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FOR LESSER DEVELOPED COUNTRIES OF THE WORLD

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A. Narrative Summary

This report covers the second year of a current two 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 stains 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 noculation methods and criteria for disease evaluations.

After the fundamental studies were completed it was possible to effectively utilize the information for developing germ plas and the plant breeding phase became 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) 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 two trainees from two different LDC's participated and three foreign graduate students are currently being supported by the barley-AID program.

The methods of using male sterile facilitated recurrent selection populations (MSFRSP) have been outlined in detail in a previous annual report (1981). This method has been used for developing broad-based multigenic resistance to a number of common diseases of barley. Several of these populations have a high percentage of resistant plants and

have been registered for general release to plant breeders. Furthermore, disease resistances have been combined in some populations to give resistance to more than one disease such as scald combined with net blotch and net blotch combined with leaf rust.

B. Project Objectives

1. Determination of different sources of resistance and linkage relationships for the major diseases of barley.

2. Development of barley populations, both two row and six row, with broad based major gene and minor gene resistance to specific diseases.

3. Development of combined resistances to specific diseases in barley stocks.

4. Assist international programs in development of methods for control of virus diseases of barley.

C. Accomplishments to Date

1. Introduction

A general discussion on progress with the RSP's will precede more detailed information for specific diseases. Fundamental information is required before sources of resistance can be incorporated into RSP's. In several diseases this fundamental work has been completed and different resistances are being actively incorporated into RSP's to form broad-based resistance.

The RSP's are being exploited in several locations.

This has occurred by head rowing of specific plants, by combining different single plants from the populations and by crossing single plants from the populations to other cultivars. Undoubtedly new cultivars which have broad-based disease resistance and are agronomically suitable for different locations are being developed by these methods.

2. Barley Recurrent Selection Populations for Broad-based Diseases Resistance

Good progress is continuing on the recurrent selection populations. Thirteen populations for eight diseases of barley are established and in various stages of development. In the past year, the following diseases have received major emphasis: scald, net blotch, leaf rust, powdery mildew, and bacterial streak.

Scald

C. C. XXXVI, the 6-row population for resistance to scald, is presently in the 7th cycle of recurrent selection. It consists of components selected for resistance in Montana, California, Georgia, Maryland, Turkey, Tunisia, Syria, S. Korea, and Mexico. Several experiments have been carried out in the past year to evaluate progress in this population.

Table 1 shows the results of a field trial at Bozeman in 1983. Reserve seed from several cycles in the development of C. C. XXXVI were planted in a replicated trial. Note the relatively high levels of resistance under Montana conditions. In the same trial 92 randomly selected head rows from cycle 6 were planted (Table 2). Only seven of these lines were homozygous susceptible, while 45 were homozygous resistant. Table 3 shows the reactions of the parents that originally went into C. C. XXXVI (including agronomic varieties, male sterile line, and sources of res.) to three diverse isolates of *R. secalis* in the greenhouse. In terms of the number of parents resistant, intermediate, or susceptible, the Montana isolate is least virulent and the California isolate most virulent. The Ethiopian isolate is intermediate. In the same greenhouse experiment reserve seed from several cycles (identical to the field experiment) was evaluated with the same three isolates (Table 4). Note the high level of resistance to the Montana isolate, the moderate, generally increasing level of resistance to the California isolate, and the low level of resistance to the Ethiopian isolate (where the population has never been grown and selected.) This illustrates some of the achievements and shortcomings of this type of broad project. Relatively high levels of resistance are present to isolates where the population had previously been selected, but the levels could be higher and there is no steady increase in resistance over time. The problem is the diversity of nurseries, where disease intensities vary from severe to absent. In some cases selection is based on another disease or agronomic traits alone. Table 5 illustrates the broad-based nature of resistance in C. C. XXXVI. Thirty-four head rows from cycle 6 were evaluated with the same three isolates. The most interesting number here is that only one line is homozygous susceptible to the Ethiopian isolate. What this means is that even without prior selection in Ethiopia (or other locations), it would be relatively easy to pull out resistant lines.

Net Blotch

C. C. XXXVIII, the 6-row population for resistance to net blotch, is presently in the 6th cycle of recurrent selection. It presently consists of components selected in Montana, California, Tunisia, Morocco, South Korea, Egypt, Mexico, Syria, and France. Several experiments were conducted in the past year to evaluate progress in this population.

Table 6 shows the response of several cycles of C. C. XXXVIII at Bozeman in 1983. Note the low levels of susceptibility. A similar test was conducted in the greenhouse with a Montana isolate of P. teres (Table 7). Levels of resistance were much lower and there is no clear trend toward higher resistance over time. Similar results were obtained using a mixture of isolates (Table 8).

These ambiguous results are similar to what was found with C. C. XXXVI. Again, the most plausible explanation is the variable handling of the different nurseries in the various locations where disease intensity varies and may be absent so that selection, in some cases, was based on other traits. However, another seedling greenhouse experiment domonstrates that resistance in C. C. XXXVIII is of a broad-based nature. Ninety-nine randomly selected head rows from cycle 6 were evaluated with mixture of diverse isolates from Montana and Syria (Table 9). Only one of the lines was homozygous susceptible, indicating that resistance is present to a range of virulence types.

RSP-4 Rpt minor a two-row population containing only the 15 2-row agronomic parents and Compana msg 10. Initially, this population was essentially 100% susceptible. Selection for resistance has been conducted yearly since 1978 in an inoculated nursery at Bozeman. Efforts have been made to avoid introduction of major genes for resistance, since these would mask any minor genes present. Only fertile plants have been harvested in the disease nurseries and all nurseries have been isolated from other barleys.

The population is presently in the 5th cycle of recurrent selection. In the first two cycles selection was based on severity of symptoms, since the population was essentially 100% susceptible. In the third and fourth cycles differences in levels of resistence began to appear with most of the selected plants intermediate in reaction. In the fifth cycle (just completed) resistant plants were present in much higher frequencies. Reserve seed from several cycles of RSP-4 Rpt minor was planted in a replicated trial at Bozeman in 1983. The results are shown in Table 10. Note that

each cycle showed improvement but that no significant progress was made until the fourth cycle in 1982 when a large increase in resistance occurred. An experiment in the seedling stage in the greenhouse with a high inoculum concentration of a Montana isolate of P. teres showed the same trend, although not as dramatic as in the field (Table 11). As reported in the previous Annual Report, a test of randomly selected head rows indicated transgressive segregation for resistance was occurring in this population.

Scald and Net Blotch

C. C. XLIII, the 6-row population for combined resistance to scald and net blotch, is presently in the third cycle of recurrent selection. This population represents the first step toward so-called "super" populations containing resistances to several diseases. This population should be useful in areas where scald and net blotch commonly occur together. Since C. C. XLIII was essentially formed by combining C. C. XXXVI (scald) and C. C. XXXVIII (net blotch), levels of resistance to scald and net blotch are not as high. However, greenhouse tests with diverse isolates indicates that broad-based resistance to both scald and net blotch are contained in C. C. XLIII.

Leaf Rust

C. C. XLI , the 6-row population for resistance to leaf rust, is currently in the fifth cycle of recurrent selection. The population presently consists of componenets selected in Texas, Mexico, Turkey, Tunisia, Egypt, and Morocco. In South Texas, where leaf rust is a severe problem, the population and its components show good levels of resistance. In another "hot spot", Sakha, Egypt, the population is also improving.

Powdery Mildew

C. C. XLII, the 6-row population for resistance to powdery mildew, is presently in the fourth cycle of recurrent selection. The population presently consists of components selected in Montana, Morocco, France, Mexico, Egypt, Syria, Tunisia, and Turkey. Presently, we have no good estimates on levels of resistance in this population.

Xanthomonas Bacterial Streak

This disease presents a difficult problem since resistance has been difficult to identify. However, in the past year we have made strides in understanding this disease problem. We now have good methods or obtaining

high levels of infection, which is important in efficient selection. RSP-5 Rxt, the 6-row population for bacterial streak resistance, is presently in the fifth cycle of recurrent selection. Selection in this population has been conducted in nurseries mainly in Montana and Idaho. RSP-5 Rxt, after several years of questionable progress, is now responding to selection. Also, new sources of resistance have been identified which will be added to the population in 1984.

Other Populations

Parallel 2-row populations have been established for resistance to scald, net blotch, and leaf rust. These have been set aside temporarily in order to emphasize the 6 row populations.

RSP-4 Rrs minor, a 2-row population to select for minor gene resistance to scald, is being abandoned because it was not responding to selection. We feel that minor gene resistance to scald does exist, so we will select carefully some new parents and establish a new population.

Future Goals for the Populations

A long-range goal is a single, "super" population containing broad-based resistance to all of the major barley diseases. In the meantime, populations containing resistance to two diseases that frequently occur in the same region will be set up by combining populations. C. C. XLIII is the first such population, combining resistance to scald and net blotch. The plan is to next combine resistances to net blotch and leaf rust.

3. Scald of Barley

Rhynchosporium secalis (Oud.) J. J. Davis, the causal agent of scald, is destructive in many cool and humid barley production areas of the world. The best means of controlling the disease is through resistant barley cultivars. Resistance has been reported in many cultivars. Nine resistance genes have been described in the literature.

The inheritance of resistance to *R. secalis* in some Ethiopian barleys is being investigated. The purpose of this study is to determine the mode of inheritance of resistance genes in these barleys and then to relate these genes to those already characterized.

A total of 181 crosses were made in Summer 1983. Ten resistant Ethiopian barleys (Table 12) were crossed

on to the susceptible cultivar Betzes. Some reciprocal crosses were also made. These resistant Ethiopian barleys were also crossed among themselves to determine if the resistance genes they possess are all identical. Also, the Ethiopian barleys were crossed onto 12 previously studied barleys (Table 13) which contain known genes for scald resistance to determine if they carry the same or different genes for scald resistance.

Four different isolates of the fungus are being used to test for resistance. The fungus isolates were collected from Ethiopia, Montana, California, and Morocco.

Part of the F_1 seeds were sent to Arizona to produce F_2 seeds to be tested both under greenhouse conditions and in the field. Backcroses will be made in Arizona as well as in greenhouse.

The Ethiopian barleys show good overall resistance to the fungus isolates whereas the 12 previously studied resistant barleys show various degrees of reaction ranging from complete immunity to susceptibility.

4. Net Spot Blotch of Barley

Net spot blotch of barley caused by *Pyrenophora teres* Drechs. f. sp. *maculata* Smedeg. is an important disease of barley in Montana. It is also reported from other states and other countries. Earlier reports indicated that the disease is prevalent in Morocco, Turkey, and Tunisia. The organism was also isolated from a leaf sample from Nepal exhibiting spot symptoms.

Symptoms caused by this pathogen are highly variable. Dark-brown, pin-point lesions on the leaf accompanied by chlorosis and necrosis are produced by the Montana isolates in the growth chamber. These symptoms, however, differ from the field symptoms. Here the lesions are rounded or elliptical in shape ranging from <1 to 9 mm in length and 4 to 6 mm in width. The symptoms occur mainly on the leaf blade but in severe cases, leaf sheath, awns, and glumes are also affected. Isolates obtained from Tunisia, Morocco, and Turkey were grown under controlled environment and compared to the Montana isolates. The lesions they caused are dark brown, elongated, measuring about 2-6 mm in length and 1-3 mm in width. Little chlorosis and necrosis was observed 8 days after inoculation. These symptoms became apparent after about 15-20 days. In general, resistant varieties will have less chlorosis and no necrosis with either group of isolates.

Foreign isolates also differ from Montana isolates in cultural characteristics. They do not sporulate well

on V8 agar. The conidia and conidiophores produced by foreign isolates are also slightly different in morphology.

Almost all isolates from Montana had similar virulence patterns, whereas the foreign isolates displayed different virulence patterns. Tifang is a cultivar which showed resistance to Montana isolates and suceptibility to foreign isolates. This was found in a number of other cultivars.

The cultivars and lines AS 276, CI 5401, Unitan CI 9776, CI 9216, CI 9440, and Oderbrucker were found resistant to both groups of isolates. Dekap, Shabet, Betzes, Hector, CI 13727, Compana, Nupana, and Clark were found to be susceptible.

Field results with the Montana isolate indicate that many cultivars resistant in the growth chamber are also resistant in the field. However, cultivars like Unitan and CI 5971 showed resistant reactions in the growth chamber and susceptible reactions in the field. On the other hand, Arimont was found susceptible in growth chamber and resistant in the field. The cultivars CI 5971, Galt, and Himalaya showed resistance in the beginning of the infection but became susceptible later on; indicating some kind of "slow blotching". Sporulation studies on excised leaf tissue placed on water agar showed that susceptible cultivars sporulated earlier and the amount of spores was increased when compared to resistant cultivars.

Yield loss estimates on the culivar Dekap indicate that the reduction in grain weight was higher for the Montana isolate than for the Moroccan isolate. A 90% flag leaf infection caused about 40% loss in grain weight.

5. <u>Leaf Rust of Barley</u>

A number of segregating progenies from crosses with leaf rust resistant material were evaluated in 1982/1983. Seven cultivar/lines could be genetically characterized (Table 14). This is the first report of recessive genes for leaf rust resistance in barley. The infection type as well as the spectrum of resistance displayed by the dominant genes in Ford 1203, CI 4974, and CCIM-13 suggests the involvement of heretofore undescribed major genes. All sources of resistance have been incorporated into the recurrent selection population for leaf rust resistance.

Four hundred superior plants from head rows originating from the leaf rust RSP were selected at the San Antonio nursery. Seed was grown in the field

nursery in Bozeman in 1983. Selections for agronomic types and against male sterility were carried out. Two hundred plants were selected and planted in the winter nursery in San Antonio. The nursery was severly damaged by the unusually cold December weather. However, frozen plants started to come back in March and data on the nursery should be available in late spring. The material should (a) display high leaf rust resistance in acceptable agronomic types, (b) be free of male sterility.

6. Virus Diseases of Barley

a. Barley yellow dwarf (BYD) caused by the barley yellow dwarf luteoviruses (BYD-LV).

Development of a 6-row spring barley male sterile-facilitated recurrent selection population (MSFRSP) having tolerance to the MT-PAV type of barley yellow dwarf virus (=barley yellow dwarf luteovirus, (BYD-LV) continued. The population contains four different sources of the Yd2 gene (CI 1227, 1237, 2376, and 3920-1) for tolerance to the virus, in a background of diverse agronomic types. Tolerant plants show little or no yellowing or purpling discoloration of the leaves.

To begin development of the population, a mechanical mixture consisting of 325 g of Composite Cross (CC) XLIII, a scald and net blotch resistant MSFRSP; and 175 g of CC XXXIII-A and B, two BYD-LV tolerant MSFRSPs, was planted in Bozeman in May 1982. The CC XXXIII-A and B portion consisted of 50% A and 50% B, with 75% of the seed from Pullman, WA and 25% from Bozeman nurseries. More Pullman seed was used due to higher BYD-LV selection pressure there than in Bozeman. Also planted were 165 g of a Manchuria msg 10 (CI 2330) X Sutter (CI 15475) F_2 Sutter is a BYD-LV tolerant 6-row spring barley.

Upon heading, male fertile Manchuria-Sutter (MS) plants were hand crossed onto male sterile plants in the population mix. Also, male fertiles in the population mix were crossed onto male sterile MS. Approximately 350 hand crosses were made.

At maturity the hand crossed MS X population mix (and reciprocals) were harvested and threshed separately. Seeds from naturally outcrossed male sterile plants were harvested and bulked.

Beginning in the 3-4 leaf stage, plants were inoculated with a virulent isolate of BYD-LV, MT-PAV, using viruliferous Rhopalosiphum padi L. and Macrosiphum (=Sitobion) avenae Fabr. The aphids were applied randomly to the population on 6 separate occasions over

a 24 day period. Within 3-4 weeks following the first infestation, chlorosis and purpling typical of BYD-LV infection appeared. Approximately 5 weeks after the first infestation severly symptomatic plants were rogued. About 16% of the estimated 10,500 plants in the population were eventually eliminated, as were about 500 male sterile plants. The remaining plants, about 8,300, were bulk harvested with a plot combine.

After harvesting, the lightest 20% of the seeds were removed to further select for MT-PAV tolerant genotypes by getting rid of small, shriveled seed set on symptomatic plants. A 500 g sample of the cleaned seed was planted in isolation near Mesa, Arizona in December, 1983. Following a recombination cycle the male sterile plants will be harvested and the selection cycle will be repeated in Bozeman. A higher percentage of infected plants will be rogued from the population in 1984.

In January, 1983, 3 seed lots consisting of MS X population mix, population mix X MS, and MS + population outcrossed seed (30, 183, and 450 g respectively) were planted with 100 m isolation near Mesa, Arizona. Male sterile plants in each of the 3 isolates were harvested and threshed.

A 500 g sample of seed resulting from the MS-population outcrossed material plus 100 g samples resulting from each of the MS X population hand crosses were mechanically mixed and planted in Bozeman in May, 1983. After emergence, plants were thinned by hand to approximately 1 plant per 15 cm of row, with rows 30 cm apart.

Yield comparisons of F_2 plants from crosses between Manchuria-Sutter and the population mix described above and their reciprocal crosses could not be made because cattle escaped from a nearby pasture and severly grazed the plants in the nursery making them unsuitable for genetic study.

Dr. Peter Burnett, Barley Pathologist, CIMMYT, Mexico, requested a second shipment of seed of CC XXXIII-A and -B for evaluation and possible use of the populations. The first seed shipment was confiscated by the Mexican Agricultural Officials.

During the Barley Yellow Dwarf Workshop at CIMMYT Headquarters, El Batan, Mexico, in December 1983, Dr. W. Clive James, Deputy Director General of that organization, gave a status report on the international CIMMYT Project pertaining to BYD. A multiple source funding strategy will be used to raise the required money for research. Three million dollars are being

sought for the project. Interim funding will come from the United Nations Development Program (UNDP). Part of this money will go for work in Italy. Later, the International Development and Research Council (IDRC) and the European New Fund will be used to support research in Canada, Australia, and New Zealand and in Great Britian and Ireland, respectively. In the U.S.A., funding will be requested from the A.R.S. and the C.S.R.S. of the USDA. Developing countries will receive support via CIMMYT and UNDP.

b. Barley stripe mosaic caused by barley stripemosaic virus (BSMV).

Dr. Peter Burnett, requested and was sent seed of Mobet barley germplasm (Reg. No. GP 61, PI 46788). This germplasm has resistance to the seed transmission of three Montana strains of BSMV.

Tested 35 of 118 entries of barley from the CIMMYT crossing block nursery at the request of Dr. Burnett. The entries were evaluated for seedborne barley stripe mosaic virus via seed transmission assays and immunosorbent electron microscope tests.

c. Barley yellow striate mosaic caused by barley yellow striate mosaic virus (BYSMV).

It appears that the yellow stripe disease of barley and durum wheat occurring in Morocco and Syria is caused by BYSMV. This is strongly suggested by the recent work of Dr. B. E. L. Lockhart, Assoc. Prof., Complexe Horticole, B. P. 438, Agadir, Morocco with antiserum from Torino, Italy, and our electron microscopic evidence.

7. Bacterial Diseases of Barley.

a. *Pseudomonas syringae* was again isolated from barley leaves in five North African locations in Morocco, Tunisia and Egypt, as well as in Syria and Turkey. These strains are ice nucleation active, and several also produce fungitoxins (against *Septoria*). The significance of ice and dew nucleation ability of these bacteria is not understood, but they may have some important role in the ecology of the region (not to mention Montana and the Northwest). Two manuscripts on these phenomena have been submitted to journals.

b. Bacterial leaf streak caused by *Xanthomonas campestris* pv. translucens was also observed in the Middle East. Recurrent selection populations for resistance to this disease were grown in locations in Sidney, Bozeman, Sun River and Fairfield, Montana; Riverside, Woodland and Davis, California; Aberdeen,

Idaho; and Obregon, Mexico. The recombination nursery was grown in Arizona. Population locations this coming year include Kenya, three in Montana, and Idaho. Some improvement in resistance levels has been observed.

This bacterial pathogen is primarily seed transmitted. We developed a field assay where infected or infested tissue turns blue if briefly incubated with a colorless dye. This assay is effective for determining infestation of seed lots and was developed with the help of two AID supported graduate students. This work will be presented at the 1984 American Phytopathological Society Annual meetings.

Seed Treatment

Seed treatment efficacy has been a serious problem with this disease. Infested seed was sent to Ciba Geigy, Boca Raton, Florida for screening against their new bactericides. The two most effective compounds are being field tested in Montana this spring against highly infested seed.

Resistance Genetics

Several hundred advanced lines were screened for resistance to this pathogen. Crosses of resistant x resistant and resistant x susceptible lines were performed in Bozeman in the summer of 1983, and F_1s were grown in Arizona and in the greenhouse in Bozeman. Analysis of the F_2s will be done in the summer of 1984 and the resistant germplasm will be added to recurrent selection populations.

Phosphorus Uptake

A recurrent selection population has been established for ability of plants to grow on low levels of phosphate. This population, in its third year, shows some promise for a partial genetic solution to this problem. Root extract inocula containing mycorrhizae, are partially responsible for phosphate uptake.

8. Other Diseases of Barley

a. Barley Stripe

During the past year, studies on virulence of 24 *P. graminea* isolates from various sources on three barley cultivars that exhibit varying degrees of resistance and susceptibility have been continued.

Materials and Methods

Leaf samples from plants symptomatic of barley stripe disease were collected in Tunisia, Egypt, Syria, Turkey, and Montana, USA. Sample leaf pieces were placed on moistened filter paper in petri dishes after surface sterilization in 10% Clorox solution. Single conidiospore isolates were obtained from the leaf pieces. Cultures were allowed to grow on barley leaf piece agar (BLPA) for 12-16 days at 15 C after which time a single, six mm bore from the perimeter of growing mycelia was placed in autoclaved barley kernels. After mycelial increase on the barley kernels, a single barley kernel with mycelia was placed on PDA + 4 (4 g/l wheat bran) medium in plastic petri dishes. Cultures were again allowed to grow at approximately 15 C for 12-15 days.

Three barley cultivars were used in these experiments: Betzes, was increased in Montana and harvested in September, 1982; Summit seed was increased in Arizona and harvested in April, 1983; and, Lami seed was increased in Arizona and harvested in April, 1983. Forty seed lots were surface sterilized for 4-5 minutes in 10% Clorox plus 2% ETOH, after which the seed lots were dried on paper towels in an air control chamber.

Inoculation was by the layered mycelium method (Houston and Oswald, 1948). Individual seed lots were sandwiched between two layers of mycelia actively growing on PDA + 4 medium. Petri dishes were sealed with plastic and placed in a growth chamber at approximately 8 C (12 h light/dark cycle) for seven days, after which time the seeds had germinated, and radicles were 0.5 to 1.5 cm long. The seeds were removed from the petri dishes and planted in a 1:1 sand:soil mixture in aluminum trays. The trays were returned to the same chamber. After four weeks, plants were removed to a greenhouse maintained at 16-20 C. Plants were first evaluated at four weeks post-planting and every five to six days thereafter until eight weeks post planting. Symptomatic plants were pulled at each evaluation. Percentage symptomatic plants of the total plants emerged from each seed lot were recorded for analysis.

Three different split plot experiments using the same procedures were conducted, each with eight *P. graminea* isolate (RPB/MT6), and a noninoculated check. The check isolate, RPB/MT6, had been serially transferred for more than eight months on BLPA. The noninoculated check consisted of surface sterilized seed lots germinated in an agar sandwich as above, but with no fungus. Each isolate cultivar combination had three replications. Analysis of the data was by a split plot

design with the isolates as the main plot and cultivars as the subplot.

Results and Discussion

In this report, the variation in virulence of P. graminea isolates from Montana (numbered isolates), Tunisia (TN-__isolates), Egypt (E-__isolates), Syria (S-__isolates), and Turkey (TK-__isolates) is reported. Percentage symptomatic plants of total emerged plants is given for each isolate X cultivar interaction (average of three replications each) in Tables 15, 16, and 17. Percentage emergence of the cultivars differed in the experiments. Over the three experiments, average emergence for Lami was 82.9%, for Summit, 82.1%, and for Betzes, 59.9%. The Betzes seed lot had poor emergence throughout the experiments. Analysis of covariance with per cent emergence as the independent covariance did not increase precision, however. The severity of symptoms was not taken into account. Rather, any symptomatic plant was evaluated as infected and pulled.

Virulence of these isolates on the cultivar Lami varied from zero to 100% infected plants. Lami is highly susceptible to P. graminea (Smedegard-Petersen and Jorgensen 1982, Knudsen 1980, Metz and Scharen 1979); however, percentage infection of Lami did vary which indicated a low level of resistance.

Summit has been reported to be highly susceptible to P. graminea (Konak 1983); however, the data presented here indicate a low level of available resistance in Summit to P. graminea. The Summit seed lot used in these tests was harvested from a barley stripe disease infected nursery. Intense roguing was undertaken in this nursery prior to heading, and plants lacking symptoms were selected. Selection may explain the low levels of virulence of these isolates on this Summit seed lot.

Betzes barley had been reported to be "immune" to barley stripe disease (Metz and Scharen 1979), until Konak described symptomatic plants in artificial inoculation experiments (Konak 1983). Virulence of the P. graminea isolates used in these experiments on Betzes resulted in zero to 16% infected plants. Eighteen of the 24 isolates tested produced no disease when inoculated on Betzes. Konak has proposed that Betzes has at least one dominant gene for resistance (Konak 1983). Inoculation tests with Betzes crosses are continuing and will be reported later.

The data presented here indicate that differential interactions occurred between specific barley cultivars and P. graminea isolates from infected barley plants.

The significant isolate X cultivar interaction in the analysis of variance for each experiment (p values less than 0.01 for each experiment) indicated differential, cultivar-specific virulence. These differences in cultivar-specific isolate virulence were apparent in experiment 1 (Table 15) where a difference in isolate X cultivar infection ranking from susceptible to resistant reaction was Lami, Summit, and Betzes, respectively. Isolates 33-313 and TN-9 reversed the Summit and Betzes ranking such that Betzes was less resistant than Summit. No significant differences between these means occurred. The LSD's between Summit and Betzes infection means for isolates TN-9 and 33-313 had t-values between 0.10 and 0.20, and greater than 0.50, respectively.

Smedegard-Petersen and Jorgensen (1982) also described variation in virulence of different *P. graminea* isolates on barley cultivars. Even with relatively susceptible cultivars, these workers reported variation in virulences of specific isolates from "full susceptibility to immunity." Data of Smedegard-Petersen and Jorgensen, along with those reported in this paper, and by other researchers (Knudsen 1980, Metz and Scharen 1979), indicate the occurrence of race specific resistance to *P. graminea.*

From the data presented here, as well as that of other researchers (Kline 1971, Knudsen 1980, Konak 1983, Metz and Scharen 1979, Smedegard-Petersen and Jorgensen 1982), available sources of resistance in commercial barley cultivars to barley stripe disase are apparent. The available resistant cultivars are waiting to be used by adept barley breeders.

b. Take-all

Where take-all, caused by the soil-borne fungus *Gaeumannomyces graminis* var *tritici*, is a problem on spring wheat, growers often turn to barley since it is not as susceptible as wheat. We began a study in 1983 to determine the reaction of barley cultivars to take-all.

Field plots were established at Bozeman by adding varying quantities of oat-kernel inoculum of the take-all fungus to the seed furrow at the time of planting. Two six-row cultivars, Steptoe and Unitan, and two two-row cultivars, Klages and Clark, were seeded in 3.3 m rows, 4 replications per treatment. Each row received either 5.0, 0.5, or 0.05 g of inoculum. The check row received 5 g of non-infested autoclaved oat kernels. The plots were seeded on April 22, 1983. Symptoms of leaf yellowing and stunted growth were evaluated on June 7, June 17, and July 5.

The results are given in Table 18. Unitan was the most susceptible and Klages the least susceptible. Since the plots were severely damaged by hail one week prior to harvest, yields were not determined. Wheat cultivars in the same test showed more severe symptoms, averaging 4.8 in severity at the 5 g inoculum rate. This compares to an average rating of 3.1 for the four barley cultivars. Whether barley cultivars really do vary in susceptibility needs further research but it appears that such variability may exist.

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 scientifice personnel and administrators in the various countries. In April-May of 1983 Dr. Sands and Mr. Richard Ruff 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. Additionally, members of our department are often involved with CIMMYT and ICARDA in International meetings and workshops. (See Visits and Presentations section).

Several thousand copies of the "Field Manual on Common Barley Diseases" completed in 1981 have been distributed to barley workers and requests are still coming in. This past year we completed a Spanish translation of the manual and 500 copies have sent to CIMMYT. Furthermore, we have made arrangements for the manual to be translated and prepared in Arabic and are negotiating for another translation into the Turkish language. The demand for this manual in different languages indicates its utility and wide acceptance in both the LDC's and other countries.

The proceedings of the "Barley Diseases and Associated Breeding Methology Workshop" held in Rabat, Morocco, 1981 have been published. Copies have been sent to all US participants. The international centers CIMMYT and ICARDA will handle the distribution to the overseas participants.

Our staff and graduates continue to receive offers for cooperative research, employment, and consultation in International Agriculture both on a short and long term basis.

E. Training Program

Under the training portion of the Montana USAID contract two trainees participated in 1983 and there are five graduate research assistants presently in the program as follows:

Trainees:

Fredj Mhiri--------Tunisia
Andreas Kari-------Cyprus

GRA's:

Chanda Karki-------Nepal
Richard Ruff-------USA
Segenet Kelemu-----Ethiopia
Jim Crosslin-------USA
Gurbutz Mizrak-----Turkey

Three other foreign GRA's supported by other funds, but participating in our cereal program are:

Celsa Garcia------Mexico
Ricardo Madariaga--Chile
Amor Yahyaoui------Tunisia (MIAC)

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 at MSU from June 15 through September 15, and August 1 through January 1, respectively. This time sequence covered disease development on barley in the field, harvest and some laboratory work. 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 to 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 of resistance genes through use of male sterility. All trainees prior to departure received a certificate verifying participation in a training period on barlely diseases and associated plant breeding.

Ricardo Madariaga (Chile) who participated in the cereal program, but was not funded by AID, completed his masters degree in March, 1983, and has returned to Chile.

We continue to have more applicants than we can accomodate.

F. Trip Report

Dr. David Sands and Mr. Richard Ruff

April 20 - May 9, 1983

North Africa and Middle East Trip

April 20, 1983. Rabat, Morocco.

We spent the greater part of the day at the Guich Experiment Station at Rabat. The barley, all planted under the wire as usual, had a drier than normal year. Three RSP's were planted and we arrived probably ten days too late to get really good readings on green tissue. We made readings and flagged the net blotch, leaf rust, and powdery mildew populations.

The net blotch population exhibited very little net blotch in relation to the varieties around it. There were occasional lesions of the streak or net blotch type and fewer of the spot blotch type. Since net blotch was very rare in this population, the priority selection was for mildew resistance, secondary selection was for leaf rust resistance, and the third selection was for agronomic heads or large heads, however, only about 90 some plants were tagged due to the second tertiary selections. No plants were taken with any net blotch. The net blotch populations exhibited good earliness; compared to the lines planted next to it. In addition the population has shown a marked agronomic improvement in terms of head size and lack of lodging.

Leaf Rust Population: In this population 90-100 heads were selected for high level of resistance. Powdery Mildew Population: The primary selection was for mildew resistance and secondarily for some agronomic selection. This population was not quite as early as the net blotch but earlier than the rust population. It was not as agronomically desirable as the net blotch population, but it too showed an improvement over several years ago at this location.

We spent much of the evening with Malcolm Purvess of the University of Minnesota, who is in charge of international programs. The University currently has a 25 million dollar program in Morocco. He is interested in cooperating in certain programs such as pathology, IPM, etc. He said there is money available for such things as sabbatical leaves, etc., including graduate student training.

April 21, 1983. Morocco.

We started by finishing the recurrent selection populations in Guich. Lynn Gallagher picked 10 heads in the

net blotch RSP that he thought were of special agronomic value to be put in with the rest of our selections. We read all 360 of Gallagher's F5 lines. These are generally crosses between Northrup King material which is considered by Lynn to be of good agronomic value and Schaller's material which has the Yd2 gene for yellow dwarf and various genes for rust and net blotch resistance in it.

We looked at the durum wheat program with Willa Findley, who was previously at ICARDA and is in co-charge of durum wheat here. We saw a wheat stem maggot, some Hessian fly, and some leaf rust and P. syringae. Syringae was on very few lines.

Malcolm Purvis, the International Coordinator at the University of Minnesota, suggested that we not only meet McSwain at USAID but if possible have a meeting with Chase, who is in charge of the AID-Morocco. Chase asked for priorities in our area for Morocco and we listed them as Hessian fly, root rot resistance, and barley yellow dwarf. He asked for estimations of impact of these three problems and implementation of new varieties if we succeeded in these three areas.

Merchouch, Morocco. April 22, 1983.

Visited the Merchouch farm to look at Lynn Gallagher's plots, especially his F2's that we have grown for him as F1's in Montana. His crosses were out of Northrup King, Schaller's material in California, and Ramage's material in Arizona. Merchouch had a dry year with maybe 310 mm of rainfall, yet wherever he selected for earliness we could see segregation in the F2 and good head production before the drought hit hard. In comparison ICARDA lines had not reached maturity and CIMMYT lines were somewhere in between, although some of the CIMMYT lines were pretty early too. We saw lots of root rot, maybe with a pinkish Fusarium roseum like appearance.

In other varieties of wheat we saw quite a bit of white heads, possibly due to Fusarium and in some we saw net blotch. In some varieties of barley we saw minor damage due to leaf minors, and in one variety we saw considerable P. syringae on the flag leaves but not the second or third leaf down. About 10 miles north of Merchouch on the way back to Rabat was a field of barley still green but definitely headed out. About 10% of the plants appeared to be killed. We suspected Hessian fly, and found Hessian fly pupae on about 60% of the dead plants. There was also root rot in the area.

April 23, 1983. Guich, Rabat.

Rick Ruff met with Boulif for about an hour discussing H. gramineum, barley stripe. Boulif is trying to obtain differential reactions to about 25 isolates of H.

gramineum, (mostly Moroccan) using different barley lines. He innoculates with a sandwich method and reads heading percentage of plants infected. Lynn Gallagher is interested in coming to Bozeman for two weeks in late July 1984 to learn selection methods for root rot resistance from Don Mathre.

April 25, 1983. Cairo.

Arrived 2:00 A.M. on the 24th, on the morning of the 25th met Al Ala Din, Rashad L. Elenein, Aknad Sabray, and Jim Sims at the hotel in Cairo. We planned our stay and left with Sabray for Alexandria. Stopped only once and saw bread wheat with stripe rust, leaf rust, Septoria and on some plants *P. syringae*. On the drive to Alexandria we discussed various aspects of agriculture and how it is changing in Egypt. (a) The push towards the North coast and development of more adapted cultivars. (b) The more judicious use of water in the new lands and throughout the delta. (c) The more accurate and judicious use in fertilizer. Other aspects are the high labor costs due to the exportation of young laborers and to the undesirability of farm work. There is an increasing amount of mechanization. Another new development is poultry. According to Sabray, Egypt imported most of its poultry 2-3 years ago. They are now self sufficient. Poultry is of course competing with humans for fava beans. The fertilizer from the poultry houses is spread but is not yet considered of marketable value.

We went to Alexandria University where I met with Dean Shahasi. We went down to the North Coast and made 5-6 collections of dry land barley. This was one of the best years in the last 50. The area is currently only getting a good crop every five years.

April 26, 1983. Alexandria

Throughout the north coast we saw heathy roots, and roughly 1-5% of the plants had quite a bit of barley stripe or *H. gramineum*. When the plant was infected, the seed would be very shrunken and black. There was leaf rust but it seemed to be very late. We saw quite a lot of *P. syringae* on the green flag leaves that were left, but most of the flag leaves had already dried up. There was some powdery mildew; Ismail Ahmed pointed out boron deficiency resulting in black flecks or spots similar to a powdery mildew induced hypersensitivity. Coming back we saw a large center pivot operation on the desert road, maybe 100 km from Cairo. They had planted late, only two months ago instead of December, getting pretty poor stand. It is doubtful if they're going to get more than 8 or 10 bushels per acre. This equipment was brought in by an American company and looks as though it will take some time before it is adapted to this area. The soil was sandy and appeared to have leaching problems. We saw *P. syringae*; leaf rust and *H. gramineum*. Although they watered every 3 days it appeared to be in very poor

condition. A lot could be learned by having a collaborative agreement on sprinkler irrigation and all its aspects.

April 27th Cairo

We went to the Agriculture Research Center where we discussed with Rashad observations from the North coast in the new lands. We went to see the director of a general poultry company. They run about 110 million broilers a year.

April 28th.

We took a trip with Maher, Ismail and Rashad to Sakka. As for the RSP's, we managed to pick at least 200 heads from each, they will also keep 200 heads from the same plants. They are becoming really interested in these RSP's as evidenced by the fact that they had already tagged quite a few plants in each population. The most impressive RSP was the leaf rust RSP which showed a lot of improvement over the last four years. We flagged about 200 plants for resistance, big heads, and where possible, earliness and shortness were included for diversity. We saw some powdery mildew; no doubt by selecting for clean plants, we are selecting against this as well. Of the three populations it seemed to be the cleanest for disease in general and was easily the best for agronomic type. Rashad commented that it contained more clean material than any of the ICARDA material. He is planning to select about 100 plants to head row out of it and compare next year. On the road to Sakka we saw quite a bit of leaf rust on a wheat cultivar, which Rashad insisted was resistant. It appears that this variety has been out for four or five years and is now coming down with leaf rust. We pointed out that if they want long term resistance and want to avoid having to produce a new variety every three years, then this recurrent selection is one way to do it. The net blotch RSP was free of P. teres, but selection pressure was light. For this reason we selected for leaf rust and tried to find plants with a moderately resistant reaction, good head type, and, of course, diversity for earliness and stature. The powdery mildew population was too far along to read for powdery mildew, although Ismail said it had come on heavily early in the season. We selected largely for agronomic types We met two trainee prospects. One will probably go to Australia, we may want the other or both. Both know about RSP's. They are breeders and have been selecting in the population. However, they aren't sure how to use the material properly.

May 1, 1983 Aleppo.

We drove from Damascus, met with Mekni and Kamel, and toured the RSP's with Mohammed Moushraf. It was too early to read any symptoms in the RSP's. Yellow rust was just starting to show. Of the disease RSPs the leaf rust

population looked best agronomically as it did in the other locations.

May 2, 1983. Aleppo.

Met Jit Srivastava at 8 A.M. in the hotel and gave him the letter from Gene Sharp concerning the terms under which they would be allowed to translate the barley manual and use the color plates. Mekni and Kamel got copies of the letter and their secretary typed up a response. It was made clear that they were to contact Gene Sharp if the terms were not acceptable.

We saw more of Eslick's RSP's today. Most were not early enough but all had a few early plants. Mohammed Moushraf, who has worked with Mekni for 5 years, expressed an interest in being a trainee and Mekni is very supportive of the idea possibly to the point where they will pay his way as a trainee.

We met with Mark Winslow, a new staff member from the University of California - Davis. He is a plant physiologist out of Manuel Epstein's laboratory. We brought up our observations concerning the possibility that mycorrhizae are possibly improving water and nutrient uptake. We met with Phil Williams, the cereal quality man from Winnipeg, and agreed to send him some sourdough baladi organism soon. He thinks that funding is available from the Canada wheat board.

May 3, 1983.

We drove to the border of Turkey and took a bus between the two border stations. We took a taxi to Adana over a mountain pass and stayed at the Inci Hotel. We collected barley samples from 4 locations. One before Antioc, one 15 km after Antioc in the hills. Later in the bottom land near Adanna we saw *H. graminium*, *P. syringae*, powdery mildew, net blotch, and lots of covered smut. We also saw quite a few virus diseases and took a sample at the top of the pass. We visited the Agriculture Experiment Station south of Adana and met the director. The staff there is in wheat breeding, safflower and sunflower work. They also work with maize and cotton. It looked like a very active station. They do have a problem with birds eating the seed. Their wheat trials look especially good; it appears that the best cultivars for this region come from Italy.

May 4, 1983.

We flew on to Istanbul and then into Izmir, picked up Cahit Konak and went out to the station. There we met with the director, Temiz, who was interested in barley. He says that the national program has been cut back completely five or six years, but now they are going to carry it on strong

again. He thought the addition of two people, Cahit and Temiz, should strengthen their barley program. We went out to the plots. They had a very dry year and consequently very little disease. We found quite a lot of H. gramineum, apparently due to infection from last year's seed. In our RSP's we found a fair dose of powdery mildew. We were able to find just 200 plants that were clean. There was very little other disease to interfere with this reading. The leaf rust population was just starting to get some leaf rust. We did not see any scald yet in the area, possibly because it was just too dry.

May 5, 1983.

We took a field trip the next day. At first we saw marginal foothill use of barley, lots of H. gramineum, perhaps 3 to 5% of the plants. It was grown in the foothills, not often on the level land, or it was grown as a cover crop in olive orchards. We also saw covered smut, perhaps 3 to 5%, and quite a lot of P. syringae. It was dry. The cultivars we saw were quite dirty, and there were a lot of seed-transmitted diseases. We also saw a kernel fly which only attacks 6-row barleys, but not the 2 row cultivars. The farmers prefer 6-row barley, whereas the malters prefer 2-row barley.

We made several stops in the grain growing area, Sahilil. We saw one very bad infestation on barley of P. syringae. It was just starting in areas, approximately 50 square meters. It was hitting the earliest plants and the flag leaf preferential to the lower leaves. In this area we saw lots of H. gramineum and some scald. It was too dry for any rust and there was very little or no net blotch. We came back to the station and discussed with Cahit and Temiz the situation. Temiz suggested that he wants us to draw up a joint cooperative agreement with his station and our university to cover research on many common aspects. He also asked for a write up of the seminar that Dave Sands gave. He would like to have it published in Turkish.

May 7, 1983.

We met with Moncef Harrabi in Tunisia, went to Mateur, and looked at 5 RSP's. They were planted late because they were mailed to INRA instead of INAT. They were planted in January getting 500 mm of rain flooding early and then nothing. The plants were showing big differences in this environment. The late ones were running out of water. There were lots of weeds but they had been weeded the day before. The RSP's were (1) scald combined with net blotch, (2) scald, (3)leaf rust, (4) powdery mildew and (5) net blotch. Generally they were clean of the disease they were developed for except that the powdery mildew population had some infection and we rogued it. In all cases we rogued for earliness and yellow dwarf resistance. The late plants and,

of course, plants with large heads simply were not maturing. Some of the plants, although they were not early, had sent down roots far enough to reach moisture and make pump seeds and those were also selected.

Next day Moncef took us to the northeastern tip of Tunisia. Along with the leaf rust infection we identified drought stress, root rot probably due to *Fusarium*, and Hessian fly. We looked at some fields on the way back and found *H. gramineum* and *P. syringae* in the barley.

We also met with Bill Herder at the AID in Tunis. He feels that in the future cropping systems will be emphasized in Tunisia. He feels that there should be a follow-through on our training people one-on-one with professors, similar to the Egyptian program.

May 9, 1983.

Returned to U.S.A.

G. Visits and Presentations

H. E. Bockelman

Aug. 15-19, 1983, American Society of Agronomy, Washington, D.C. "Development of minor gene resistance to barley net blotch".

Jan. 23-25, 1984, American Barley Researchers Workshop, Williamsburg, VA, "Resistance to *Xanthomonas* bacterial streak of barley".

T. W. Carroll

Invited symposium speaker at national meeting of the American Phytopathological Society, June 26-30, 1983. Topic presented was entitled "Future trends in detection methodology for seed-borne viruses".

Presented two invited papers at the Barley Yellow Dwarf Workshop, December 6-8, 1983, at CIMMYT, El Batan, Mexico. The papers were entitled "Barley yellow dwarf virus in Montana" and "Status of barley yellow dwarf virus in maize".

A. L. Scharen

Participated in a workshop on leaf diseases of barley and wheat sponsored by CIMMYT in Brazil, October, 1983. Trainees from six southern South American countries participated in the two week course.

E. L. Sharp

Several discussions and presentations to AID officials on Montana barley AID program. Washington D.C. 1983-84.

Transgressive segregation for resistance to net blotch. American Barley Workers Workshop. Williamsburg VA. Jan. 21-27. 1984.

H. Visitors

Discussions included barley disease work and associated breeding.

May, 1983

Guido Herrera - Santiago, Chile

July, 1983

Jit Srivastava - ICARDA, Syria

August 1-5, 1983

The following barley workers participated in the Septoria Conference held at Montana State University:

Girma Bekele - CIMMYT, Mexico
W. J. R. Boyd - University of Western Australia, Nedlands, Australia
Olberio Canatu - Northrup King Company, Woodland, CA
Barry M. Cunfer - Dept. of Plant Pathology, Experiment, GA
Jesse Dubin - CIMMYT/INIAP, Quito, Ecuador
Jim Frank - USDA/ARS, Plant Pathology, University Park, PA
P. M. Fried - Swiss Federal Research Station for Agronomy, Zurich, Switzerland
Helen Griffiths - Dept. of Biology, Utah State University, Logan, Utah
Gareth D. Jones - University College of Wales, Aberystwyth, Dyfed, UK
Mohan M. Kohli - CIMMYT, Santiago, Chile
A. M. Leemans - Laboratory of Phytopathology, Wageningen, The Netherlands
Robert Matchett - Northrup King Company, Woodland, CA
Abdellah Ouassou - Rabat, Morocco
J. M. Prescott - CIMMYT, Mexico
Enrique Torres - CIMMYT, Mexico
Bryan Khan - Dept. of Agriculture, Western Australia

August 14-19, 1983

Alicia di Biasi - Castedai, Argentina

I. Publications

Bockelman, H. E., M. Reinhold, E. L. Sharp, and R. F. Eslick, 1983. Registration of leaf rust resistant barley composite cross XLI. Crop Sci. 23:1224-1225.

Bockelman, H. E., E. L. Sharp, R. F. Eslick, and R. T. Ramage, 1983. Registration of powdery mildew resistant barley composite cross XLII. Crop Sci. 23:1225.

Bockelman, H. E., R. F. Eslick, and E. L. Sharp, 1983. Registration of scald and net blotch resistant barley composite cross XLIII. Crop Sci. 23:1225-1226.

Carroll, T. W., E. A. Hockett, and S. K. Zaske. 1983. Registration of Mobet Barley Germplasm. Crop Sci. 23:599-600.

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Harrabi, Moncef. 1983. The inheritance of resistance of barley (*Hordeum vulgare L.*) to *Rhynchosporium secalis* (Oud.) J. J. Davis. PhD Thesis, Montana State University.

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J. Literature Cited

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Metz, S. G. and A. L. Scharen. 1979. Potential for development of *Pyrenophora graminea* on barley in a semi-arid environment. Plant Dis. Reptr. 63:671-675.

Schaller, C. W., J. D. Prado, and C. I. Chim. 1973. Registration of Sutter barley. Crop Sci. 13:285.

Smedegaard-Petersen, V., and J. Jorgensen. 1982. Resistance to barley leaf stripe caused by *Pyrenophora graminea.* Phytopath. Z. 105:183-191.

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

K. Appendix

Table 1. Response to scald of several cycles of C. C. XXXVI at Bozeman, 1983.

Component	Cycle	% of plants		
		R	I	S
X_{78}	3	73	12	15
X_{78-79}	3	68	21	12
X_{79}	4	81	17	2
X_{79A}	4	65	10	25
$X_{79A}M1$	4	70	16	13
X_{80}	5	72	14	15
X_{80A}	5	73	13	14
X_{81}	5	83	7	10
X_{82}	6	82	9	9

Table 2. Reactions of 92 random head rows (F_2) from cycle 6 (1982) of C. C. XXXVI at Bozeman, 1983.

	No. of head rows
Resistant	45
Segregating	40
Susceptible	7

Table 3. Reactions of parents of C. C. XXXVI to three isolates of *R. secalis* in the seedling stage in the greenhouse.

Isolate	No. of Parents		
	R	I	S
LB77-81 (Bozeman, MT)	29	12	9
83 UCD-1 (Davis, CA)	5	18	27
Eth (Ethiopia)	10	17	23

Table 4. Response of several cycles of C. C. XXXVI in the seedling stage in the greenhouse to three isolates of *R. secalis*.

Cycle	Year Seed Harvested	Isolate % Plants Resistant LB77-81	83 UCD-1	Eth
3	1978	86	53	18
4	1979	85	52	31
5	1980	82	68	19
5	1981	88	80	34
6	1982	94	65	35
7	1983	88	71	20

Table 5. Reactions of random head rows (F_3) from cycle 6 (1982) of C. C. XXXVI in the seedling stage in the greenhouse to three isolates of *R. secalis*.

Isolate	No. of head-rows R	Segr.	S
LB 77-81 (Bozeman, MT)	24	10	0
83 UCD-1 (Davis, CA)	15	19	0
Eth (Ethiopia)	2	31	1

Table 6. Response to net blotch of several cycles of C. C. XXXVIII at Bozeman, 1983.

Cycle	Year	% of Plants R	I	S
2	78	72	7	4
3	78-79	85	10	5
3	79	78	17	4
4	79-80	79	18	3
4	80	78	18	4
4	81	76	19	5
5	82	84	13	2

Table 7. Response of several cycles of C. C. XXXVIII in the seedling stage in the greenhouse to a Montana (R) isolate of *P. teres.*

Cycle	Year	% of Plants R	I	S
2	78	32	35	33
3	78-79	34	34	32
3	79	39	22	39
4	79-80	27	21	52
4	80	41	28	31
4	81	28	41	31
5	82	51	25	24

Table 8. Response of several cycles of C. C. XXXVIII in the seedling stage in the greenhouse to a mixture of isolates of *P. teres* from Montana (Mt 77-1) and Syria (Syr 79-57).

Cycle	Year	% of plants R	I	S
2	78	72	7	4
3	78-79	85	10	5
3	79	78	17	4
4	79-80	79	18	3
4	80	78	18	4
4	81	76	19	5
5	82	84	13	2

Table 9. Reactions of random head rows (F_2) from cycle 6 (1983) of C. C. XXXVIII in the seedling stage in the greenhouse to a mixture of isolates of *P. teres* from Montana (Mt 77-1) and Syria (Syr 79-57).

	No. of head rows
R.	12
Seg.	86
S.	1

Table 10. Response to net blotch of several cycles of RSP-4 Rpt minor at Bozeman, 1983.

Cycle	Year	% of plants R	I	S
1	78	8	24	69
2	80	9	41	50
2	80-81	11	36	53
3	81	7	48	45
3	81-82	14	40	47
4	82	34	44	22
4	82-83	42	45	13

Table 11. Response of several cycles of RSP-4 Rpt minor in the seedling stage in the greenhouse to a Montana (Mt 77-1) isolate of *P. teres*.

Cycle	Year	% of plants R	I	S
1	78	2	28	70
2	80	2	20	79
2	80-81	1	21	79
3	81	2	24	74
3	81-82	5	37	59
4	82	8	35	57
4	82-83	13	39	48

Table 12. Ethiopian lines resistant to *R. secalis*.

	Head type
1. PI. 382282	Two-row
2. PI. 382471	Two-row
3. PI. 382488	Two-row (Black seed)
4. PI. 382509	Two-row (Black seed)
5. PI. 382607	Two-row
6. PI. 382724	Irregular
7. PI. 382944	Six-row
8. PI. 383036	Six-row
9. PI. 383094	Six-row
10. PI.383098	Irregular (2 and 6-row in one head)

Table 13. Previously described sources of resistance to *R. secalis*.

		Head Type
11.	Brier	Six-row
12.	CI. 3940 (Abyssinian)	Six-row
13.	Atlas	Six-row
14.	Atlas 46	Six-row
15.	Turk	Two-row
16.	Osiris	Six-row
17.	La Mesita	Six-row
18.	Trebi	Six-row
19.	Modoc	Six-row
20.	Jet	Two-row (Black seed)
21.	Nigrinudum	Two-row (Black seed)
22.	Kitchin	Two-row
23.	Betzes (Susceptible parent)	Two-row

Table 14. Inheritance of resistance to *Puccinia hordei*.

Cultivar/Line	Number of genes	Mode of inheritance
Ford 1203	3	2 dom./rec.
Menelik	2	rec.
CI. 11577	1	dom.
CI. 4974	1	dom.
386-16-2	1	dom.
CCIM-13	1	dom.
Modjo	1	rec.

TABLE 15: Barley plants infected by *Pyrenophora graminea* as a percentage of total plants emerged (average of three replications).

Isolates	Cultivars 'Lami'	'Summit'	'Betzes'	Isolate Means
Noninoculated Ck.	0.000 A*	0.000 A	0.000 A	0.000
E-8	3.037 A	0.000 A	1.156 A	1.398
TN-1	6.575 A	4.943 A	0.000 A	3.839
24-216	19.13 A	1.969 A	0.000 A	7.033
33-267	22.53 AB	9.593 A	0.000 A	10.71
TN-9	44.13 BC	1.017 A	16.44 A	20.53
TN-6	47.59 C	2.709 A	0.000 A	16.77
24-212/19	49.40 CD	4.910 A	0.000 A	18.10
33-313	71.55 DE	2.030 A	6.700 A	26.76
RPB/MT6	73.36 E	3.514 A	4.549 A	27.14
Cultivar means	33.70	3.068	2.890	

*Different capital letters on two isolates within a single cultivar indicate a significant difference between means (LSD 0.05).

TABLE 16: Barley plants infected by *Pyrenophora graminea* as a percentage of total plants emerged (average of three replications).

Isolates	Cultivars 'Lami'	'Summit'	'Betzes'	Isolate Means
Noninoculated Ck.	0.000 A*	0.000 A	0.000 A	0.000
TN-4	0.000 A	0.959 A	1.241 A	0.733
E-9	0.000 A	0.000 A	0.000 A	0.000
S-2	10.16 AB	0.000 A	0.000 A	3.387
E-17	37.33 BC	25.85 AB	0.000 A	21.06
E-14	45.73 CD	10.45 AB	1.456 A	19.21
E-10	49.77 CD	11.72 AB	0.000 A	20.50
E-11	66.83 D	20.15 AB	0.000 A	28.99
E-19	96.16 E	36.19 B	1.289 A	44.55
RPB/MT6	100.0 E	10.97 AB	3.663 A	38.21
Cultivar means	40.60	11.63	0.7649	

*Different capital letters on two isolates within a single cultivar indicate a significant difference between means (LSD 0.05).

TABLE 17: Barley plants infected by *Pyrenophora graminea* as a percentage of total plants emerged (average of three replications).

Isolates	Cultivars 'Lami'	'Summit'	'Betzes'	Isolate Means
Noninoculated Ck	0.000 A*	0.000 A	0.000 A	0.000
TK-18	0.000 A	0.000 A	0.000 A	0.000
E-29	0.884 A	0.000 A	0.000 A	0.295
TK-8	1.118 A	0.000 A	0.000 A	0.373
TK-14	1.716 A	0.959 A	0.000 A	0.892
TK-13	5.722 A	0.908 A	0.000 A	2.210
TK-11	8.169 A	0.000 A	0.000 A	2.723
S-7	31.29 B	6.448 A	0.000 A	12.58
TK-9	32.59 B	4.027 A	0.000 A	12.21
RPB/MT6	94.29 C	0.000 A	0.000 A	31.43
Cultivar means	17.58	12.34	0.000	

*Different capital letters on two isolates within a single cultivar indicate a significant difference between means (LSD 0.05).

Table 18. Susceptibility of spring barley to varying rates of inoculum of *Gaeumannomyces graminis* var *tritici* at Bozeman in 1983.

Cultivar	Disease Reaction[1] Inoculum Rate (g/3.3 m) 0	0.05	0.5	5.0
Klages	1.0	1.0	1.0	2.5
Clark	1.0	1.0	1.2	2.8
Steptoe	1.0	1.2	1.2	3.5
Unitan	1.0	1.0	1.5	3.8

[1]Disease reaction: 1 = no symptoms to 5 = 100% of plants with leaf yellowing and stunted growth.

Plants were evaluated in July 5, 1983.