-pollinated crop, such as barley, an easy means is needed to obtain large numbers of crosses. In barley this is accomplished with genetic male sterility.

A major goal of the Montana-USAID barley project is the development of germplasm with multi-genic resistance combined with good agronomic types utilizing male sterile-facilitated recurrent selection populations. The components of these populations are: (1) Genetic male sterility (a single, recessive gene). (2) Agronomic varieties (see Tables 1,2). These varieties are an integral part of the populations, enabling a plant breeder to select adapted plants. The varieties were selected for their proven performance in a number of barley-growing areas and for certain traits (e.g. hulless, large seed, earliness, shortness, waxy endosperm). (3) Lines with resistance. A number of different sources of resistance are used to include many genes for resistance. They are selected mainly on the basis of greenhouse seedling tests utilizing isolates of the disease organisms collected from numerous barley-growing regions. The initial assembly of the populations begins with hand crosses of the agronomic varieties and resistance sources onto the male sterile line. F_2 seed from each cross is then bulked.

The recurrent selection cycle consists of two generations: (1) selection for resistance and (2) recombination. Selection for resistance is conducted yearly in a number of locations (see Table 3). This diversity of locations is important to the development of multi-genic resistance. Assuming that the virulences of the pathogens are different in each location, then selection of resistant plants in these locations will be selection for different resistance genes. Seed returned from the disease nurseries is mixed and planted in isolation in a recombination nursery in the desert southwest during the winter months. F_1 seed is harvested from open-pollinated male sterile plants. This combines genes selected in the various locations. With continuing cycles a high percentage of the plants will be multi-genic for resistance.

Our experience has shown that the populations in their present state appear generally poor agronomically. This is to be expected since many of the lines with resistance in the populations are off-types from the world collection. However, a background of the good agronomic types should still be present. We have always used large numbers (more than 10,000 genotypes harvested for the next generation) to avoid loss of variability through a bottleneck. The first step for a breeder to exploit a population in a breeding program is to improve its agronomic quality in his environment. The breeder can make plant selections of promising material. These can be evaluated in head rows and tested further as any other segregating material in a pedigree breeding program. Since material selected from a population will contain multi-genic resistance care should be taken to avoid breaking up this resistance (i.e. avoid crossing to other material, especially susceptible lines). If a number of agronomically-similar selections can be made, then these could be combined into a "multi-line", where each component is multi-genic for resistance, but differing in individual genes. As a population is improved agronomically and with continued selection for disease resistance, the likelihood of selecting-out good material improves.

A total of 13 populations have been established and are in various stages of development (Table 4). The most advanced population is Composite Cross XXXVI (Bockelman et al. 1980), the 6-row population for scald resistance. Presently, five cycles of recurrent selection have been completed. Under conditions of natural infection in Montana about 95% of the plants are resistant. In California and other severe locations for scald, a substantial percentage are resistant. Wherever we have grown the population resistant plants have been present. C.C. XXXVI now includes components selected in Montana, California, Georgia, Maryland, Turkey, Tunisia, Syria, Korea, and Mexico.

The second-most advanced population is RSP-5 Rpt (to be registered as C.C. XXXVIII), the 6-row population for net blotch resistance. Presently, four cycles of recurrent selection have been completed. Under natural infection in Montana the population is 95% resistant. In California about 50% are resistant. RSP-5 Rpt presently contains components selected in Montana. California, Tunisia, Morocco, Egypt, Korea, and Mexico.

RSP-4 Rrs Minor and RSP-4 Rpt Minor are designed to select for minor-effect, additive genes for resistance to scald and net blotch, respectively. These populations contain the fifteen 2-row agronomic varieties along with Compana msg 10. Initially, these populations were 100% susceptible. Selection has been based on "less susceptible" plants or plants in which the spread of lesions upward in the plant is slower. Presently, after two cycles of recurrent selection in each population, they are still almost 100% susceptible, but "slow scalders" and "slow netters" are more frequent.

Commonly, more than one disease is important in a particular region. Therefore, germplasm with combined resistances would be useful. Presently, we are combining C.C. XXXVI and RSP-5 Rpt. The population sizes are reasonable.

In conclusion, large numbers of plants (and genes) can be handled in a male sterile-facilitated recurrent selection population with a small input of labor. These populations should be considered long-term germplasm resources to be continually exploited and continually improved.

B. Project Objectives

1. Different sources of resistance to the major diseases of barley and linkage relationships 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. Resistances to different specific diseases will be combined into barley stocks.

4. Assistance will be given in cooperative research for developing methods for determination of and control of various virus diseases of barley.

C. Accomplishments to Date

1. Introduction

Accomplishments on the project will be discussed within the specific diseases. In some cases fundamental information is being obtained which is prerequisite to identifying different sources of resistance and their incorporation into RSP's. In other cases, the fundamental work has been completed and different resistances are being actively incorporated into RSP's to form broad-based resistance. For scald, net blotch and leaf rust caused by *Rhynchosporium secalis*, *Pyrenophora teres* and *Puccinia hordei* respectively a number of resistance genes have been identified and many of these have already been incorporated into the RSP's.

2. Recurrent Selection Populations.

Progress is continuing on the development of germplasm with multi-genic, broad-based resistance utilizing male sterile-facilitated recurrent selection populations. Most emphasis is presently on the populations with 6-row types. A good percentage of overseas nurseries were successful in the past year. Following is a description of the RSP's and their present status.

a. RSP-5 Rrs (C.C. XXXVI) = 6-row population with scald resistance.

Four plus cycles of recurrent selection have been completed. A high percentage of the plants were resistant in most of the disease nurseries. At Davis, California more than half of the plants were resistant. The latest bulk includes components selected in Montana, California, Georgia, France, Korea, Turkey, Morocco, and Syria.

b. RSP-5 Rpt (C.C. XXXVIII) = 6-row population with net blotch resistance.

Three plus cycles of recurrent selection have been completed. High levels of resistance are present in this population when grown in a number of locations. A new form of *Pyrenophora teres* causing spot-type symptoms was detected at Fairfield, Montana. The population is mostly susceptible to this new form. The latest bulk of components includes material selected in Montana, California, Korea, Morocco, and Syria.

c. RSP-5 Rrs-Rpt = 6-row population with scald and net blotch resistance.

This population is the result of combining RSP-5 Rrs and RSP-5 Rpt in the recombination nursery, 1980-81. Scald and net blotch resistant plants were selected at Bozeman and Fairfield in 1981. This population should be of value in locations where both scald and net blotch occur.

d. RSP-5 Rph = 6-row population with leaf rust resistance.

Two-and-a-half cycles of recurrent selection have been completed. Fifteen new sources of resistance were added in 1981 (see Table 5). During the past year resistant plants were selected in south Texas, Morocco, and Turkey.

e. RSP-5 Reg = 6-row population with powdery mildew resistance.

One plus cycles of recurrent selection have been completed. Resistant plants were selected in Montana, France, and Morocco in 1981. At this early stage levels of resistance are low. However, this should improve because of the many good sources of resistance included.

f. RSP-5 Rxt = 6-row population for Xanthomonas resistance.

Three-and-a-half cycles of recurrent selection have been completed. Severe selection for resistance was done at three Montana locations in 1981. It is unclear whether resistance to Xanthomonas has been detected in this population since no improvement is apparent.

g. RSP-5 Rps = 6-row population for Pseudomonas resistance.

Work is continuing on this population at a low level. At present it is unclear whether resistance to Pseudomonas exists.

h. RSP-5 Ruh = 6-row population for covered smut resistance.

Progress in this population is continuing at a slow rate due to the low infection rates (i.e. 1-2%). However, it i easy to keep going and requires only a small amount of time and effort.

i. RSP-4 Rrs, RSP-4 Rpt, RSP-4 Rph = 2-row populations for scald, net blotch, leaf rust resistance, respectively.

These three populations are similar to the counterpart 6-row's. They are being advanced slowly since the 6-row populations are receiving the major emphasis. If the need arises for specifically 2-row barleys, these 2-row populations are available and can be advanced quickly.

j. RSP-4 Rrs minor and RSP-4 Rpt minor = 2-row populations for additive, minor gene resistance to scald and net blotch, respectively.

These two populations began as essentially 100% susceptible, containing no major genes for resistance. Presently, after two-and-a-half cycles of recurrent selection RSP-4 Rrs minor is still susceptible. RSP-4 Rpt minor is showing increased resistance levels and looks promising. Alternative selection techniques will be attempted, including selection for larger seed size (based on the premise that a susceptible plant will produce seeds of a reduced size and weight).

Disease Reaction of International Barley Nurseries

Entries from the 11th Regional Disease and Insect Screening Nursery, 10th Preliminary Observation Nursery, 11th Regional Crossing Block, and 8th International Barley Observation Nursery, were planted in hill plots at Bozeman and inoculated with Montana isolates of Rhynchosporium secalis (causal organism of scald) and Pyrenophora teres (causal organism of net blotch). A summary of the scald reactions is shown in Table 6. Net blotch infection was insufficient for readings.

3. Scald of Barley

a. Virulence patterns of Rhynchosporium secalis from several barley-growing regions. The results (see Table 7) illustrate the variability present in this pathogen. Three lines were resistant to all nine isolates. The most virulent isolates were from California, Tunisia, and Morocco.

b. Changing gene frequencies

The frequency of resistant and susceptible plants was calculated in each cycle for both greenhouse and field experiments (Table 8 and 9). The percentage of plants showing some degree of resistance in the field to the Montana isolate (Lew B77) reached 94% in three cycles of recurrent selection starting with a frequency of 68% in Cycle 0 (stage 1). This indicates there is about 5% increase in resistance after each cycle. A similar increase was noted in the greenhouse experiments. The frequency of resistant plants to the Tunisian isolate started with 41% and reached 65% after three cycles of recurrent selection indicating a 7% increase in resistance per cycle. There was a somewhat slower increase in resistance to the California isolate.

The percentage of resistant plants to both the Tunisian and the California isolates may have been greater if there was inoculation with each isolate at each cycle and thus increased selection pressure. In the Mediterranean locations and Korea no artificial inoculation is done with either of these isolates as opposed to artificial inoculation with Lew B77 isolate done here in Montana at each cycle.

With two isolates (Tun. 1 and Lew B77) a slight decrease of resistance was observed in the last cycle. This may possibly be attributed to difficulty in selecting resistant plants in some locations due to insufficient or absence of natural infection. In some cases selection in the overseas nurseries was based on agronomic traits rather than disease reaction as no disease had occurred.

4. Net blotch of barley

a. Additive genes for resistance.

The objective of this research was to demonstrate transgressive segregation for resistance to net blotch in barley. Several parents with susceptible or intermediate reaction types were chosen. Minor gene action would thus not be masked by any major genes.

The F_2 population was grown in the field and artificially inoculated with six isolates of P. teres representing the Montana virulence types. Several plants showing some improved resistance were selected from each cross. The F_3 - lines were subsequently screened for seedling resistance to net blotch using a single highly virulent isolate of P. teres. The selection process was repeated as for the F_2 - population. The established F_4 - lines were then screened for seedling resistance to a single isolate as well as to a combination of isolates for P. teres (Table 10). It was demonstrated that a high percentage of plants exceeds the resistance of their respective parents after only 2 cycles of selection indicating the presence of additive minor effect genes for resistance to P. teres. The results obtained when inoculating the F_4 - lines with a combination of isolates indicates that the resistance is nonspecific in action.

b. A possible biological control agent for net blotch of barley.

A bacterium, Bacillus licheniformis, produced metabolites in culture that were antagonistic to Pyrenophora teres. In the greenhouse, application of a suspension of the bacterium to leaves of barley seedlings normally susceptible to the net blotch disease rendered the plants highly resistant to subsequent inoculation with the pathogen. The bacterium had no obvious effects on the barley. Four treatments in the field were (1) control; (2) bacteria only; (3) fungus pathogen only: and (4) bacteria plus fungus. Bacteria were sprayed on the barley plants one day prior to inoculation with the pathogen. Bacteria established themselves on leaves of barley plants, and apparently prevented infection by the pathogen. Yields of barley were not significantly different from one another among the 1980 field treatments even though symptoms in the diseased plot were severe. Late infection was suspected as the reason for the lack of yield differences.

5. Leaf rust of barley

During the last year the intensive screening program of barley varieties has been continued. New sources of resistance to Puccinia hordei were detected (Table 11). They have already been incorporated into the RSP for leaf rust resistance.

Some of the material evaluated in the last two years was also genetically characterized. Several varieties carry recessive genes for leaf rust resistance (Menelik, CI 4974, Ford 1203). Dominant genes were found in CCIM-13 and CI 11577. The resistance gene in Estate (Pa_3) is identical with the one detected in the cross Giza 117/Bahtim/Giza 118/FAO 86 (386-16-2).

Field assessments of a large number of varieties were carried out in San Antonio, Texas and Rabat, Morocco. Twenty varieties/lines expressed good resistance at both locations (Table 12). This germplasm will also be added to the RSP. The RSP was also planted at San Antonio, a location which suffers heavy leaf rust attacks each year. Although the epidemic started relatively late compared to other years, detailed leaf rust readings were taken. Fifty percent of the plants were completely resistant at the Texas location. Twenty-five percent expressed a moderate infection type and twenty-five percent were fully susceptible. The isolate obtained from the San Antonio area was earlier described as having few genes for virulence (see Annual Report 1980). Since most resistance genes are effective against the isolate, the high percentage of resistant plants was not surprising.

Seed of three recurrent selection cycles was also evaluated with two leaf rust isolates. This was done to determine if there was an increase in resistant plants (Table 13). In spite of adding the base varieties (Table 14) in 1980 the percentage of resistant plants, or moderately resistant plants (infection types 0, 1 and 2) increased from 36 to 60 percent when using the San Antonio isolate. When using the isolate from Sakha, Egypt a surprisingly high number of resistant plants were already present in the first cycle (Table 13). It was found that the male sterile source Manchuria msg 10 gave an immune reaction to this isolate. By adding other resistance sources and recurrent selection the number of resistant plants could still be increased from 71 to 83 percent.

During the winter 81/82 leaf rust nurseries will be grown again at 2 locations in Texas. This time, hopefully, an early epidemic will develop and allow the detection of slow rusting varieties.

6. Virus diseases of barley

a. Barley yellow dwarf virus (BYDV).

Composite crosses XXXIII A & B developed by Mr. Rex Thompson, Mesa, Arizona, for tolerance to BYDV, were evaluated at Bozeman, MT, and Pullman, WA in 1979. Subsequently $F_{(4)}$ seed of each cross was sent to the following individuals:

Mr. Michael Bjarko, ICARDA, Aleppo, Syria
Dr. Enrique Rodriguez, CIMMYT, Mexico
Dr. Jesse Dubin, CIMMYT, Equador
Dr. Lynn Gallager, US AID, Morocco
Dr. J. D. Franckowiak, Fargo, North Dakota

Since Dr. Dubin was unable to harvest seed from the two composite cross populations this year, he requested that I send more seed of each population. Seed of both populations was sent to Dr. Dubin on August 24, 1981. In addition, because BYDV appeared to be important in Tunisian barley, seed of these composite crosses were sent to Mr. Amor Yahyaoui, Barley Breeder, Central Tunisia Project, El Kef, Tunisia on September 14, 1981.

The Net Blotch RSP (RSP-5 Rpt-6 rowed population) and the Scald RSP (RSP-5 Rrs-6 rowed population) are not only being worked for resistance to their respective pathogens, but they are also being worked for tolerance to BYDV whenever and wherever possible. For example, a substantial number of BYDV-infected plants were present in each of these populations that had been grown in Morocco and Tunisia during 1981. So, selection against BYDV susceptibility was made in these barley populations, by <u>not</u> tagging plants with symptoms typical for barley yellow dwarf (BYD). Subsequent seed harvest from tagged plants would thus eliminate BYDV-susceptible genotypes from each population. Since each of these populations contains two sources of tolerance to BYDV: Atlas 68 (Yd_2 from CI 3920) and CM 67 (Yd_2 from CI 2376), continued selection of BYDV-free plants for seed, should increase the frequency of tolerant genotypes in these populations.

After field testing spring barleys to determine the effect of the MT-PAV isolate of BYDV on yield, it was determined that both Sutter and Coracle barley would be highly suitable sources of tolerance for the AID Project. Sutter (Yd_2 from CI 1237 in a tolerant background of Tennessee Winter) is a 6 rowed barley and as such it can be added to the RSP-5 populations. The F_2 seed of Sutter X Manchuria (2330) msg 10 is available for inclusion into these 6 rowed barley populations next summer. Coracle (Yd_2 from CI 3906-1) a 2 rowed spring barley developed in Wales, could be crossed onto Compana msg this summer in preparation of adding it to the 2 rowed RSPs.

Two recent outcomes of the BYDV Workshop held in Mexico City during January of 1980, are as follows:

An international BYDV project has been developed, and is now awaiting funding approval by the IFAD agency in Rome, Italy, Once monies are available, the project will be initiated by CIMMYT. Art Klatt, Associate Director of the CIMMYT wheat program, will serve as the BYDV project Coordinator or Manager. Jesse Dubin (CIMMYT, Ecuador) will be Technical Coordinator for Plant Pathology. A plant pathologist will be recruited and based at CIMMYT, Mexico to coordinate international activities, etc. The main emphasis of the

BYDV project will involve screening wheat, barley and triticale for resistance to the virus. Secondary emphasis will be on determining which virus strains and aphid vectors are most important in the developing countries. Tentatively, $1,500 per year for screening elite lines, and $4,000 per year for virus strain identification has been designated to assist the on-going BYDV program of T. W. Carroll (TWC) at Montana State University (M.S.U.). Graduate training will also be included in the project. Students from developing countries can study for M.S. or PhD degrees in plant pathology at M.S.U. Separate funding for these students will be provided. Probably most of the students will come from South America.

An initiation by Dr. Man Mohan Kohli, CIMMYT Regional Representative, Santiago, Chile, to visit three experiment stations in Chile, relative to the epidemiology and control BYDV was postponed until October of 1982. Health problems and academic responsibilities prevented TWC from making the trip in 1981. Travel and visitation costs and arrangements will be under the auspices of IICA-BID (Cooperative Program of Agricultural Research in the Southern Cone Countries of South America).

Field trials conducted at Bozeman during 1980 and 1981 with the MT-PAV isolate of BYDV, inoculated via viruliferous oat, bird-cherry aphids (Rhopalosiphum padi), revealed that six barley cultivars commonly grown in Montana, were extremely susceptible to the virus. Yield reductions ranged from 47.6% to 90.7%. By comparison infected Sutter and Coracle barley yielded 32.9% more, and 7.3% less respectively, than did their uninoculated controls. The effect of BYDV on growth characters and yield components is shown in Table 15.

Results of field surveys in central Montana indicated that four isolates of BYDV were responsible for the crop damage. The most severe isolate affecting spring barley, spring wheat, and winter wheat was the MT-PAV or vector non-specific variant of BYDV. The remaining three vector-specific isolates were less serious to these crops. They included the MT-MAV, MT-RPV, and the MT-RMV isolates or variants of the virus. These latter variants were transmitted by their respective species of aphid vector: Macrosiphum avenae (English grain aphid), Rhopalosiphum padi (Oat, bird-cherry aphid), and Rhopalosiphum maidis (Corn leaf aphid). Aphid transmission results obtained at Bozeman were confirmed later when aphid transmission experiments and ELISA (Enzyme-linked immunosorbent assay) tests were conducted at Cornell University by Dr. R. F. Rochow.

b. BYDV and Aphids

Barley yellow dwarf virus (BYDV) was first described from California in 1951. The virus has caused and continues to cause substantial losses in cereal crops in many areas of the world.

Loss estimates for barley yellow dwarf (BYD) disease have been in the millions of dollars in North America.

BYDV is transmitted by at least 16 spp. of aphids in a persistent manner (the virus persists in the aphid vector for 2-3 weeks). Transmission of BYDV readily occurs when acquisition and inoculation feeding times are 1-2 days. Apparently, the virus does not multiply in the vector, but rather circulates from the gut through the body cavity, and eventually into the salivary gland of the aphid. Live trapping data indicated that in Wales, only 15% of the winged forms of a given aphid species were vectors of the virus.

In reality BYDV, according to Rochow, is a group of viruses with a spectrum of relationships among them. The viruses in this group differ in virulence, host range, serological properties, and vector specificity.

The most important viruses in the BYDV group in North America have been identified primarily on the basis of vector specificity. The four vectors are Rhopalosiphum padi, Rhopalosiphum maidis, Macrosiphum (Sitobion) avenae, and Schizaphis graminum. The viruses in the BYDV group, also referred to as variants, strains or isolates of BYDV, consist of the R. padi + M. avenae virus (PAV), the R. padi virus (RPV), the M. avenae virus (MAV), the S. graminum virus (SGV), and the R. maidis virus (RMV). PAV is vector nonspecific whereas RPV, MAV, SGV, and RMV are vector specific. In the electron microscope, purified preparations of RMV, RPV, MAV, and PAV revealed isometric particles 20-24 nm in diameter.

BYDV strains are not mechanically transmissible. They are also not seed or soil-borne. Although BYDV is actually a group of viruses, for simplicity of discussion, it will be referred to as a single virus whenever appropriate.

Symptoms

Symptoms in barley caused by BYDV include yellowish stripes, blotches, or mottles starting at the leaf tips. Occasionally leaf symptoms may be reddish or yellowish colors. Some leaves may also appear water-soaked, and some leaves may be serrated. Most infected barley plants are stunted, especially if they become infected when young. Sterility may occur in some cultivars.

Epidemiology

In nature, weedy grasses, grain crops, and pasture and range grasses provided a reservoir of BYDV. Oftentimes infected grasses display no symptoms. Aphids can feed on infected grasses and then transmit the virus to the barley crop. Aphids acquire the virus by feeding in the food conducting tissues or phloem of the infected plants. This is the only means by

which they can acquire the virus. The aphids may fly or be blown in from distant areas as has been the case in the great plains of North America, or they may come from weedy grasses near the barley crop. If the barley plants are young when infected, severe yield losses may result. Plants infected during the boot stage are generally less adversely affected.

Yield losses are also determined by such factors as the virulence of virus isolate or isolates, the virus dosage, the environment and the susceptibility of the host. For example, the vector nonspecific isolate of BYDV is quite virulent in many barley cultivars, whereas the RMV isolate is not. Frequently, the incidence of the PAV isolate has increased over the years in many areas surveyed. Moreover, it has occurred with RMV or both in barley. The double and triple infections are particularly severe in the plants.

Large amounts of virus inoculated into the plants have also affected the plants more adversely than have small amounts of virus. Therefore, heavy infestations of inoculative aphids have resulted in severe damage. Generally, temperatures ranging from 10-20C favor BYDV.

Diagnosis

Diagnosis of BYD based solely upon plant symptoms may be unreliable because similar symptoms can be caused by several other factors. One such factor is the aster yellows agent that causes symptoms in barley closely resembling those of BYD. Thus, confirmation of a field diagnosis has required special methods or tests.

In the past, aphid transmission tests were used routinely to identify BYDV. However, they took two or more weeks for answers and they required special facilities. So, plant virologists have developed two new sensitive serological procedures to speed up and even improve the accuracy of the diagnosis of BYDV. Unfortunately, both require antisera which are in short supply because the antisera are difficult and expensive to make. One technique is called ELISA or enzyme linked immunosorbent assay. It is a microplate technique that takes about three days to complete. Positive samples containing BYDV cause a color change in the reactants from clear to yellow.

The other technique is SSEM, or serologically specific electron microscopy. For this technique a specimen support for the electron microscope is coated with antiserum, and then treated with leaf extract. An extract containing BYDV reveals spherical or icosahedral virus particles 26nm in diameter.

Control

The most effective control measure is to use barleys tolerant to BYDV. These barleys contain the Yd_2 gene or allele. The

source of Yd_2 and the genetic background into which it is placed, seem to determine the level of tolerance conditioned by the gene. The Yd_2 gene has varied in expression from completely dominant to fully recessive.

Adjusting the time of seeding to avoid aphid activity when the plants are young is also an important means of reducing the severity and losses due to BYDV.

Use of insecticides has given only partial control in some areas.

Montana work on BYDV

Accomplishments and work in progress include the following:

1. Developed facilities for aphids.
2. Evaluated composite crosses XXXIII-A and -B.
3. Increased seed of barleys tolerant to BYDV.
4. Studying effect of BYDV on six cultivars of barley grown in Montana, in comparison to Sutter and Coracle barley.
5. Identified three strains of BYDV from Montana.
6. Proceeding with purification of BYDV for antiserum production.

The first effort in Montana was to develop facilities for aphids so virus isolates could be identified and field plants could be inoculated. These facilities were completed two years ago.

In 1979 barley composite cross populations XXXIII-A and B were evaluated for their tolerance to BYDV. Population XXX III-A was developed, not only for BYDV tolerance, but also for short, stiff-straw, and rapid, early growth. It contained four sources of BYDV tolerance: C.I. 1227 (Benton), C.I. 1237, C.I. 2376, and C.I. 3920-1 (Abate). It also contained the male-sterility gene msg_1 from California Mariout, and msg_2 from composite cross XXXII. Population XXXIII-B, was the same as the A population, except it contained more tall straw types. Both populations were planted in Pullman, Washington, and Bozeman, Montana. PAV isolates were used in both locations. At Pullman, 40-50%, and at Bozeman, 10-20% of the plants in each cross exhibited symptoms. All plants with symptoms were rogued. Seed derived from these tests were bulked by cross and sent to various national and international research centers.

In 1980 a study on the effect of BYDV on barley was initiated. Six cultivars of barley commonly grown in Montana, and Sutter, the tolerant check from California were inoculated with the PAV strain of BYDV. Results of that trial indicated that Piroline was the most susceptible barley, and it suffered a yield loss of over 90% (Table 15). By comparison, infected Sutter yielded over 32% more than uninfected Sutter.

To date three isolates of BYDV have been identified from Montana by aphid transmission tests. ELISA tests by Rochow have confirmed the identification of the Montana PAV and MAV isolates.

c. Barley stripe mosaic virus (BSMV)

Increased seed of a barley germ plasm, resistant to the seed transmission of three Montana strains in preparation for germ plasm registration.

Evaluated the Key Location Disease Nursery for Barley at ICARDA relative to the presence of BSMV and other virus diseases.

7. Bacterial diseases

a. Ecological Studies

Bacterial leaf streak of cereals caused by Xanthomonas campestris pv translucens was found in a large number of native Montana range grasses. The host range of these isolates was determined and barley was found to nearly always be a susceptible host. Conclusions are that there may be a reservoir of inoculum in native grasses that could serve as a source of genetic variability. This source of inoculum must be added to our previous findings of seed transmission and wind-rain spread.

b. Gene identification

A typical strain of X. c. translucens (strain X58) attacks four hosts: barley, oats, rye and wheat, although some other isolates attack only one or some of these hosts. We, by transposon mutagensis, have knocked out genes in X58, limiting its host range to less than four. Preliminary findings are that genes specifically attacking a particular host tend to be independent of effect on other hosts, are multiple allelic, and some, at least, are not required for bacterial growth in culture. Potential uses of these data are to enable us to identify different genes for virulence to simplify breeding efforts. To speculate, an additional use of such methodology would be to use these host-modified isolates to attack weed species as bio-control agents.

c. Resistance genes

Several new sources of resistance to bacterial leaf streak have been identified, including Ethiopian, Swedish and English germplasms and a series of related old-line varieties from the U. S. Midwest. These barleys have been crossed and some are being submitted to F_2 progeny analysis.

d. Pseudomonas in rain

Pseudomonas syringae is a ubiquitous bacterium, living on and in numerous plant hosts. One unique property of this bacterium is its ability to cause ice to form on and in plants at temperatures just below freezing. We have reported the occurrence of this bacterium in rain, at 1800 meters aloft, and have speculated (in a hypothesis) that these bacteria may be involved in

rainfall nucleation, downwind of infected fields. The possible effect of these bacteria on continental rainfall patterns is a matter of considerable interest.

e. Antiviral compounds

Seed transmitted viruses, e.g., Barley Stripe Mosaic Virus (BSMV), can cause real problems if they infect breeding populations of barley. We, in working with bacterial viruses, have developed a simple screen for potential viricides. In the process we have found one treatment that significantly reduced seed transmission of BSMV. This, and other treatments used singly or in combination, may permit us to eradicate viruses from genetically useful populations.

8. Other diseases of barley

a. Root rots

The effects of common root rot caused by Cochliobolus sativus on components of grain yield in sixteen barley cultivars which were agronomically adapted to the Middle East were studied. These cultivars were representative of the four barley types: Hannchen, Smyrna, Coast, and Manchuria. In spite of the mean increase in disease ratings in C. sativus inoculated plots, the high soil moisture levels and moderate temperatures during maturation negated the early pathogenic effects of the pathogen, resulting in no net change in yield. Hannchen and Smyrna type cultivars had a significant reduction in fertile tillers due to C. sativus which was compensated for by increased kernels per head and kernel weight. Coast and Manchuria type cultivars responded to a slight decrease in fertile tillers by increasing the number of kernels per head. A combination of increased number of kernels and increased disease rating due to common root rot resulted in decreased kernel weight in Coast and Manchuria type cultivars.

A barley plant is subjectively placed in one of four disease classes based upon the extent of discoloration on the sub-crown internode due to common root rot. In a population of plants, the number of plants per each disease class was used to calculate a weighted average or disease rating. Computations performed by a step-wise discriminating function on the percentage of plants in each of four disease classes indicated that the severe class was the most discriminating class among cultivars, followed in importance by the healthy class. This finding should allow us to more quickly rate plants for disease reaction in the future.

b. Spot Blotch

Mention of a trademark or a proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

Abstract

The spot blotch fungus (Cochliobolus sativus) commonly known as Helminthosporium sativum causes leaf spots, kernel discoloration, and seedling blight of barley. Dark-brown to black discoloration of leaves can cause early maturity, defoliation and shrunken kernels. The organism, which occurs in all barley growing regions of the world, over-seasons as mycelium or spores in or on seeds or debris in the soil. It grows well as a saprophyte, producing spores from plant debris to furnish initial inoculum to a crop. The disease is most severe in warm, wet weather. Resistant varieties, destruction of crop debris, crop rotation, seed treatments, or foliar fungicides reduce the severity of the disease.

Introduction

Cochliobolus sativus (Ito et Kurib.) Drechs. ex Dastur (imperfect state, Helminthosporium sativum P.K. et B. = Bipolaris sorokiniana (Sacc. ex Sorokin) Shoemaker is the cause of the spot blotch disease that attacks a wide range of grasses and is common on wheat as well as barley. Lesions may be found on seedlings, crowns, culms, leaves, glumes and kernels. Seedling and crown damage is common under relatively dry conditions, while abundant infections of all plant parts occur in humid, warm seasons, causing up to 35% reduction in yield of grain.

The disease

The disease is found commonly on barley, wheat, oats, corn, wheat relatives and at least 79 species of Graminae in North America (Sprague, 1950).

The disease is widespread, probably existing wherever barley is grown. It is most important and severe on barley in relatively well-watered regions such as the southeastern and north central USA (Hampton, 1976, Tekauz, 1975). Problems with spot blotch have been reported from Egypt and from India (R. Wilcoxson, personal communication). Losses from the disease vary with the season, but can be severe (Hampton, 1978). It is reported to be the most destructive disease of barley in Minnesota, often causing losses of 5-10% and, in epidemic years, up to 35% (Christensen and Wood, 1955). Under natural epidemic conditions, yields in Minnesota in 1977 in the susceptible cultivar 'Larker;, C.I. 10648, were 2530 kg/ha, while those sprayed with fungicide yielded 3014 kg/ha (Musick et al., 1979, Rasmusson and Wilcoxson, 1977). Heavy seed infection

may reduce emergence by 40%, but plants per row must be reduced more than 50% to cause significant yield decreases (Clark and Wallen, 1969). Seedlings originating from infected seed exhibit a black, dry-rot beginning in the coleoptile, and are often killed. Dark brown lesions extend into the leaf blade. Infected seedlings develop slowly and may tiller excessively (Dickson, 1956). Crown rot develops at or below the soil surface.

Leaf spots vary in size and shape, but are usually spots rather than stripes, and there is no delineation of veins as in net blotch (Dickson, 1956). Lesions are round or oblong, with definite margins and a uniform dark brown color. Spots may coalesce to form large blotches, and sometimes kill entire leaves. An olivaceous hue is conferred by the abundant development of conidia and conidiophores. Heavily infected leaves dry out and mature early. Under favorable conditions, lesions form on floral bracts and kernels. These black spots and brown discolorations result in the "black point" symptom on kernels (Dickson, 1956). Heavily infected kernels are often shriveled.

Mycelia develop first between the host cells and later within the cells (Christensen, 1922). Parenchyma cells are invaded, collapse and dry out. A general invasion of adjoining cells of veins follows.

The causal organism

C. sativus has brown conidiophores that emerge from stomata or between epidermal cells after death of the host tissue. The conidiophores are single or in groups of 2 or 3, 110-150 x 6- 8 μ, up to 8 septate. Each conidiophore has 5 or 6 well defined knee-shaped bends. The spores are curved, tapering evenly toward each rounded end, or may be irregularly thickly boomerang-shaped. They are 3-10 septate, 60-120 x 15-20 μ, dark olive-brown with a thick, brittle outer wall (Sprague, 1950). On potato dextrose agar, the fungus produces a velvety layer of gray to olive-black mycelium. It usually sporulates profusely, the spores first being light olive-brown, but soon becoming fusoid, ellipsoid, or bent, with the characteristic dark brown color and brittle wall (Sprague, 1950). The organism is extremely variable in culture and in nature, exhibiting many virulence types as well as extreme susceptibility to environmental influence (Christensen, 1922, Hayes et al., 1923). In culture, reasonable purity of type may be maintained by lyophillization or on wheat straw in a freezer. Both the thick-walled mycelia and the conidia are resistant to stresses and can over-season in or on the soil. The organism lives as a saprophyte on debris in the soil or on the soil surface during the crop growing season, thus adding to the abundance of inoculum that is present. It may also over-season as a saprophyte (Dickson, 1956). The perfect state is seldom seen and not considered important in the etiology of the disease.

Control measures

Resistant cultivars are the most desirable means of disease control, since they do not add to the cost of production and require no additional activity by the farmer. It has been difficult, however, to breed cultivars that are resistant to the "Helminthosporium" diseases of barley (Roane, 1973). The inheritance of resistance is complex and not well known even today. Nevertheless, some sources of resistance are known that confer a useful level of disease resistance to the variable field populations of the spot blotch organism. A North Dakota (USA) line, B-112, is the best source of resistance in the north-central U.S.A. (R. Wilcoxson, personal communication). It is the source of resistance in the cultivars Morex C.I. 15773, Manker C.I. 15549, Beacon C.I. 15480, Glenn C.I. 15769, and Park C.I. 15768, all of which are less damaged by spot blotch than some susceptible cultivars such as Larker. In a 1977 test comparison of susceptible Larker and resistant Manker in Minnesota, Larker yielded 2256 kg/ha when diseased and 2280 when protected with Dithane M-45 fungicide, indicating a 22% loss. Manker yielded 2976 kg/ha whether sprayed or not (Rasmusson and Wilcoxson, 1977). Cultivars Harrison and Jefferson, released by the Indiana (USA) experiment station, are resistant to both spot blotch and net blotch.

Some work has been done in several countries with fungicides as seed treatments and foliar sprays for control of C. sativus. Couture and Sutton (1978) sprayed 6 different fungicides on foliage of barley and reduced symptoms, but did not show significant yield increases. Hampton (1976) in New Zealand found carboxin-thiram best and benomyl-thiram next best as seed treatments to control seedling blight phase of the disease. Musik, et al. (1979) used mancozeb as a foliar spray to control natural or artificial epidemics. They showed increases in kernel plumpness and test weights for both Manker and Larker varieties. Tekauz (1975) in Canada noted that he knew of no really good source of resistance to C. sativus. An application of Mancozeb significantly increased the yield of a highly susceptible variety.

Chemicals applied either as seed treatments or foliar sprays are not practical for many barley growers. Cultural practices, including crop rotation and destruction of plant debris, are somewhat helpful, but by no means solve the problem. That leaves us with resistant varieties which are also difficult to obtain. The organism is variable and the genetics of virulence and resistance seem to be complex. Resistance to the root and crown rot, the leaf blotch, and the seed discoloration all seem to be governed independently of one another, thus making the problem even more difficult to solve. But scientists are attacking the problems and some sources of resistance and resistant cultivars are available. Progress can be expected in the task of understanding the inheritance of resistance to C. sativus.

c. Helminthosporium stripe

Barley stripe disease, caused by Pyrenophora graminea is a seed-borne single cycle disease that may occur wherever barley is grown. It is a problem in northern Africa, the middle-east, northwestern Europe, and southeastern United States.

Barley stripe is a potential threat to barley production. The disease was serious at one time, but has become relatively unimportant in recent years due to widespread use of mercury containing fungicides. Negative effects of mercury in nature have recently restricted the use of these compounds in many countries. As long as available non-mercurial fungicides are not fully efficient, incorporation of genetic resistance to stripe into barley is desirable.

According to Knudsen (1980) resistance is mainly determined by quantitative factors. This assumption is in accordance with the findings of Isenbeck (1930), that resistance was conditioned by several dominant factors. In contradiction with this, Arny (1945) found resistance to be governed by two and three factors. A simple inheritance of resistance was also proposed by Nilsson (1975).

A study was started in 1980 to investigate inheritance of resistance to barley stripe. For this purpose, 70 reciprocal crosses were made between American and Turkish barley varieties. At the same time a study is being done of the best inoculum production for artificial inoculations by comparing barley kernel, sandwich and soil inoculum methods.

At the moment F_1 seed is planted in Arizona and F_2 seeds will be harvested in May and will be seeded in the growth chamber in Bozeman. Meanwhile comparisons of inoculation methods and resistance of parent varieties are being done. At the end of 1982 summer field results will be obtained and analyzed.

d. Powdery mildew

Three barley composite cross populations (CC populations) i.e. CC II, CC V and CC XII have been allowed to reproduce by their natural mating systems in Davis, California, Moccasin and Bozeman, Montana without conscious selection. These CC populations can provide an effective method of conserving genetic variability, and this can extend to genes which govern disease resistance. We are using a model with the barley Powdery Mildew fungus (Ersiphe graminis Dc. f. sp. hordei Em. Marchal) to study how disease resistance has evolved under natural selection.

Several samples of early, intermediate and late generations of each of those 3 CC populations were tested towards 4 different isolates of the powdery mildew fungus:

#1 - A Montanan isolate, not reported in the literature, but closely related to the race CR_3.
#2 - 59.11
#3 - 63.12
#4 - 64.54, from Israel
#2, #3 and #4 were obtained from the USDA laboratory of Dr. J. G. Moseman in Beltsville, Maryland.

All the generations of the three CC populations were inoculated by each isolate individually during the seedling stage, and the subsequent reaction type was read and recorded for further analyses. More than 10,000 plants were used for each isolate after incubation in controlled environmental chambers.

Frequency tables, analyses of variance and linear regression are perfomed and the frequency of resistant versus susceptible plants was monitored from generation to generation for each CC population.

A postulation is that the frequency of resistant plants should increase by long-term natural selection. There is already some indication toward such a trend within some CC populations. These resistant plants may then be used as sources of resistance in a breeding program.

A thesis will be presented in the Spring of 1982 after completion of the interpretation of the computer results on the behavior of the CC populations towards selection pressure by the powdery mildew fungus.

9. Agronomic improvement of barley

For a comprehensive review of the general philosophies procedures and work in progress the reader is referred to the annual report covering the period Aug. 1, 1979 to Aug. 1, 1980, pp 14-18.

Selection in the scald resistant population (CC XXXVI, formerly RSP 5 Rrs) is the most advanced for agronomic improvement. The black and purple seed genes have been eliminated from the population, and the population has been separated into a covered and a hulless component.

Having reviewed progress of present breeding programs for North Africa and Mideast countries and having determined that large cultivar differences in day-length-temperature sensitivities exist as separate entities from maturity genes in any given environment; this investigator is of the opinion that sensitivity is one of the most critical critera determining adaptation. Given a completely insensitive cultivar one may classify varieties for sensitivity by determining heading date in two latitudes or using two dates of spring planting in northern latitudes. The number of days difference in heading between the insensitive cultivar and the unknown cultivar is a relative measure of the sensitivity.

Given the problem of developing appropriate sensitivity responses for various environments, in the absence of detailed information, it would appear that if one selected a cultivar (s) that has been most successful in an area as having the approximate desired sensitivity, and developing lines with similar sensitivity, would be a desirable approach. A comparison of preliminary sensitivity determinations on a number of United States cultivars with latitudes where they have performed well indicates that as little change as 4° latitude may call for an altered sensitivity. Latitudes of a few locations are given in the table below for perspective.

Location	Approximate Latitude - degrees	Location	Approximate Latitude - degrees
Bozeman, MT., USA	46	Tunis, Tunisia	37
Aberdeen, ID, USA	43	Pusan, Korea	35
Ankara, Turkey	40	Rabat, Morocco	34
Akron, CO, USA	40	Zuwarah, Tunisia	33
Izmir, Turkey	38	Mesa, AZ, USA	33
Davis, CA, USA	38	Cairo, Egypt	30
Suweon, Korea	37	Agadair, Morocco	30
Aleppo, Syria	37	Obregon, Mexico	27
Adana, Turkey	37	Mexico City, Mexico	19
Adas Ababa, Ethiop'a	9		

Accordingly the hulless and covered components (1 lb. each) of CC XXXVI were grown in Arizona during the winter of 1980-81 and only plants maturing as early or earlier than Beecher were harvested. Both male steriles and fertiles, hulless and covered, early and very early were returned to Bozeman. The 8 populations were grown at Bozeman and rogued to the heading date of Beecher and Martin. The Beecher and Martin, hulless and covered, populations were planted in Arizona for the winter 1981-82 and will be rogued to Beecher and Martin heading dates.

Beecher has been a successful cultivar in much of N. Africa, particularly Egypt. Martin has been a successful cultivar in Tunisia. The original intent was to include a 3rd cultivar from Aleppo, Syria which represented the local farmer cultivar check. Surprisingly this cultivar was winter habit and did not head at Bozeman. This suggests that some work needs to be done with winter habit barleys at Aleppo. This may be of importance from the grazing standpoint.

Perhaps the effectiveness of this procedure should be checked by divergent selection of the same population for the sensitivity of Unitan and Steptoe, cultivars that have been widely adapted and grown in the Rocky mountain and Pacific Northwest areas. This population was shelved a year ago but will be returned to the program.

Emphasis will shift to the combined net blotch Rsp 5 Rpt (CC XXXVIII) and Rsp 5 Rrs (CC XXXVI) population. This population was selected for Beecher and Gem heading dates at Bozeman in 1981 and will be selected in a similar manner in Arizona in 1981-82.

Other work continued, as outlined in the 1979-80 report. Included was a 10 head row check of the 13 isogenic Betzes maturity series. A number of these were determined to be mixed or segregating. These rows will be grown again in two-row drilled plots for purification in 1982. The next step will be to check sensitivity on these lines.

D. Outreach program

Central to our outreach program and dissemination of results on decreasing losses from barley diseases are the annual trips to the Middle East to evaluate the various RSP nurseries and discuss problems and progress with scientific personnel and administrators in the various countries. In April-May of 1981 Dr. Carroll and Mr. Moncef Harrabi made this trip and their report is included in another section. We cooperate closely with CIMMYT and ICARDA not only in sending out our RSP nurseries to them but also in evaluating their crossing blocks and elite lines to barley diseases (see Table 6). Additionally, members of our department are often involved with CIMMYT and ICARDA in International meetings and workshops. (See Visits and Presentations section).

One of the highlights of the past year was a Barley Workshop held in Rabat, Morocco and jointly sponsored by Montana-USAID, CIMMYT, ICARDA and INRA of Morocco. Representatives of most of the developing countries participated in this meeting with a total attendance of about 55 participants. At this workshop, Montana - USAID furnished an illustrated color manual of the common diseases of barley with appropriate writeups on the diseases and possible breeding methods for control. This manual has been well received. Several thousand copies have since been distributed and more are being reproduced to satisfy demands. At present we are negotiating with CIMMYT personnel to prepare a Spanish translation of the manual. Proceedings of the Workshop will be published.

Our staff and graduates continue to receive offers of employment in International Agriculture both on a short term and long term basis.

E. Training Program

Under the training portion of the Montana USAID contract two trainees and five graduate research assistants (GRA's) from the developing countries were accommodated this past year. The trainees and GRA's participating this past year were as follows:

Trainees

Chandra B. Karki ----------Nepal
Haytham Altounji----------Syria

GRA's

Guy De Smet----------Morocco
Hee Kyu Kim----------S. Korea
Cahit Konak----------Turkey
Elias Elias----------Syria
Moncef Harrabi a/----------Tunisia.

a/ funded directly by AID-Tunisia.

The GRA's were assigned thesis problems with barley diseases and were otherwise subject to the same rules and regulations as resident GRA's. The trainees were generally here for a 3 month period from June 15 to September 15. This time sequence covered disease development on barley in the field. The trainees had opportunity to work with all the major diseases of barley from a laboratory and field standpoint. This included diseases caused by fungi, bacteria and virus with some supplemental instruction on nematodes. They were given mini courses in each of these subject areas, followed by a written examination. The main emphasis, of course, was with a "hands-on" approach in field work. The training included isolation and identification of pathogens, inoculation of artificial medium and host plants (including mass field scale), evaluation of various diseases and selection of the best appearing resistant plants. Additionally, they became familiar with use of RSP's and the associated recombination through use of male sterility. All trainees prior to departure received a certificate verifying participation in a training period on barley diseases and associated plant breeding.

Three of the above GRA's have completed the preliminary examinations for the degree of Doctor of Philosophy in Plant Pathology and should be graduating and returning to their respective countries during 1982. The two other GRA's, Konak and Elias, are presently pursuing a masters degree (M.S.) in Plant Pathology. Chandra B. Karki, previous trainee, has been accepted within the department for graduate work.

Additionally, we have had requests from two prospective trainees from Egypt and several prospective students have corresponded indicating an interest in participating in our graduate program. The latter correspondence has included the countries of Tunisia, Algeria, Egypt, S. Korea, Ethiopia and Chile. The selection and acceptance of these students is naturally contingent upon renewal of our barley Montana - USAID contract.

F. Trip reports

Report on Travel and Visits Regarding the Control of Barley Diseases for Lesser Developed Countries of the World - AID/DSAN-C-0024.

April 16 - May 11, 1981

Dr. T. W. Carroll (TWC), Professor of Plant Pathology and
Mr. M. M. Harrabi (MMH), Graduate Student - Department of Plant Pathology
Montana State University

Itinerary

Depart Bozeman, April 16 (MMH) or April 18 (TWC) via SLC, N.Y., Paris - Rabat
Arrive at Rabat April 17 (MMH) or April 19 (TWC)
Leave Rabat April 24
Arrive Tunis through Marseille April 24 - Friday
Depart Tunis April 29
Arrive Damascus April 29, late afternoon
Drove to Aleppo that night
Depart Damascus May 5
Arrive Istanbul May 5
Arrive Istanbul May 5
Depart Istanbul to Izmir May 5
Depart Izmir May 8 - Arrive Istanbul same day
Depart Istanbul May 8
Arrive Athens May 8
Depart Athens May 10
Arrive Denver May 10
Depart Denver May 11
Arrive Bozeman May 11

Purpose of the trip

1. To participate in the Barley Workshop held at Rabat, Morocco. Title of workshop:
   Barley diseases and associated breeding methodology

2. To collect isolates of barley pathogens from different parts of the Mediterranian region, including locations new to this project.

3. To assess the importance of fungal, bacterial and viral diseases in the region.

4. To select resistant material in the recurrent selection populations (RSP's) developed at Montana State University.

5. To make technical knowledge available.

Organizations and Persons Contacted

Inasmuch as Dr. E. L. Sharp will be writing a report on the visit of Montana-AID people to Morocco, this report will only pertain to the countries of Tunisia, Syria, and Turkey.

Tunisia

1. Office of Cereals

   Mr. A. Ladab, President
   Mr. L. Sendassi, Acting Head, Technical Division.
   Mr. Salah Rezgui

2. I.N.A.T.

Mr. Kamel Belkodja, Former Director
Mr. M. Jarraya, Director, effective May 1, 1981.

3. Ecole Superieure de Grandes Cultures du Kef (Agricultural School)

Mr. R. Zoubeidi, Director

4. Central Tunisia Project - AID via Oregon State University. Housed in the old Ecole Agricole du Kef

Mr. Amor Yahyaoui, Barley Breeder

Syria

1. ICARDA, Aleppo

Dr. M. A. Nour, Director General, effective July 1, 1981.
Dr. Jit Srivastava, Director of the Cereal Improvement Program
Dr. Mohammed Mekni, Leader of the Barley Improvement Program
Mr. Mohammed Mushref, Research Assistant, Barley Improvement Program
Dr. Miloudi Nachit, Leader of the Triticale Improvement Program
Mr. Michael Michael, Research Assistant, Durum Wheat Improvement Program
Mr. Issam Naji, Leader of Farmer Trials, Cereal Improvement Program

2. U.S. AID- Mission, Damascus

Mr. Archie Hogan, Agricultural Development Officer

Turkey

1. Ege Regional Research Center, Menemen, Izmir

Mr. Kasif Temiz, Director
Mr. Cevdet Dutlu, Assistant Director
Mr. Fikret Demirkan, Leader of the Barley Improvement Program, Western Region of Turkey
Mr. Abdulkadir Basgul, Breeder, Barley Improvement Program, Western Region of Turkey
Mr. Suleyman Guzel, Breeder, Barley Improvement Program, Western Region of Turkey

Accomplishments and Impressions:

Tunisia:

Dr. Robert Jackson, AID, Washington, D.C.; Dr. John M. Poehlman, AID Reviewer, University of Missouri, Columbia; Dr. Eugene L. Sharp, Principal Investigator of the Montana AID-Barley Project; MMH, and TWC, arrived in the afternoon of April 24, and were met at the airport by Mr. Yahyaoui, and Mr. Rezgin, and then taken to a hotel. The following morning we were picked up by Mr. Yahyaoui and taken to the Office of Cereals, where we visited with Mr. Sendassi. He described the activities of the technical

division. Later we met with Mr. Belkodja, and Mr. Jarraya who talked about INAT and its efforts. During that visit Mr. Jarraya requested that a formal agreement be developed between Montana State University (MSU) and INAT, with respect to the exchange of barley germplasm and technical assistance. Mr. Jarraya also mentioned that INAT wanted to send people to MSU for technical training. Later that morning, we met with Mr. Ladab. During our meeting, Dr. Sharp described the Montana AID Project on Barley. Mr. Ladab was enthusiastic about the transfer of technology from Montana to Tunisia. Mr. Ladab emphasized the new importance given to barley production by the Office of Cereals and the Tunsian Government. In the afternoon of April 25, we drove to Mateur to observe the barley nurseries of the Office of Cereals. Prevalent diseases were leaf rust, net blotch, scald, helminthosporium stripe and barley yellow dwarf. That evening we were hosted to a superb supper through the kind generosity of the Director of the Office of Cereals, Mr. Ladab. A stimulating and moving seminar followed the supper.

On April 26 we went by car in the early morning to the Beja Agricultural Experiment Station to observe barley nurseries. We were accompanied by Mr. Yahyaoui. Powdery mildew was most severe in several lines of barley. Helminthosporium stripe was scattered throughout many lines. Barley yellow dwarf was seen at the margins of the plots and in some lines of barley. Only a trace of net blotch was detected. On the way to El Kef, a farmer's field of barley was checked for diseases. Heavy scald and moderate net blotch were seen. At the Agricultural school at El Kef we talked with Mr. Zoubeidi who described the research and training objectives of his institution. In the afternoon we went to the barley plots, where we tagged about 200 plants each in the 1980-81 Scald RSP (RSP-5 Rrs-6 rowed population) and the 1980-81 Net Blotch RSP (RSP-5 Rpt-6 rowed population). Dr. Jackson, Dr. Poehlman, Dr. Sharp, Mr. Yahyaoui, two technicians from the school, and MMH and TWC worked the two RSPs. Heavy powdery mildew was observed in scattered areas throughout both RSPs. Barley yellow dwarf was severe in some plants, particularly those at the borders and in areas adjacent to the borders in both RSPs. A trace of scald and net blotch was also present in each RSP. The nurseries were properly space planted and well maintained. On the morning of April 27 Dr. Jackson, Dr. Sharp and TWC met with Dr. Floyd E. Bolton, Principal Counselor of Agronomy for the AID Project on Agricultural Research for Central Tunisia (on leave from Oregon State University). Dr. Bolton exchanged important agronomic information with us. He also explained the Central Tunisia Project. That afternoon Dr. Jackson, Dr. Poehlman, and Dr. Sharp departed by airplane to Cairo, Egypt. On April 28, MMH and TWC were accompanied by Mr. Yahyaoui on a survey of diseases in farmer's fields within the El Fahs region of Tunisia. The barley development varied from heading to hard dough stage. The plants were under moisture stress as evidenced by their short stature and rolled and dried leaves. Many of the plants had dried heads and would yield no grain. According to Yahvaoui, less than 300 mm of precipitation fell in this area during the growing season. Apparently the extreme dryness here curtailed the development of diseases, for none was noticed. On April 29 we departed Tunis bv airplane for Damascus.

Syria:

MMH and TWC arrived in Damascus on the evening of April 29 and drove to Aleppo with Dr. M. Mekni. We stayed that night and subsequent nights in the Baron Hotel because the guest house was full. The morning of April 30 we were driven to the ICARDA headquarters where we promptly devised a visitation schedule and took care of airline reservations, etc. Later that morning we visited the laboratories at Tel Hadya. The development of ICARDA over the last 4 years has been astonishing. In 1977 arrangements for the acquisition of land for the Tel Hadya research center were being made. Today Tel Hadya consists of farm equipment buildings, temporary laboratories, seed handling facilities, and harvest sheds. The research center occupies 1000 Ha. A 2.5 meter high chain-link fence surrounds the entire center and protects it from grazing animals. The afternoon of April 30 we met briefly with Dr. M. Mekni at the ICARDA headquarters to discuss barley breeding and disease resistance. Afterwards we visited the barley plots at Tel Hadya, including the 1980-81 Scald RSP (RSP-5 Rrs-6 rowed population) and three earlier RSPs (RSP-5 Rrs-Scald; RSP-5 Rpt-Net Blotch; RSP-5 Reg (rs, pt) - Powdery Mildew) that were sent to ICARDA. They are being cycled locally by Mekni for possible use in the Mediterranean region. The Net Blotch RSP was being exploited in that 4 rows of fertile pollinator barleys (those of good agronomic performance with acceptable resistance to local diseases)alternated with 4 rows of the RSP barleys which contained male sterile plants. The outcrossed seed produced would be planted the next year so it would give rise to plants that could be cross pollinated by pollinator barleys, and so on. Mid-afternoon of April 30 we accompanied Mr. Issam Naji and Dr. M. Nachit to a farmer trial of cereals. In the barley trial, Beecher served as the ICARDA check, whereas Arabic Abied (white glumed, Syrian land race) and Arabic Asouad (black glumed, Syrian land race) served as the farmer checks. The checks are being compared to new ICARDA hybrids and selections relative to pest resistance and yield potential. All barleys in the trial were given a low level of nitrogen fertilization. The trial barleys were in turn compared with unfertilized farmer grown barley which surrounded the trial nursery on three sides. The farmer's barley consisted of a mixture of Arabic Abied and Arabic Asouad. According to Mr. Naji scald is consistently the most serious disease of barley in Syria, although leaf rust appeared to us to be the most prevalent disease this year in both trial and farmer barleys. Some covered smut was also present in the farmer's Arabic abied and asouad barleys. On May 1 we departed by car with Mr. M. Mushref and Mr. M. Michael at 7:00 AM for the Jebla Research Center near Lattakia. This center is 5 km from the Mediterranean Sea, and receives about 800 mm of rain annually. We tagged about 200 plants in the 1980-81 Net Blotch RSP-r, Rpt (6-row) population having the least powdery mildew and leaf rust, and displaying the best agronomic traits. The next morning we met with Dr. J. Srivastava and Dr. M. Mekni to discuss the cereal improvement program, with emphasis on the diagnosis and control of barley diseases. That afternoon, at the request of Dr. Srivastava, we surveyed the Key Location Disease Nurseries (KLDNs) for each of the following: Bread Wheat, Durum Wheat, Barley, and Triticale. Our evaluation of the nurseries with respect to plant diseases and especially virus diseases, and our conclusion and recommendation were presented to Dr. Srivastava in a

written report. This report will be forwarded to Dr. M. A. Nour, who will become Director General of ICARDA, July 1, 1981. Infectious diseases present in bread and durum wheat were barley yellow dwarf (trace to light infection), stripe rust (light to moderate infection), and pseudomonas syringae blight (trace to light infection associated with plants damaged by frost); infectious diseases in barley were barley yellow dwarf, leaf rust and powdery mildew (all trace to light infections). No diseases of importance were seen in the Triticale nursery. The morning of May 3 we drove to Tel Hadya and tagged about 200 plants in the 1980-81 Scald RSP-5, Rrs (6-row) population having the least disease and the best agronomic qualities. We were assisted by Mr. M. Mushref. The light rain that fell while we worked the Scald RSP eventually turned heavy so we rapidly finished tagging the plants, and sought shelter in the storage room for barley seed. The Scald RSP was generally free of scald, although much scald inoculum was present in artificially inoculated barley about 100 m away. The inoculated scald "spreader" plants exhibited severe symptoms on all leaves, including flag leaves. Thus, it appears that this RSP now contains a high level of field resistance to scald. At 7:00 AM on Monday, May 4, we departed Aleppo by car, arriving at the ICARDA guest house in Damascus at about 11:00 AM. Shortly thereafter T. Carroll met with Mr. Archie Hogan, Agricultural Development Officer, U.S.AID - Mission, Syria. During this meeting Mr. Hogan kindly arranged to send pathogen samples to the Plant Inspection Station, APHIS, USDA, at Jamaica, New York, via diplomatic channels. The pathogen samples were collected in Morocco, Tunisia, and Syria. Importation of these samples into the U.S. was authorized by APHIS, USDA, under permit number PPQ-526-EDH, issued 3-30-81. Mr. Hogan, was also most helpful in obtaining confirmation of our air-line reservations. He had a secretary at the U.S. Embassy handle all of the necessary details. We left Damascus the next morning for Istanbul and Izmir.

Turkey:

We arrived in Izmir the evening of May 5, and were met by Mr. Abdulkadir Basgul, and a driver from the Ege Regional Research Center, Menemen, Izmir, who took us to our hotel. The next morning, we were met again by Mr. Basgul and the driver, and taken to the Ege Research Center. We were received by Mr. Cevdet Dutlu, Assistant Director of the Center. During our brief visit with him we discussed the cereal improvement program at Izmir. Next, we talked with Mr. Kasif Temiz, Director of the Center. Our conversation focused on barley research in Turkey, and general concerns and objectives of the Ege Center. Later that morning we met with Mr. Fikret Demirkan, Leader of the Barley Improvement Program, Western Region of Turkey, and Mr. A. Basgul and Mr. S. Guzel, Barley Breeders, to learn about the barley program at Izmir. Afterwards, we went to the field where we tagged 200 plants in the 1980-81 RSP-5 Rrs-Scald nursery. Only a trace of scald was present in this RSP, however severe scald infections were found in adjacent barley plots. Light to moderate leaf rust and spot blotch were also observed in the scald RSP. Two hundred plants were also tagged in the 1979-80 RSP-5, Rph-Leaf Rust. A light infection of leaf rust occurred in this RSP, and most of the individual plant infections appeared to be those of the resistant type of reaction. Traces of spot blotch, powdery mildew, and barley yellow

dwarf were also seen in the Leaf Rust RSP. Just a few plants in the 1980-81 RSP-5 Rxt-Xanthomonas nursery were tagged because no Xanthomonas was observed. This RSP had moderate leaf rust, trace to light powdery mildew and spot blotch, and a trace of barley yellow dwarf. Mr. A. Basgul and Mr. S. Guzel assisted us with the tagging. Afterwards Mr. F. Demirkan showed his barley plots and described his breeding program. In the late afternoon we talked again with Mr. C. Dutlu to report our activities and findings. Part of the time was spent editing the English summary for the doctoral dissertation Mr. Dutlu will present to his Graduate Committee on May 12, 1981. Before departing the Ege Center that evening for our hotel in Izmir, we met once more with Mr. Temiz. During this meeting we described our field efforts and observations. He requested that T. Carroll also write a report evaluating the barley program at Izmir. This report was forwarded to Ankara on May 20, 1981. The following morning it rained so we stayed in the hotel and wrote our impressions of the visits. We also summarized the information regarding the pathogen samples. That afternoon we met for the last time with Mr. A. Basgul to discuss the Montana AID Contract and the barley program at Izmir. On May 8 we flew from Izmir to Istanbul and then to Athens. On May 10 we departed Athens for Denver, via New York. We stayed overnight in Denver, and traveled to Bozeman the next day by air.

In the main, the trip was a huge success. Our Scald and Leaf Rust RSPs have obtained a good level of resistance to their respective pathogens. In addition, the timing of the visit coincided well with plant growth and disease incidence. We collected 31 disease specimens, particularly in newer areas, to add to our virulence pool for incorporating broad-based resistance. Finally, there was a real interest in and acceptance of our methods for developing broad-based resistance to diseases of barley. In fact, the breeders at ICARDA and Izmir are already exploiting our RSPs for their own use.

G. Visits and Presentations

E. L. Sharp

Presented paper entitled "Virulence groups of *Pyrenophora teres* and some possible sources of resistance" at the 11th Barley Researchers Workshop, Minneapolis, January 26-28, 1981.

Attended Cereals Planning Conference in Istanbul, Turkey, February, 1981. Presented information on Montana - USAID barley program and worked with J. Prescott (CIMMYT) and J. Srivastava (ICARDA) in planning program for Barley Workshop to be held April 1981 in Rabat, Morocco.

Organized, together with J. Prescott (CIMMYT) and J. Srivastava (ICARDA), the workshop on Barley Diseases and Associated Breeding Methodology, Rabat, April 20-23, 1981, and presented paper entitled "Genetics of Pathogenicity and Resistance for *Pyrenophora teres* in barley".

Accompanied Drs. R. Jackson and J. Poehlman following the Workshop on site reviews of the Montana USAID project at various research stations in Tunisia and Egypt.

Presented two papers entitled "Experience of using durable resistance in the U.S." and "Changing gene frequencies in populations" at the NATO Advanced Study Institute, Franca Martina, Italy September 29-October 10, 1981.

T. W. Carroll

Presented a paper entitled "BYDV and Aphids" at the Workshop on Barley Diseases and Associated Breeding Methodology, Rabat, Morocco, April 20-24, 1981

Presented a poster entitled "Development of a barley germplasm resistant to the seed transmission of barley stripe mosaic virus" at the Annual Meeting of the American Phytopathological Society at New Orleans, August 2-6, 1981.

A. L. Scharen

Toured southeastern experiment station. Attended Southern Small Grain Workers Conference - Lexington, KY. Presented information on MT Barley Program. April 13-16, 1981

Presented paper entitled "Spot Blotch of Barley" at Workshop on Barley Diseases and Associated Breeding Methodology, Rabat, Morocco, April 20-24, 1981.

Visited INRA Station, Rennes, France. Visited cereal breeding, pathology program of Maxim Trottet. April 27-28.

Presented paper entitled "A possible biological control of Net Blotch of barley" at the APS-CPS Annual Meeting, New Orleans, August 3-6, 1981.

Visited National Cereals Research Center, Passo Fundo, Brazil, October 1-31. Presented 3 seminars on aspects of the cereal research in Montana.

D. C. Sands

Presented paper entitled "Xanthomonas Leaf streak on barley" at the Barley Diseases and Associated Breeding Methodology, Rabat, Morocco, April 20-24, 1981.

D. M. Mathre

Presented a paper entitled "Root rots of barley" at the Workshop on Barley Diseases and Associated Breeding Methodology, Rabat, Morocco, April 20-24, 1981.

R. F. Eslick

Presented a paper entitled "Agronomic improvement of barley" at the Workshop on Barley Diseases and Associated Breeding Methodology, Rabat, Morocco, April 20-24, 1981.

H. Bockelman

Presented a paper entitled "Present status of recurrent selection population for disease resistance" at the 11th Barley Researchers Workshop, Minneapolis, January 26-28, 1981.

Presented two papers entitled "The Montana USAID program for the development of broad-based resistance in barley" and "Virulence patterns of Rhynchosporium secalis" from several barley-growing areas" at the Workshop on Barley Diseases and Associated Breeding Methodology, Rabat, Morocco, April 20-23, 1981.

M. Reinhold

Presented a paper entitled "Resistance in barley to several virulence types of Puccinia hordei" at the 11th Barley Researchers Workshop, Minneapolis, January 26-28, 1981.

H. Visitors

Dr. Sakti Jana, Univ. of Saskatchewan, April 13, 1981. Discussed cooperative work on recurrent selection populations.

Dr. M. Gamal Hassouna, Univ. of Alexandria, Egypt , April - June, 1981. Worked on physiological diseases.

Dr. Rashad Ahmed Abo Elenin, Agricultural Research Center, Giza, Egypt, Sept. 9, 1981. Discussed cooperative work on recurrent selection populations.

Dr. Gomaa, Agricultural Research Center, Giza Egypt. September 8, 1981. Regarding research on BYDV and aphids.

Mr. Amor Yahyaoui, INAT - Tunis, Tunisia, February 16, 1981. Discussed cooperative work on leaf rust.

Dr. T. Ramage, Barley Breeder, University of Arizona, Tucson. September 15-28, 1981. Discussed barley breeding methods.

Dr. A. Ghodbane, Director INAT - Tunis, Tunisia, May 4, 1981. Discussed cooperative cereals program

Dr. H. Ketala, Plant Breeder, INAT - Tunis, Tunisia, May 4, 1981. Discussed cooperative cereal breeding programs.

I. Publications

Bockelman, H. E., E. L. Sharp, and R. F. Eslick, 1981. Registration of barley composite cross XXXVIII. Crop Sci. 21:800.

Bordelon, B. P. 1981. Transgressive segregation for resistance in barley to net blotch. M.S. Thesis, Montana State University. 81 p.

Carroll, T. W., S. K. Zaske and E. A. Hockett. 1981. Development of a barley germplasm resistant to the seed transmission of barley stripe mosaic virus. Phytopathology 71:865 (Abst.).

Carroll,T. W., S. K. Zaske, and R. H. Brlansky. 1982. Separation of Montana isolates of wheat streak mosaic virus on Michigan Amber wheat. Plant Dis. (In Review)

Carroll, T. W., E. A. Hockett, and S. K. Zaske. 1982. Registration of Mobet barley. Crop Sci. (In preparation).

Grey, W. E. 1981. Effect of common root rot on yield components of spring barleys. M. S. Thesis, Montana State University, Bozeman. 91 p.

Grey, W. E. and D. E. Mathre. 1981. Yield components and disease reaction of spring barleys to common root rot infection. Phytopathology (Abstr.) 71:1004.

Hall, Valerie, Hee Kyu Kim, and David C. Sands. 1981. Transmission and epidemiology of Xanthomonas Translucens (in preparation).

Lister, R. M., T. W. Carroll, and S. K. Zaske. 1981. Sensitive serological detection of barley stripe mosaic virus in barley seed. Plant Dis. 65:809-814.

Miller, R. V., T. W. Carroll, and D. C. Sands 1981. The possible use of barley stripe mosaic virus to assay for antiviral compounds. (in preparation)

Reinhold, M. and E. L. Sharp 1981. Resistance to leaf rust of barley in southern Texas, Cereal Rust Bull., (in review).

Reinhold, M. and E. L. Sharp 1981. Virulence types of Puccinia hordei from North America, North Africa and the Middle East. Plant Disease, (in review).

Sands, D. C., V. E. Langhans, A. L. Scharen and G. DeSmet 1982. The association between bacteria and rain and possible resultant Meteorlogical Service. (Accepted for the 1982 volume).

Sands, D. C., R. V. Miller and V. N. Hall. 1982. "Rationale for Pathogenesis" in The Prokaryotic Phytopathogens (eds. G. Lacey and M. Mount), Academic Press, New York. (In press).

Sharp, E. L. and M. Reinhold. 1981. Resistance sources in barley to Puccinia hordei. Plant Disease, (in review).

Smail, Virgil W. 1981. The Pleitropic effects of maturity and row type isogenic lines on the yield stability and development of barley (H. vulgare L.). PhD Thesis, Montana State University, Bozeman, MT. 1-180.

Zaske, S. K., T. W. Carroll, and R. H. Brlansky. 1981. Utilization of Michigan Amber wheat to characterize Montana isolates of wheat streak mosaic virus. Phytopathology 71:1008 (Abst.).

Yount, D. J. and T. W. Carroll. 1981. Identification of three distinct barley yellow dwarf virus strains in Montana by aphid transmission and enzyme immunosorbent assay. Phytopathology 71:267. (Abst.).

Bockelman, H. E., E. L. Sharp, D. C. Sands, A. L. Scharen, D. E. Mathre, T. W. Carroll, J. Riesselman, and R. F. Eslick, 1981. Field manual of common barley diseases. Montana Ag. Exp. Sta. Bulletin No. 734.

J. Literature Cited

A'Brook, J. and A. M. Dewar. 1980. Barley yellow dwarf virus infectivity of alate aphid vectors in west Wales. Ann. appl. Biol. 96:51-58.

Anonymous. 1979. Barley: Origin, Botany, Culture, Winter Hardiness, Genetics, Utilization, Pests. U.S.D.A. Agriculture Handbook No. 338, 154 pp.

Arny, D. C. 1945. Inheritance of resistance to barley stripe. Phytopathology 35:781-804.

Bockelman, H. E., R. F. Eslick, and E. L. Sharp. 1980. Registration of Barley Composite Cross XXXVI. Crop Sci. 20:675-6.

Boulton, R. E. and P. L. Catherall. 1980. The effect of increasing dosage of barley yellow dwarf virus on some resistant and susceptible barleys. Ann. appl. Bio. 94:69-75.

Bruehl, G. W. and V. D. Damsteegt. 1964. Degree of resistance to barley yellow dwarf in selected Ethiopian barleys. Plant Dis. Rep. 48:470.

Catherall, P. L. and J. D. Hayes. 1966. Assessment of varietal reaction and breeding for resistance to the yellow-dwarf virus in barley. Euphytica 15:39-51.

Catherall, P. L., A. T. Jones and J. D. Hayes. 1970. Inheritance and effectiveness of genes in barley that condition tolerance to barley yellow dwarf virus. Ann. appl. Biol. 65:153-161.

Christensen, J. J. 1922. Studies on the parasitism of Helminthosporium sativum. Minnesota Ag. Exp. Sta. Tech. Bul. 11, pp 1-42.

Christensen, J. J. and Leon Wood. 1955. Barley Stripe, Net Blotch and Spot Blotch: Why do these diseases vary over the years? Minn. Farm and Home Sci. Vol XII (2):16-17.

Clark, R. V. and V. R. Wallen. 1969. Seed infection of barley by Cochliobolus sativus and its influence on yield. Can. Plant Dis. Survey 49:60-64.

Couture, Luc and John C. Sutton. 1978. Efficacies of Fungicides in Controlling Spot Blotch of Barley. Can. J. Plant Science 58:311-317.

Damsteegt, V. D. and G. W. Bruehl. 1964. Inheritance of resistance in barley to barley yellow dwarf. Phytopathology 54:219-224.

Dickson, J. G. 1956. Diseases of Field Crops. 2nd ed. McGraw & Hill Book Co. New York. 517 pp. (pp. 43-49).

Hampton, J. G. 1976. Spot Blotch of Barley. Proceedings of the 29th N.S. Weed and Pest Control Conf. 221-4.

Hampton, J. G. 1978. Seed treatments for the control of Drechslera sorokiniana in barley. N.Z. Journal of Experimental Agriculture 6:85-89.

Hayes, H. K., E. C. Stakman, F. Griffee, and J. J. Christensen. 1923. Reaction of barley varieties to Helminthosporium sativum. Univ. of Minn. Tech. Bul. 21. 47 pp.

Isenbeck, K. 1930. Unterzuchungen uber Helminthosporium gramineum Rabh. im Rahmen der Immunitatszuchtung. - Phytopath. Z. 503-55.

Jones, A. T. and P. L. Catherall. 1970. The effect of different virus isolates on the expression of tolerance to barley yellow dwarf virus in barley. Ann. Appl. Biol. 65:147-152.

Jones, A. T. and P. L. Catherall. 1970. The relationship between growth rate and the expression of tolerance to barley yellow dwarf virus in barley. Ann. Appl. Biol. 65:137-145.

Knudsen, V. Chr. Norgaard. 1980. Resistance to Pyrenophora graminea in 145 barley entries subjected to uniform natural inoculum. Kgl. Vet. - og Landbohojsk. Arsskr. 81-85.

Lister, R. M. and W. F. Rochow. 1979. Detection of barley yellow dwarf virus by enzyme-linked immunosorbent assay. Phytopathology 69:649-654.

Musick, R. R., R. D. Wilcoxson, D. Warness, and L. Smith. 1979. Yield Increases in Resistant and Susceptible Barleys Due to Foliar Fungicides. Phytopathology 69:1040 (abstr.).

Nelson, R. R., D. R. Mackenzie, and G. L. Scheifele. 1970. Interaction of genes for pathogenicity and virulence in Trichometasphaeria turcica with different numbers of genes for vertical resistance in Zea mays. Phytopath. 60:1250-54.

Nilsson, B. 1975. Resistance to stripe (Helmithosporium gramineum) in barley. In: Barley Genetics III, pp. 470-475. 849 p.

Paliwal, Y. C. 1977. Rapid diagnosis of barley yelow dwarf virus in plants using serologically specific electron microscopy. Phytopath. Z. 89:25-36.

Parlevliet, J. E. and J. C. Zadoks. 1977. The integrated concept of disease resistance; a new view including horizontal and vertical resistance in plants. Euphytica 26:5-21.

Rasmusson, D. and R. D. Wilcoxson. 1977. Yield losses due to Spot Blotch. Barley Newsletter 21:17. (Quoted by permission of R. D. W.)

Roane, C. W. 1973. Barley pp 237-252 in R. R. Nelson, Ed. Breeding Plants for Disease Resistance. Penn. St. Univ. Press., Univ. Park, 401 pp.

Rochow, W. F. 1970. Barley yellow dwarf virus. Descriptions of plant viruses. No. 32. Commonw. Mycol. Inst., Kew, Surrey, England.

Rochow, W. F. 1979. Field variants of barley yellow dwarf virus: detection and fluctuation during twenty years. Phytopathology 69:655-660.

Schaller, C. W., C. O. Qualset and J. N. Rutger. 1964. Inheritance and linkage of the Yd_2 gene conditioning resistance to the barley yellow dwarf virus disease in barley. Crop Sci. 4:544-548.

Schaller, C. W., D. C. Rasmusson and C. O. Qualset. 1963. Sources of resistance to the yellow-dwarf virus in barley. Crop Sci. 3:342-344.

Sprague, R. 1950. Diseases of Cereals and Grasses in North America. The Ronald Press Co., New York. 538 pp. (pp. 376-381.)

Tekauz, A. 1975. Present status of barley leaf spot diseases in Manitoba. Annu. Conf. Manitob. Agron. pp 83-84.

Thompson, R. K. and J. C. Craddock. 1979. Registration of barley composite crosses XXXIII-A and B. Crop Sci. 19:931-932.

Yount, D. J. and T. W. Carroll. 1980. Identification of three distinct barley yellow dwarf virus strains in Montana by aphid transmission and enzyme immunosorbent assay. (Abst.) Phytopathology 71:267.

K. Appendix - Tables

Table 1. Agronomic Varieties in the 2-row Populations.

Herta	Union
Ingrid	Vireo
Bruens Wisa	Summit
Zephyr	Maris Mink
Early Betzes	Hulless Compana
Dekap	Cumhuriyet 50
Hector	Two-row, hulless Glacier
Waxy Compana	Compana msq 10

Table 2. Agronomic Varieties in the 6-row Populations

Gem	Steptoe
Unitan	Hulless Vantage
Arimont	Hulless Glacier
Waxy Titan	Minn. 21
Nordic	Athenais
Atlas 68	Atsel
Beecher	CM 67
Galt	Manchuria (2330) msq 10

Table 3. Locations of Disease Nurseries, 1980-81.

Montana	Morocco
California	Tunisia
Georgia	Syria
Texas	Turkey
Mexico	Egypt
Korea	France
Ecuador	

Table 4. Populations established.

RSP-5 Rrs (C.C.XXXVI)	(6-row scald)
RSP-5 Rpt	(6-row net blotch)
RSP-5 Rph	(6-row leaf rust)
RSP-5 Reg	(6-row powdery mildew)
RSP-5 Rxt	(6-row Xanthomonas)
RSP-5 Rps	(6-row Pseudomonas)
RSP-5 Rpg	(6-row stem rust)
RSP-5 Ruh	(6-row covered smut)
RSP-4 Rrs	(2-row scald)
RSP-4 Rpt	(2-row net blotch)
RSP-4 Rph	(2-row leaf rust)
RSP-4 Rrs Minor	(2-row scald, minor genes)
RSP-4 Rpt Minor	(2-row net blotch, minor genes)

Table 5. New sources of leaf rust resistance added to RSP-5 Rph, 1981.

Modjo,	C.I. 14048	Cebada Capa,	C.I. 6193
Ariana,	C.I. 2524	Estate,	C.I. 3410
Batna,	C.I. 3391		C.I. 4978
	C.I. 1243		C.I. 3634
	C.I. 11801	Badajoy,	C.I. 7480
Aim,	C.I . 3737	Mari x Athenais	
Bolivia,	C.I. 1257	Asse,	P.I. 371630
Sudan,	C.I. 6489		

Table 6. Scald reaction of entries in the International Barley Nurseries at Bozeman, 1981.

	number of entries									
	0	1	2	3	4	5	6	7	8	9*
11th RDISN	75	29	43	29	29	65	81	102	74	36
10th PON	38	19	13	15	15	14	11	9	5	4
11th RCB	16	7	14	25	24	17	15	14	6	8
8th IBON	10	28	27	18	21	35	31	45	49	72

* rating scale = 0 - most resistant, 9 - most susceptible

Table 7. Seedling Reactions of 20 Barley Cultivars to 9 Isolates of *Rhynchosporium secalis*.

Cultivars		Isolates: LewB77 (Montana)	79 Ftb (Montana)	79 Dav-2 (California)	79 Dav-3 (California)	L (Lebanon)	T (Turkey)	Tun 1 (Tunisia)	Mor 25 (Morocco)	Syr79-58 (Syria)
Abyssinia	C.I. 3940	0*	0	1	0	0	0	0	0	0
Abyssinian 5	C.I. 4354	0	0	1	0	0	0	0	0	0
Steudelli	C.I. 2226	1	0	1	1	0,1	1	1	1	0,1
Osiris	C.I. 1622	0	0	0,1	0	0	0	1	2,3	0
Atlas 46	C.I. 7323	0	0	0,1	3	0	0	2	0	0
Abyssinian	C.I. 668	0	0	1	0	0	0	2	2,3	0
Turk	C.I. 14400	0	0	3	1,2	0	0	3	0	0
Jet	C.I. 967	0	0	2,3	0,1	0	0	2,3	3	0
Nigrinudum	C.I. 11549	2	0	3	0	0	0	2,3	3	0
Modoc	C.I. 7566	0,1	0	3	1	0	0	3	3	0
Beecher	C.I. 6566	1	0,1	3	2,3	3	0,1	0,1	1	0
Trebi	C.I. 936	0	0	2,3	0	0	2,3	3	2,3	0
LaMesita	C.I. 7565	0	0	3	0	0	0,1	3	3	2
Kitchin	C.I. 1296	0	0	2,3	0	0	0,1	3	3	2
Bey	C.I. 5581	0	0	3	0	0	0	3	3	2
Unitan	C.I. 10421	1,2	2	3	1,2	2	0	1	2,3	0
Steptoe	C.I. 15229	1,2	1	3	1,2	2	1	2,3	2,3	2
Gem	C.I. 7243	2	0,1	3	2,3	3	2	0,1	1	0,1
Atlas	C.I. 4118	2,3	1	3	3	3	1,2	1,2	3	0
Betzes	C.I. 6398	3	3	3	3	3	3	3	3	3

*0 and 1 = resistant
2 = intermediate
3 = susceptible

Table 8. Frequency of barley plants resistant and susceptible to *Rhynchosporium secalis* through five cycles of recurrent selection when tested under field conditions with the Montana isolates (Lew B77)

	Cycle 0	Cycle 1	Cycle 2	Cycle 3	Cycle 4
% Resistant	68	84	87	94	85
% Susceptible	32	16	13	6	15

Table 9. Frequencies of barley plants resistant and susceptible to *Rhychosporium secalis* through five cycles of Recurrent Selection when tested under greenhouse conditions.

	Cycle 0			Cycle 1			Cycle 2			Cycle 3			Cycle 4		
	Isolate			Isolate			Isolate			Isolate			Isolate		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
% Resistant	68	59	41	86	60	44	91	60	55	89	65	62	86	65	54
% Susceptible	32	41	59	14	40	56	10	40	45	11	35	38	14	35	46

Isolate 1 = Lew B77 (from Montana)

Isolate 2 = CA 75 (from California)

Isolate 3 = Tun 1 (from Tunisia)

Table 10. Reaction of F_4 progenies to a single isolate and a combination of five isolates of *Pyrenophora teres*.[a]

F_4-Lines		Percent Plants for each Reaction Type					
		Single Isolate			Combination of Isolates		
		R	I	S	R	I	S
Manchuria msg 10/Firlbeck's III	2R-7-B	3.3	30.0	66.7	9.1	54.5	36.4
	2R-7-C	0.0	48.3	51.7	25.0	75.0	0.0
Manchuria msg 10/Hector	3R-4-B	89.1	8.7	2.2	54.5	22.7	22.7
	3R-4-C	78.6	17.9	3.5	70.0	20.0	10.0
	3R-4E	2.7	45.9	51.4	21.0	63.2	15.8
	3R-4-G	62.5	9.4	28.1	61.5	19.2	19.2
	3R-4-H	77.4	19.4	3.2	70.4	7.4	22.2
	3R-4-I	93.5	0.0	6.5	76.2	9.5	14.3
Tifang/Georgie	19R-3-C	4.5	77.3	18.2	81.8	18.2	0.0
	19R-3-D	15.4	84.6	0.0	100.0	0.0	0.0
Betzes msg/Firlbeck's III	22R-5-A	50.0	50.0	0.0	100.0	0.0	0.0

[a] All parents = susceptible

Table 11: New sources of resistance to *Puccinia hordei*

Resistant to all isolates:	Giza 117/Bahtim/Giza 118/FAO 86 Giza 119/Tanekasse 105
Resistant to most isolates:	Badajoy CI 7480 Gizeh 134 Athenais/Nopal 's' Athenais Mari/Athenais CI 3434 CI 8612 CI 4978

Table 12: Varieties resistant to Puccinia hordei in field nurseries in Texas, USA and Rabat, Morocco.

Aim	CI 3737	(Pa_3)	San Carlos	CI 11533
Cebada Capa	CI 6193	(Pa_7)	CI 11577	
Quinn	CI 1024	(Pa_2+Pa_5)	CI 4974	
Ariana	CI 2524	(Pa_2)	Hor. 2596	CI 1243
Forrajera Klein/Reka	CI 11801	(Pa_7)	La Estanzuela	(Pa_7)
Batna	CI 3391	(Pa_2+?)	Athenais	
Estate	CI 3410	(Pa_3)	Ford 1203 (Ford Collection)	
Ricardo	CI 6306	(Pa_2)	CCIM-13 (CYMMIT Line)	
Giza 117/Bahtim/Gizah 118/FAO 86			selected from local cross at Sakha, Egypt.	
Giza 119/Tanekasse 105				
3309 - Attiki/xv2240-OSK				

Table 13. Reaction of different recurrent selection cycles to two isolates of *Puccinia hordei*

Recurrent selection cycle	percent plants with infection type			
	0	1	2	3
	San Antonio isolate:			
1. RSP-78 (Base population few resistance sources added)	8	6	22	64
2. RSP-80 (2 selection cycles, new resistance sources + base varieties added)	11	9	28	52
3. RSP-81 (3 selection cycles, new resistance sources added)	38	9	13	46
	Sakha isolate:			
1. Same as above	63	3	5	30
2. " " "	58	7	6	29
3. " " "	72	5	6	17

Table 14. Reaction of Base varieties of RSP-RPh to *Puccinia hordei*

Variety		Reaction to *P. hordei* isolate from: San Antonio	Sakha
Arimont	CI 15509	2	2
Atlas 68	CI 13864	3	3
Athenais	-	0	2
Atsel	CI 6250	3	3
Beecher	CI 6566	3	3
CM 67	CI 13782	2	2
Galt	CI 11770	3	3
Gem	CI 7243	3	3
Manchurian	msg 10	3	0
Minn. 21	CI 15481	3	3
Nordic	CI 15216	3	3
Nucier	CI 13831	3	3
Nuvan	-	3	3
Steptoe	CI 15229	3	2
Unitan	CI 10421	3	3
Watan	-	3	3

Table 15. Percent Reduction in Growth and Yield Parameters for Eight Spring Barley Cultivars Infected with the MT-PAV isolate of BYDV.

Cultivar	Year	Plant Height	Tillers/Plant	Florets/Head	Seeds/Head	1000 Kernel Wt.	Yield/Plant
Hector	80	11.8	14.3	9.1	9.5	26.7	47.6
	81	27.7	56.9	19.4	25.4	32.4	74.8
Klages	80	26.1	14.3	8.3	13.6	55.5	84.9
	81	27.4	51.0	13.1	17.2	26.1	72.7
Compana	80	19.7	14.3	25.0	26.3	38.6	69.1
	81	13.4	39.3	3.4	11.3	37.8	66.9
Piroline	80	26.1	16.7	13.0	21.7	61.9	90.7
Coracle (yd_2)	81	2.3	7.5	+6.4	+5.9	+2.1	7.3
Unitan	80	20.5	0	22.2	21.4	21.4	51.2
	81	16.6	33.0	5.1	23.5	31.4	72.2
Steptoe	80	19.2	0	14.6	18.3	27.9	48.8
	81	19.0	11.0	12.2	28.2	28.4	58.7
Sutter (yd_2)	80	8.9	+20.0	0	0	+7.7	+32.9
	81	2.9	0	+7.9	+6.6	+2.1	+7.8