

PROCEEDINGS OF THE
BARLEY DISEASES AND ASSOCIATED
BREEDING METHODOLOGY
WORKSHOP

Rabat, Morocco

1981

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The United States Agency for International
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The International Center for the Improvement
of Maize and Wheat (CIMMYT)

Preface

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This publication contains material presented at the Barley Diseases and Associated Breeding Methodology Workshop that was held at the Hassan II University, Rabat, Morocco, on 20-23, April 1981.

The workshop was sponsored jointly by USAID-Montana State University, the International Center for Agricultural Research in the Dry Areas (ICARDA), and the International Center for the Improvement of Maize and Wheat (CIMMYT).

There has been a long, working partnership between these groups who are all deeply interested and involved in barley improvement in the developing countries. They sponsored this workshop in order to (1) discuss barley diseases and research in the region and their implications on breeding programs, (2) promote interactions between national and international barley breeding programs and the exchange of germplasm and information, and (3) facilitate personal contact between national scientists working in the region.

The workshop was conducted at a most appropriate time because there is an increasing awareness that barley is one of the most important crops regarding efficient use of water and nitrogen. More and more research is being directed to the improvement of barley.

* External Organizers: CIMMYT, Montana State University, and ICARDA

In view of the considerable and spontaneous transfer of knowledge which occurred between research workers, the workshop achieved its goals and made a significant contribution to new knowledge on barley research.

Welcome**H. Faraj***

Our Minister of Agriculture is visiting Rome today for a meeting, otherwise he would have attended the opening of this workshop. He is very interested in the progress of agricultural research, especially the improvement of barley. On his behalf, I convey an apology to you for his absence and his best wishes for a highly successful workshop.

It gives me much pleasure to welcome all the participants to this important meeting here, and indeed to Morocco. Altogether there are nearly 60 people present of whom 40 are visitors to our country. This large delegation is from countries of North Africa, West Asia, Middle East, and from far off places like The Netherlands, South Korea, Thailand, U.S.A. and Mexico. We also have representatives from organizations like USAID-Montana State University, ICARDA, CIMMYT and other institutions. To all of you, I would like to say how happy we are to see you.

In Morocco, half of the area devoted to cereals is barley. It is widely used for human and animal nutrition, and it is the only cereal which can be grown in very difficult regions in our country. Until recently, we have considered barley to be only a marginal crop and, consequently, we have devoted our time to improving wheat and other crops. Now, barley is no longer being neglected because we have increased our research efforts

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on this cereal.

We are, therefore, particularly pleased that Morocco was chosen for the venue of this workshop. We will follow with great interest all your discussions and exchange of information on barley diseases and breeding methods to improve this important crop.

We trust that your deliberations will be highly successful and fruitful, both for the visitors and for ourselves. We are glad that you are here. Welcome to our country - our house is yours.

Vote of Thanks**R.J. Jackson***

We are indeed pleased to have this barley workshop in Rabat and to have the opportunity to share our thoughts and discuss the various aspects of disease control and associated breeding methods. Particularly, we are thankful to H. Faraj, M. Besri, A. Benjelloun, A. Ouasson and L. Gallagher who have been instrumental in local arrangements of great importance in assuring the success of such an endeavor. We also thank all participants for attending and look forward to successful and enlightening sessions.

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Opening Remarks

Mohamed A. Nour*

It is a real pleasure for me to see that this workshop is convened to discuss barley diseases and associated breeding methodologies. The first barley workshop was held in 1977 in Amman, the year ICARDA was established by Consultative Group on International Agricultural Research (CGIAR). That workshop provided an up-to-date appraisal of the status of barley production, research and major limiting factors to increased barley productivity in the countries of North Africa and the Middle East, establishing benchmarks needed to measure future progress.

Convening of the second workshop on barley reflects the growing interest of the national programs and the international organizations in improving barley productivity in the region.

ICARDA's interest in barley is understandable. It is the second most-important crop of the region and the predominant crop of the 200-350 mm of rainfall areas. The role of barley in an integrated crop-livestock system goes far beyond grain production. Straw may equal or exceed the economic value of the grain in some areas, and barley stubble is extensively used for grazing. Thus, the entire above-ground biomass produced by barley is of immense economic importance to poor farmers of the drier areas.

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It is significant and most opportune that this workshop is being held in Morocco. After Turkey, it is the largest barley-producing country in the ICARDA region. Between 1969-71 and 1979-81, its area, yield and production have gone down. In general, barley is grown on marginal lands by resource-poor farmers under poor crop management practices and has benefited little from recent technological advances. However, Morocco attaches great importance to barley and has increased research efforts on this crop. Decision to host this workshop in this country indicates the interest of Moroccan authorities in improving barley production.

I have been informed by ICARDA scientists that a number of research results promise significant yield increases from barley under dryland conditions. I am anxious to share your experiences and am confident that combined efforts of all of you will lead to real breakthroughs in improving barley productivity in the region.

**BARLEY - ITS STATUS AND POTENTIAL
IN NORTH AFRICA AND THE MIDDLE EAST**

J. P. Srivastava*

Barley, after wheat, is the most important food and feed crop in North Africa and the Middle East. Wheat and barley together occupy around 70% of the total area annually devoted to food crops in this region. During 1979-81, barley was grown on 11.2 million hectares producing 11.8 million metric tons of grain a year (Table 1). It occupied around 24% of the area, and contributed about 21% of the total winter cereal grain produced in the region. However, barley is the predominant crop in the drier areas (200-350 mm annual rainfall), and its role in an integrated crop-livestock system goes far beyond grain production (Nordblom, 1983). Straw may equal or exceed the economic value of the grain in some areas, and the stubble is extensively used for sheep grazing. During dry years, farmers find grazing a standing crop more profitable than harvesting a poor crop. Somel (1982) indicated that whether the crop is grazed in the field or harvested and separated into grain and straw, most of the above-ground biomass produced by barley in the drier regions is consumed by sheep. In the farming system of dry areas, barley has a grain value, a straw value and a grazing value. Therefore, we should concern ourselves with factors affecting grain as well as total dry-matter productivity of barley.

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Important features of barley cultivation in the region are as follows.

1. It is one of the most dependable cereal crops in harsh environments. It is grown in dry areas as well as in cold, short-season areas.
2. Barley's early maturity allows it to escape the hot, dry period in sub-Saharan and semi-arid areas. In these areas of low and variable rainfall where moisture, especially in the spring, is a limiting factor, barley is better adapted to grow and set seed than bread or durum wheats.
3. Barley's tolerance to soil salinity, coupled with a short maturity period, makes it the only winter cereal which can grow successfully in large tracts affected with soil salinity and limited moisture availability.
4. Barley appears to utilize water more efficiently than wheat at low moisture levels (Saari and Srivastava, 1977).
5. Under high rainfall conditions, barley is heavily infected by diseases, and the crop lodges reducing its yield potential.
6. Since barley is grown in areas where rainfall is generally low and subjected to great yearly fluctuations and distribution, the yields in such areas are low, highly unstable from one year to the next and may even result in a complete crop failure in years when rainfall falls below a certain threshold value.
7. Barley is cultivated under most diverse crop-growing conditions and yet, the adaptation of individual varieties grown in the region is generally restricted to specific areas.
8. In North Africa, barley is used as both food and animal

feed; while in the Middle East, it is chiefly used as animal feed. It is used as a livestock feed in the forms of green grazing, straw roughage or grain and frequently in some combinations of these. Its use as direct human food varies from country to country (from none to over 60%) and is largely considered to be a poor man's crop.

9. In 300-400 mm rainfall areas where barley has definite yield advantage over wheat, farmers tend to grow wheat. The cultivation of barley has been extended in areas receiving less than an average of 250 mm of annual precipitation, where actually no crop should be grown.

10. In general, barley is grown on marginal lands by resource-poor farmers under poor crop management practices and poor marketing and infrastructural services.

11. Local cultivars occupy approximately 90% of the area (Table 4). In many countries the entire barley area is still under indigenous land races, and yields have remained static. In most of the countries, barley has remained a neglected crop, and little has been done to provide and extend seeds of improved varieties or production technologies to farmers.

12. About 80% of the barley crop does not receive any chemical fertilizer, and weed-control measures are practiced in no more than 15% of the area. However, one-fourth of the area is under moderate fertility and higher rainfall conditions.

13. Spring habit barley (both 6-row and 2-row types) is grown throughout the region except in the higher areas of Turkey, Iran and Afghanistan where winter habit or facultative type with considerable cold tolerance are required.

14. It is generally believed that diseases do not cause serious crop losses under dry conditions. However, fungal diseases are especially serious in years with mild and rainy winters and spring conditions (Table 6).

15. National barley research efforts in the region have low priority and only few countries have full-time barley research staff.

16. The average barley yield for North Africa (833 kg/ha) is the lowest in the world (Tables 1 and 2). In the Middle East, the national average yields vary from 400 kg/ha in Jordan to over 1900 kg/ha in Cyprus and Turkey.

17. The region's barley imports increased 6-fold, from less than half a million tons in 1969-71 to nearly 3 million tons in 1979-81 (Table 3). This massive increase in barley imports is attributed mainly to developments in livestock production. It is estimated by FAO that, at the end of the 1970's, 27% of feed supplies in the Middle East came from imports, and this trend is expected to continue and increase.

18. The gap between actual farmers' yield of the barley crop and potential yield as demonstrated by "on-farm trials" is highest in low rainfall areas (Table 5). They offer more possibilities for improvement than is generally known. This potential can be realized through improved moisture conservation, increased soil fertility, better crop management, integrated pest control, availability of improved varieties and realistic pricing policies.

It is true that so far there has been no real breakthrough in yield in the rain-fed areas, comparable to what has been

achieved through "green revolution" in irrigated areas. However, a number of research results promise significant yield increases under dry-land cultivation.

Nutrient deficiencies or unbalanced nutrition, besides moisture stress, are main factors limiting barley yields in the region. Phosphorus and nitrogen fertilizer studies at ICARDA have shown that barley crops in 200-300 mm of rainfall respond remarkably to phosphorus application (Cooper et al. 1981). The required application of phosphatic fertilizer (and addition of nitrogen if necessary) to the crop resulted in enhanced early crop development, advanced maturity by 2 weeks and almost doubled of grain yield. Weed control practices in North Africa have resulted in marked increase in barley yields.

The work on nitrogen response (Anderson, 1981) has shown that differences between barley genotypes exist in the efficiency conversion of nitrogen to grain yield. He indicated that observed differences in nitrogen response could be due to differences in efficiency of uptake of applied nutrients or in differences in efficiency of utilization of nitrogen within the plant. It appears that the scope exists for identifying genotypes with more efficient nutrient-use characteristics even under low nutrient availability typical of rain-fed cultivation.

Plant breeders at ICARDA have identified barley varieties with better chances to survive and produce grains in spite of increasing moisture stress during the grain-filling stage. Some varieties are able to continue to fill grains despite drought stress and have the capacity to respond to good

management and improved moisture and nutrient availability. Considerable progress has been made in incorporating genetic resistance against major barley diseases that inhibit barley cultivation in higher rainfall areas. Barley stands a good chance, in the near future, to be grown in more favorable crop growing conditions if the barley growers are given a more realistic price for their produce.

As compared to wheat, the relatively modest resources invested in barley research by national and international programs has started greater interest and research activities in this much neglected crop. It is necessary to accelerate its pace by further strengthening all aspects affecting barley production including research, training, seed production, extension and marketing.

The production potential of barley (grain as well as straw) is much larger than current utilization implies. I am glad that this workshop will consider some of the production constraints in depth and possible suggestions to overcome them. ICARDA, in cooperation with national programs of the region, other barley-producing countries and institutions, particularly CIMMYT and Montana State University, hopes to strengthen research aiming to sustain barley as one of the most viable and profitable crops in the drier areas.

References

- ANDERSON, W.K. (1981). Adaptation of Cereals to Low Soil Fertility. Cereal Improvement Program - Research Highlights. ICARDA, Aleppo, Syria.
- ANONYMOUS. ICARDA Annual Reports. 1980, 1981, 1982. Aleppo, Syria.
- ANONYMOUS. (1981, 1982). Cereal Improvement Program-Research Highlights. ICARDA, Aleppo, Syria.
- ANONYMOUS (1982). Pathways to 1990. ICARDA, Aleppo, Syria.
- BRONZI, P. (1977). Agro-Climatological Environments and Barley Production. Proc. Fourth Regional Winter Cereal Workshop. Vol. II. Amman, Jordan.
- COOPER, P., ALLAN, A., HARONSEN, K., KEATING, D., and STAPPER, M. (1981). Soil, Water and Nutrient Research. Project Report 3. ICARDA, Aleppo, Syria.
- FAO Production Year Book (1979, 1980, 1981). Rome, Italy.
- KLAIMI, Y.Y. (1977). Constraints of Barley Improvement in the Near East and North Africa and Suggestions for Improving the Programs. Proc. of the Fourth Winter Cereal Workshop. Vol. II. Amman, Jordan.
- NORDBLOM, T.L. (1983). Livestock-Crop Interactions - The Decision to Harvest or to Graze Mature Grain Crops. Discussion Paper No. 10. ICARDA, Aleppo, Syria.
- SOMEL, K. (1982). Preliminary Results from the Barley Survey (mimeo). ICARDA, Aleppo, Syria.
- SANDERS, D. (1979). Cereal Situation and the Yield Gap - Country Report Summaries. Proc. of the Workshop on the Gap Between Present Farm Yield and the Potential. Algiers, Algeria.
- SRIVASTAVA, J.P. (1977). Barley Production, Utilization and Research in the Afro-Asia Region. Proc. of the Fourth Regional Winter Cereal workshop, Vol. II. Amman, Jordan.
- WELTZIEN, H.C. and SRIVASTAVA, J.P. (1981). Stress Factors and Barley Productivity and Their Implications in Breeding Strategies. Proc. of the Fourth International Barley Genetics Symposium. Edinburger, Scotland.
- WRIGHT, B.C. (1977). The Agronomic Uniqueness of Barley. Proc. of the Fourth Winter Cereal Workshop. Vol. II. Amman, Jordan.

Table 1. Area, Yield and Production of Barley in Important Barley Producing Countries in North Africa and the Middle East.

Country	Area 1000 Ha		Yield kg/ha		Production 1000MT	
	1969-71	1979-81	1969-71	1979-81	1969-71	1979-81
Algeria	773	885	660	754	470	667
Egypt	44	41	2124	2691	93	110
Libya	213	287	326	290	70	83
Morocco	2003	1754	1093	976	2190	1712
Tunisia	243	457	546	610	133	279
North Africa	3276	3424	883	833	2893	2851
Afghanistan	316	320	1151	1030	363	330
Cyprus	73	49	1237	1939	90	95
Iran	1532	1283	681	883	1042	1133
Iraq	582	783	1190	764	692	598
Jordan	50	25	493	400	25	10
Lebanon	7	7	859	1048	6	7
Pakistan	151	168	642	750	97	126
Saudi Arabia	14	10	906	1600	13	16
Syria	784	1219	478	927	375	1130
Turkey	2611	2830	1425	1936	3720	5480
Yemen A.R.	43	48	1067	1021	153	49
Yemen Dem.	1	2	3236	1533	4	2
West Asia	6264	6744	1050	1331	6580	8976
Percent Change		+7.7		+26.8		+36.4
Overall total	9540	10168	993	1163	9473	11827

Source: FAO Production Yearbook 1981

Table 2. Area, Yield and Production of Barley in the World

	Area Harvested (100 Ha.)		Grain Yield (Kg/Ha.)		Production (1000 M.T.)	
	1969-71	1979-81	1969-71	1979-81	1969-71	1979-81
USSR	21782	33490	1613	1335	35132	44635
Asia	12532	10937	1157	1501	14501	16416
Europe	16438	20440	2949	3383	48480	69131
N. America	8676	6106	2275	2508	19740	20388
Africa	4252	4529	878	844	3731	3810
Oceania	2091	2643	1240	1331	2594	3514
S. America	1004	701	1047	1215	1052	853
World	66775	80846	1875	1965	125230	158747

Table 3. Barley Imports by Selected Countries in North Africa and the Middle East

Country	Imports (100 M.T.)	
	1969-71	1979-81
Algeria	100	3141
Libya	1142	1147
Morocco	47	0
Tunisia	255	423
Cyprus	534	952
Iran	640	4067
Iraq	0	2523
Jordan	123	383
Kuwait	324	902
Lebanon	970	664
Saudi Arabia	301	13497
Syria	447	1031
Total	4883	28730

Table 4: Barley use of Improved Varieties; Importance of Diseases and Insects

	Area with Improved Varieties	Major Constraints		
		Variety	Disease	Agronomic Practices
Algeria	20	Yes	Yes	Yes
Cyprus	0	In 350mm	No	No
Egypt	25	In Irrigated	Yes	Yes(rainfed)
Greece	90	No	No	No
Iraq	33	In 350mm	Yes	Yes
Jordan	10	In Rainfed	No	Yes
Kenya	100	In Irrigated	Yes	No
Lebanon	70	In 350mm	Yes	Yes
Lybia	-	No	No	Yes
Morocco	0	Yes	Yes	Yes
Pakistan	0	Yes	Yes	Yes
Portugal	40	Yes	No	Yes
Spain	80	No	No	Yes
Tunisia	0	Yes	Yes	Yes
Turkey	90	In Irrigated	Yes	Yes
Yemen	0	In 350mm	Yes	Yes

Source: Saunders, D. 1979. Fifth Cereals Workshop, Algeria

Table 5. The Gap between Farm Yield and the Potential Yield of Barley in Selected Countries

Country	% Farm Yields to Experimental Yields		
	Rainfall		
	Low	High	Irrigated
Algeria	36	43	
Cyprus	50		
Egypt	38		56
Greece		69	
Iraq	36		46
Jordan	25		
Kenya		86	
Morocco	33	24	
Pakistan	34		
Portugal		45	
Spain		56	58
Tunisia	25	30	
Turkey	36	56	
Yemen A.R.	43		52

Based on: Saunders, D. 1979. Fifth Cereals Workshop, Algeria

Table 6. Diseases of Barley (Ranked according to importance)

Region	SR	YR	LR	PM	HEL	SC	Smut	Others
Middle East	6	3	5	1	2	5	4	-
South & Far East	5	1	6	3	2	7	4	-
North Africa	7	5	4	3	1	6	2	Viruses
East Africa	7	4	3	5	2	1	5	-
Mediterranean Europe	7	3	6	2	1	5	4	-

Source: Srivastava, J.P. (1977). Fourth Regional Winter Cereal Workshop. Vol. II. Amman, Jordan.

SR = stem rust; YR - yellow rust; LR = leaf rust;

PM = powdery mildew; HEL = Helminthosporium; SC = scald

BARLEY DISEASES IN THE HIGHER RAINFALL AND IRRIGATED AREAS**E. E. Saari***

Barley is grown mostly north of the Tropic of Cancer and south of the Tropic of Capricorn with two basic exceptions, namely the highlands of East Africa and the Andean Zone of South America. The barley production areas also coincide, by and large, with the areas where wheat is cultivated. However, barley traditionally is grown in the less-favorable environments; that is, on the marginal lands, lower moisture profiles, on saline or alkaline soils, or in situations when it has become too late for wheat cultivation.

There is relatively little irrigated barley in the developing countries; Iraq is an exception, and there is also a small area in Egypt. These countries irrigate barley on the poorer soils where wheat has difficulty, usually due to the presence of excess salt. The majority of barley cultivation is under moisture stress situations. Low-moisture conditions usually mean less disease. Over a period of time, the varieties which have been adapted or selected under these situations do well under environmental stresses. The disease selection pressure is low, and the evolution of barley varieties with disease resistance has not been very high. This results in a basic germplasm for the crop noted for its ability to yield in harsh environments, but its susceptibility to disease problems when it is moved to a more favorable or moister climate.

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Research Investments

Barley has not received the attention that wheat has. It is only recently that barley has begun receiving substantial amounts of input from the International Center's standpoint. There have been active programs in Europe, Australia and North America, and the work on disease resistance breeding in these areas far exceeds that done elsewhere.

The local varieties that have been selected in the developing countries represent land race cultivars or selections from these populations. Their ability to stand environmental stresses represents specific adaptation, and they are often difficult to beat in terms of yield. When these varieties are taken out of their environment and moved into more favorable conditions, there is a substantial increase in the amount of diseases. The obvious diseases are the foliar ones, partly because they are so visible. The testing of barley on a larger scale, regionally and internationally, is revealing. The barley diseases tend to be much more geographically isolated or specific than the wheat diseases as a general rule. There are, of course, the exceptions. The Helminthosporium diseases seem to be universal, but some caution needs to be exercised because we need to consider three diseases in this group.

The Helminthosporium diseases (Spot blotch, Net blotch, Stripe)

These diseases are found world-wide attacking barley, other cereals and grasses. In more tropic or sub-tropic areas, H. sativum becomes a major disease on barley. In places like

Northern Thailand it can be very severe. Net blotch caused by Helminthosporium teres is widely spread and one of the main diseases of barley in the irrigated areas of Egypt. It is also a major disease in many of the higher rainfall areas of temperate regions. Helminthosporium gramineum (barley leaf stripe) is seed borne and increases in areas where susceptible varieties are maintained by the farmers.

A great deal of effort is required to sort out which species of Helminthosporium is concerned in a disease outbreak, and whether the resistance for one applies to the other. We do not know enough about the genotype environment interaction or the host effects on altering the spore morphology.

Erysiphe graminis (Powdery mildew)

This is the next most common disease which is very widespread. In European environments and in winter wheat areas, it is the dominant disease and can cause severe crop losses. In the areas where spring habit barley is grown, powdery mildew seems to become less of a serious problem. This may be a reflection of the duration of the host-parasite interaction.

Puccinia hordei (Leaf rust)

This disease is of great importance in the Mediterranean basin. It also occurs in Kenya, India, Egypt, Tunisia, Algeria, and Morocco. I have seen susceptible varieties killed by this disease in North Africa.

Puccinia graminis (Stem rust)

It is not important on a world-wide basis partly because

the early maturity of barley tends to allow it to escape severe damage. However, if it does come early and the environment allows it to develop, then it can completely destroy the barley crop. The areas where stem rust can be severe are the East African highlands and also in the Northern Yemen mountain region and, on occasions, in the higher elevations, particularly in South India.

Puccinia striiformis (Stripe or yellow rust)

It is extremely important in certain areas of the world (e.g., India, Nepal, Northern Pakistan, and the Andean region of South America). It has not been a very significant disease problem in North Africa or the Middle East.

Stripe rust is possibly the most dangerous disease of barley. The intensity with which it develops is sometimes frightening. It can destroy the crop completely.

Rhynchosporium secalis (Scald)

It has been a very serious and important disease in certain environments. In Ethiopia, it can be absolutely devastating at the higher elevations. Occasionally it is quite severe in Kenya and Turkey.

Aphids

They can be a serious problem in barley. Related to that is Barley Yellow Dwarf (BYD) Virus; these two cannot be completely separated. The aphids of course come first, followed by BYD. There are increasing aphid problems being reported and there are many species. One of the most common

aphids is Schizaphis graminum, the green bug. Even without the virus, Schizaphis graminum may be a very serious problem because of the toxin which it produces. The corn leaf aphid, Rhopalosiphum maydis, is increasing and in many cases it has to do with a change of microclimate and a change of cropping systems. For example, aphids on wheat and barley in Egypt were considered insignificant until ten years ago. The opening of the Aswan Dam has led to an increase in the cropping intensity. There are at least two crops per year now being grown which enable aphids to survive in significant numbers. A similar case is being experienced in the Punjab of India and Pakistan where cropping intensity has increased. Aphids are becoming an increasing problem.

The above-mentioned diseases are the most frequently encountered and important ones. The Helminthosporium species as a group rank first, followed by powdery mildew in most developing countries. The smut diseases are underestimated, in my opinion, and probably the average losses in the local cultivars from the smuts exceeds all other diseases. Barley Yellow Dwarf Virus is going to increase, as are probably Barley Stripe Mosaic Virus disease and others. They are the main diseases in the higher rainfall regions. The same diseases are found in irrigated areas, although they are not as severe as in the high rainfall regions because irrigation is usually applied in the dry season, which helps minimize the disease problems.

Other diseases to mention are the root diseases caused by Helminthosporium and Fusarium, and also Take-All. In Ethiopia, scientists consider that local barley varieties possess some

tolerance to Take-All. If this is true, then this material should be incorporated into the germplasm.

In the developing countries, bacteria have not been found to be a serious problem in barley. Very often a disease remains minor until an improved variety is introduced which has not been tested against a minor endemic disease. If it is susceptible, the disease can then become a significant problem.

Regarding nematodes, Heterodera avenae is the most serious problem; and once it is in the area, it can be very devastating.

Most of the disease information comes from nursery reports, observations, taking notes on nurseries, and looking at farmer fields. There are not very many documented cases of disease and its importance, nor any information worthy of mention on disease losses. The disease loss estimates, so far, have been done by calculation of individual reports. The reports and calculations which Kramer made are probably still as valid today as they were in 1967. There is a great need to do more work on establishing the extent of field losses.

By and large, progress in barley disease work has been made by the international activities of ICARDA, USAID, USDA, and CIMMYT. This has been primarily in the area of identifying some sources of resistance and trying to incorporate them into breeding programs to develop resistant varieties. There is a great deal of scope for further progress since so little international work has been done in relative terms.

References

- Anonymous, 1960. Index of Plant Diseases in the United States. Agriculture Handbook, No. 165, pp. 531.
- Anonymous, 1953. Plant Disease: The Yearbook of Agriculture. United States Government Printing Office, U.S. Department of Agriculture, Washington, D.C., pp. 940.
- BOEWE, G.H., 1960. Diseases of Wheat, Oats, Barley, and Rye. Illinois Natural History Survey Circular 48, p. 157.
- BRIGGS, D.E., 1978. Barley. Chapman & Hall, London, p. 612.
- BRUEHL, G.W., 1961. Barley Yellow Dwarf, Monograph Number 1, The American Phytopath. Society, p. 52.
- CRAMER, H.H., 1967. Plant Protection and World Crop Production. Pflanzenschutz-Nachrichten Bayer 20/1967, Leverkusen, p. 524.
- DICKSON, J.G., 1956. Diseases of Field Crops. McGraw-Hill Book Company, Inc., New York, p.517.
- GAUL, H. (Ed), 1976. Barley Genetics III. Proceedings of the Third International Barley Genetics Symposium 1976. Abteilung für Pflanzengenetik der Gesellschaft für Strahlen und Umweltforschung MGH, München, p. 849.
- Handbook on Crop Production in Ethiopia (1st edition), 1979. Institute of Agric. Res., Addis Ababa. 41 pp.
- International Maize and Wheat Improvement Center, 1977. CIMMYT Report on Wheat Improvement 1976. El Batán, Mexico, 234 pp.
- International Maize and Wheat Improvement Center, 1978. CIMMYT Report on Wheat Improvement 1977. El Batán, Mexico, 245 pp.
- KELMAN, A. and R.J. COOK, 1977. Plant Pathology in the People's Republic of China. Ann. Review Phytopath. 17:409-420.
- KOEHLER, C.S., WILCOXSON, R.D., MAI, W.F. and ZINDAHL, R.L. 1972. Plant Protection in Turkey, Iran, Afghanistan, and Pakistan. U.S. Agency for International Development - Univ. Calif. Berkeley. Contract No. AID/csd- 3296:82 pp.
- KRANZ, J., SCHMUTTERER, H.S. and KOCH, W. 1977. Diseases, Pests and Weeds in Tropical Crops. Verlag Paul Parey, Berlin and Hamburg. 666 pp.

- LAST, F.T., 1971. The Role of the Host in the Epidemiology of Some Non-foliar Pathogens. *Ann. Review Phytopath.* 9:341-362.
- Maladies et Ravagers Des Plantes Cultives Au Maroc Tome 1, 1976. Ministere de L'Agriculture et de la Reforme Agraire, Direction de La Recherche Agronomique, Rabat. 207 pp.
- SAARI, E.E., PRESCOTT, J.M. and KAMEL, A.H., 1979. The Significance of Diseases and Insects in Cereal Production. Proceedings of Fifth Regional Cereal Workshop, Algiers, Algeria, In Press. CIMMYT, Mexico.
- SAARI, E.E. and PRESCOTT, J.M., 1977. Barley Diseases and Surveillance in the Region, p. 320-330. In Barley Vol. II. Proc. Fourth Regional Winter Cereals Workshop, Amman, Jordan, April 24-28, 1977. ICARDA-CIMMYT, Aleppo, Syria. 420 pp.
- SAARI, E.E. and SRIVASTAVA, J.P. 1977. Barley diseases and Surveillance in the Region, p. 320-330. In Barley Vol. II. Proc. Fourth Regional Winter Cereals Workshop, Amman, Jordan, April 24-28, 1977. ICARDA-CIMMYT, Aleppo, Syria. 420 p.
- SAARI, E.E. and WILCOXSON, R.D. 1974. Plant Disease Situation of High-Yielding Dwarf Wheats in Asia and Africa. *Ann. Rev. Phytopath.* 12:49-68.
- SAGHIR, A.R., 1978. Weed Control in Wheat and Barley in the Middle East. In Barley Vol. II: Proc. Fourth Regional Winter Cereals Workshop, Amman, Jordan, April 24-28, 1977. PP. 300-308. ICARDA-CIMMYT, Aleppo, Syria, 420 pp.
- SHARIF, G. and BAMDADIAN, A. 1974. Importance and Situation of Wheat and Barley Diseases in Iran. Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar, Tehran, Iran. May 21- June 2, 1973. pp. 300-305, Food and Agriculture Organization of the United Nations, Rome. 441 pp.

BARLEY DISEASES IN THE DRY AREAS

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In the ICARDA region extending from Afghanistan and Pakistan in the East to Morocco in the West, and from Sudan in the South to Turkey in the North, about 40% of the total cultivated areas are grown to cereals, and 90% of this is grown under rain-fed conditions. In this region, average annual rainfall ranges from 200 mm to more than 800 mm and in the 250-350 mm range, barley is the predominant crop.

On a regional basis, barley is grown under conditions of considerable uncertainty and on marginal soil conditions. Traditionally, it is planted in the region where wheat is not expected to produce a crop, or where due to delay in sowing, wheat is considered to be a high risk and unprofitable. Barley is planted in elevations from below sea level to more than 2000 m in mountainous areas (Srivastava, 1977). The majority of this area is sown to spring habit varieties except in the higher altitudes of Afghanistan, Iran, Turkey, Nepal and India where spring habit types with suitable cold tolerance, facultative types, or in some cases true winter habit barleys are grown.

After wheat, barley is the most important food crop in the Near East and North Africa. It occupies around 10 million hectares with a total production of about 10 million tonnes. Countries of the Near and Middle East grow about 6.4 million

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hectares of barley, of which 70% is grown on less than 400 mm rainfall. In North Africa, 94% of the barley hectareage of about 4.0 million hectares is also grown on less than 400 mm. In the Far East, India is the biggest barley grower where about 3 million hectares are grown, of which about 1.5 million are grown on less than 400 mm of rain; while in Pakistan, the majority of the barley fields are planted on residual moisture.

The majority of the barley varieties grown in the Near and Middle East, North Africa, and Far East are the local types characterized by good adaptation to their specific environments, low-yield potential and susceptibility to diseases. A 100% of the barley hectareage is under local cultivars in Afghanistan, Syria, Yemen, Bangladesh and Algeria, while 70-80% of the barley hectareage is sown to local cultivars in Iran, Iraq, India, Nepal, Pakistan, Libya, Morocco and Ethiopia (Anonymous, 1977).

Barley yields in the Near and Middle East and North Africa are quite low (about 1.0t/ha) compared with other neighboring regions. The average yields for the Mediterranean area, Europe and the world are 2.6, 3.0 and 1.7 t/ha, respectively.

Barley is mainly used as a feed crop, although in several countries, it is also used as human food in different ways. In India, Korea, Libya, Nepal and the Yemens, most of the production is used as food, while in Algeria, Iran, Iraq, Spain, Syria and Turkey, it is almost exclusively used as a feed crop. (Anonymous, 1977; Srivastava, 1977).

Diseases of barley are numerous and cause a substantial reduction in yield. These diseases are variable from one year

to the other depending mainly on the climatic conditions. National research workers have presented information on the major barley diseases in their countries (Anonymous, 1977; Abdel Hak and Ghobrial, 1977; Discussion group, 1978; Saari and Prescott, 1977). This information is shown in Table 1. A few other diseases have not been mentioned in this survey either because they are unimportant or because of difficulty in identification. Examples of these diseases are the roct rot complex, bacterial and virus diseases.

Fungal Diseases

The major diseases affecting production that are presented in this review occur in each of the countries growing more than 50,000 ha on 400 mm rainfall or less. Table 2 shows that Helminthosporium spp., powdery mildew, leaf rust and smuts are the major diseases in the Near and Middle East region where about 70% is grain under less than 400 mm rainfall, followed by scald, stem rust and yellow rust. In North Africa, where 94% of the barley is grain under 400 mm or less rainfall, these diseases are Helminthosporium spp., leaf rust, powdery mildew, and smuts followed by yellow rust and scald (Table 3). In India and Pakistan, yellow rust, Helminthosporium spp., smuts, powdery mildew and leaf rust are more important (Table 4), while in the Mediterranean countries growing barley under less than 400 mm, Helminthosporium spp., powdery mildew, leaf rust and loose smut are the major diseases (Table 5).

When the importance of each disease is considered along with the area grown in each of these regions, a different ranking of disease is evident (Table 6). In the Near and

Middle East region where about 70% of the barley crop is grown on 400 mm of annual rainfall or less, the major diseases are Helminthosporium spp., smuts, powdery mildew, scald, leaf rust, stem rust, and yellow rust.

In North African countries (Morocco, Tunisia, Algeria, Libya), about 95% of the barley area falls in the 400 mm and less rain zone, and the major diseases are Helminthosporium spp., leaf rust, powdery mildew, smuts, yellow rust and scald. In India where 50% of the barley is grown under 400 mm and less rainfall, yellow rust, Helminthosporium spp., loose smut and leaf rust are the main diseases, while in Pakistan where barley is mainly grown on residual moisture after the paddy harvest, the major diseases are yellow rust, Helminthosporium spp., smuts and powdery mildew.

The common root and crown rot of barley are two important diseases in the arid and semi-arid areas of the region. The root rot complex includes mainly Fusarium culmorum, F. nivale and Helminthosporium sativum. Fusarium is an important disease in drier areas of North Africa, mainly in Morocco and Tunisia. Helminthosporium sativum causes root and seedling rot and is known to occur in semi-arid and arid areas of the region. The former is always detected in the early stages of plant development, while the latter is always present at the later stages. (Discussion Group Meeting, 1978; Annual Barley Report, 1980). The monoculture practice used in different areas of the region stimulates the development and build up of these fungi.

Experiments carried out in Morocco have indicated a 30%

yield increase in barley through the use of fungicides to control root rots.

Bacterial Diseases

Two bacterial diseases, namely bacterial leaf streak incited by Xanthomonas translucens and bacterial leaf blight incited by Pseudomonas syringae, have always been considered of minor importance and more of a breeder's problem since their incidence is mainly restricted to the breeder's plot (Discussion group meeting 1978; Annual Barley Report, 1980). In 1978 they caused a measurable damage in fields of Gezira 17, a newly released durum variety in Syria. Losses of 20-30% and up to complete failure of the crop were not uncommon in some areas. These losses can also very well occur in barley.

These diseases are seed transmitted, and the absence of a seed industry in barley may increase their importance.

Virus Diseases

The following virus diseases are reported to attack barley in one or more of the countries in the region (Discussion Group Meeting, 1978; Annual Barley Report 1980).

BYDV	Barley Yellow Dwarf Virus	Europe, Asia, Africa
BSMV	Barley Stripe Mosaic Virus	Europe, Pakistan
CTV	Cereal Tillerling Virus	Italy
AWStMV	American Wheat Striate Mosaic Virus	World wide
WSMV	Wheat Streak Mosaic Virus	Europe, Jordan
SBWMV	Soil Borne Wheat Mosaic Virus	Egypt, Italy

WYLV	Wheat Yellow Leaf Virus	Often occurs with BYDV
BYMV	Barley Yellow Mosaic Virus	Germany

Other than survey reports of Montana State University and regional pathologists of the International Centers, very little information is available about the prevalence, incidence and intensity of the different virus diseases.

BSMV is reported from Egypt, Tunisia, Lebanon, Syria, and its symptoms are very often confused with the stripe disease incited by Pyrenophora graminea. BYDV is another example where symptoms are sometimes confused with nutrient deficiency. BYDV disease is of great importance since about 80 different grasses are hosts of this virus.

Masked symptoms are another problem in identifying virus diseases. A reduction in yield of 30-50% or higher can result from symptomless plants.

The only example of an epidemic due to virus diseases in the region was on wheat, and to less extent on barley in Egypt in the early sixties where Wheat Striate Mosaic Virus and Barley Yellow Dwarf resulted in a 10% overall reduction in yield. The outcome of this was the banning of two high-yielding bread wheat varieties from commercial cultivation.

Moreover, some of the virus diseases are seed transmitted (BSMV), and in the absence of a sound seed industry for barley on regional basis, these diseases have a potential to become important.

Nematodes

Heterodera avenae is also present in some of the major

growing barley countries of the region, and the monoculture system followed in such areas helps to develop the nematode population.

Insects Attacking Barley

Reports of national scientists have also indicated that insects play a role in reducing barley yields. Aphids are generally the major pests followed by stinkbug, hessian fly, leaf miner, fruit fly and white ants. Aphids are becoming more and more important, and this is to be expected with the use of better tillering varieties (which improve the micro climate for these insects), the better use of fertilizers and generally better crop management.

Summary

(1) Diseases cause tremendous yield losses in barley fields wherever barley is cultivated. A reliable quantification of losses caused by diseases in barley is lacking.

(2) Reports on disease importance in the countries quoted in this paper are presented, but often some diseases are underestimated either due to unseen or unmeasurable losses; examples of these are the root rot complex, virus diseases and bacterial diseases.

(3) In more arid and less fertile areas, disease losses in barley are very often underestimated or sometimes undocumented.

(4) Asymptomatic plants attacked by BSMV and yielding only 50% of the healthy plants is a good example of unseen losses.

(5) Powdery mildew is an important disease and is present wherever barley is grown.

(6) Net blotch incited by Pyrenophora teres (Helminthosporium teres) and barley leaf stripe incited by Pyrenophora graminea (Helminthosporium gramineum) are both very important diseases. The first is more a problem under high rainfall and better fertility, while the second is present in both high and low rainfall zones. Net blotch is also important in Southern Europe and North Africa, and occurs extensively in the Caspian Sea area.

(7) Smut diseases, mainly covered smut (Ustilago hordei) and loose smut (Ustilago nuda) are also very important everywhere, and the absence of an adequate seed industry helps these diseases to become important.

(8) Yellow rust is a serious problem, mainly in areas of the Indian sub-continent and Pakistan, and also at the high elevations of the more tropical zones.

(9) Leaf rust is more prevalent in the Mediterranean type climate areas, including North Africa.

(10) Scald disease, Rhynchosporium secalis is a problem where low temperatures prevail during the growing season and mainly in winter habit barley.

(11) A seed production industry in the majority of the Near and Middle Eastern and North African countries in barley is almost nonexistent. This complicates the control of various important seed-borne diseases, e.g. loose, semi-loose and covered smuts, bacterial diseases and some of the virus diseases (BSMV).

(12) The monoculture system practiced in these drier areas stimulates the development of some diseases, mainly the root rot complex and nematodes.

References

- Annual Report on Control of Barley Diseases for Lesser Developed Countries of the World. 1980. Contract No. AID/DSAN-C-0024. Report No. 2, 1979-80 Agency for International Development Department of State, Washington, D. C. 46pp.
- Anonymous. 1977. Country Reports. In Proceedings Fourth Regional Winter Cereal Workshop, Barley. Volume I, 273 pp.
- ABDEL-HAK, T.M. and GHOBRIAL, E. 1977. The Barley Disease Situation in the Near East with Special Reference to Sources of Resistance. In Proceedings Fourth Regional Winter Cereal Workshop, Barley, Volume 11. pp.311-319.
- Report of a Discussion Group Meeting. 1978. Diseases of Small Grains, Their Incidence and Control in the ICARDA Region. London, 51 pp.
- SAARI, E.E. and PRESCOTT, J.M. 1977. Barley Diseases and their Relevance in the Region. In Proceedings Fourth Regional Winter Cereal Workshop, Barley. Volume 11. pp.320-330.
- SRIVASTAVA, J.P. 1977. Barley Production, Utilization and Research in the Afro-Asian Region. In Proceedings Fourth Regional Winter Cereal Workshop, Barley. Volume II. pp.242-259.

Table 1. Summary of the Ranking of Barley Diseases Considered Most Important by National Research Workers.

Disease and Ranking of Importance								
Region & Country	Stem Rust	Yellow Rust	Leaf Rust	Powdery Mildew	Helminthosporium spp.	Scald	Smuts	Virus Dis.
NEAR & MIDDLE EAST:								
Afghanistan	4	1	6	1	3	2	4	
Cyprus			1	3	2		4	
Iran	6	2	5	3	1	7	4	
Iraq					1		2	
Jordan	6	7	3	2	4		1	
Lebanon			2	1	4		3	
Saudi Arabia								
Syria				1				
Turkey	5	7	6	1	2	3	4	
Yemen, A.R.	1							
Yemen, P.D.R.	2	1						
NORTH AFRICA:								
Algeria		3	2	5	1	5	4	
Egypt	4		2	3	1			
Libya				2		3	1	
Morocco			3	5	1		2	4
Tunisia	7	6	4	3	1	5	2	
EAST AFRICA:								
Ethiopia	8	5	3	7	2	1	4	6
Kenya	4	3	5		2	1	6	
Sudan		3	3					
Tanzania	6	5	3	4	1	2		
MEDITERRANEAN EUROPE:								
Greece			3	2	1			
Portugal				3	2	1	4	
Spain	4	4	4	2	1		3	
SOUTH AND FAR EAST:								
Bangladesh	2		3		1		4	
India	6	1	5	3	2		4	
Korea	5	5	5	4	2	6	3	1
Nepal	4	1	5	1	2	6	3	
Pakistan	3	1	2	2	4	5	4	

1 = most important disease, 2 = second most important, etc.

Table 2. Major Barley Diseases and Insects in Countries of the Near and Middle East*

Country	Total Barley (1000 ha)	%400 mm & less	Area (1000ha)	Major diseases**	Insects
Turkey	2625	70	1838	PM, Hel, Scald, CS, SR, LR	Frit Fly Sawfly Stink Bug
Iran	1500	66	990	Hel, YR, PM, LS	
Syria	1011	90	910	PM, Scald, LR, CS Stripe	Aphids Sawfly
Iraq	545	42	229	Hel, LS, CS	Aphids Stink Bug
Afghanistan	350	70	245	PM, Scald, Hel, SR	Aphids
Yemen A.R.	170	40	68	LR, Hel, PM	Aphids Sawfly
Cyprus	70	70	49	LR, NB, PM	Leaf Miner Aphids
Egypt***	65	100	65	Hel, LR, Pm, CS	Aphids
Jordan	50	90	45	CS, PM, LR, Hel	Aphids Leaf Miner

* Countries growing more than 50,000 ha under 400 mm or less.

** PM = Powdery mildew; Hel - *Helminthosporium* spp; CS = Covered smut; SR = Stem rust; LR = Leaf rust; YR = Yellow rust; LS = Loose smut; NB = Net blotch.

*** North Western Coastal area only. (Not the barley planted under irrigation in the Nile Delta).

Table 3. Major Barley Diseases and Insects in Countries of North Africa*.

Country	Total Barley (1000 ha)	&400 mm & less	Area (1000 ha)	Major diseases**	Insects
Morocco	2000	100	2000	Hel,LR,PM,LS	Hessian fly
Algeria	758	95	720	Hel,LR,YR	
Libya	600	85	510	CS,LS,PM,Hel,Scald	
Tunisia	570	80	456	Hel,Smuts,PM,LR	

* Countries growing more than 50,000 ha under 400 mm or less.

** Hel = Helminthosporium spp.; LR = Leaf rust; PM = Powdery mildew; LS = Loose smut; YR = Yellow rust; CS = Covered smut.

Table 4. Major Barley Diseases and Insects in Countries of the Far East*.

Country	Total Barley (1000 ha)	%400 mm & less	Area (1000 ha)	Major Diseases**	Insects
India	2931	50	1466	YR, Hel, LS, LR	Aphids
Pakistan	175	Res. Moisture	175	YR, Hel, Smuts, PM	Aphids White ants

* Countries growing more than 50,000 ha under 400 mm or less.

Table 5. Major Barley Diseases and Insects in Mediterranean Europe*.

Country	Total Barley (1000 ha)	%400 mm & less	Area (1000 ha)	Major Diseases	Insects
Spain	3262	40	1305	Hel,PM,LS	Frit fly Aphids
Greece	398	100	398	Hel,PM,LR	Frit fly

* Countries growing more than 50,000 ha under 400 mm or less. In Europe 19 million hectares are grown to barley of which 7.2 million are in the Mediterranean part. Out of these about 5.0 million are grown under 400 mm or less.

Table 6. Major Barley Diseases and Insects in Different Regions.

Region	Total Barley (1000 ha)	Barley under 400 mm or less (1000 ha)	Major Diseases	Insects
Near & Mid East	6386	4439	Hel, Smuts, PM, Scald, LR, SR, YR	Aphids Sawfly Stink Bug Leaf minor Frit fly
North Africa	3993	3751	Hel, LR, PM, YR, Scald, Smuts	Aphids Hessian fly
Far East	3106	1641	YR, Hel, Smuts, LR, PM	Aphids

NET BLOTCH OF BARLEY

E. L. Sharp*

Net blotch caused by Pyrenophora teres, Drechs. is found wherever barley is grown including semi-dry and moist areas, and is one of the major disease problems of barley. The fungus persists mainly on plant debris but may also be seed-borne to initiate new infections. Secondary infection can occur throughout the growing season. The spores are spread by wind and splashing rain.

Characteristic net-like lesions form on the leaves, and these can occur at any stage of growth from seedling to adult. The lesions are surrounded by chlorosis and tend to coalesce with heavy infection to give a striped appearance. Even in this stage, the netting may be observed along the leaf margins. Occasionally, a spot type of symptom develops which may be confused with the spot blotch disease caused by Helminthosporium sativum.

One of the best means of control of this disease involves resistant cultivars. This paper deals with resistance studies and variability within the pathogen.

Previous Work

One of the earliest studies on resistance to net blotch in barley was conducted by Schaller & Wiebe (1952). In testing 4,526 barley lines they found 25 to be highly resistant to

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California isolates of P. teres. Many of the resistant lines originated in Manchuria. Buchannon and MacDonald (1965) later tested 6,174 barley lines to isolates of P. teres from Canada, Mexico and the United States, and found 40 lines to be resistant in the seedling stage. Seventeen of the resistant lines originated in Ethiopia. Khan & Boyd (1969a) evaluated 142 barley lines to 17 isolates of P. teres from Australia. These 142 lines had previously been reported resistant to net blotch. Of the 142 lines, 12 were highly resistant and 22 others were considered resistant. Resistance was found in lines originating from both Manchuria and Ethiopia. In 1975, Caddel and Wilcoxson (1975) reported that 80 out of 2,608 barley lines were resistant to Moroccan isolates of P. teres. Isolates from different geographic regions differed markedly in pathogenicity. Many of the barley lines resistant to California isolates were susceptible to isolates from Canada, and most barley lines that were resistant elsewhere were susceptible to Moroccan isolates. The Australian isolates were composed of 3 virulence types (Khan and Boyd, 1969a).

In genetics of resistance studies, it was found that Tifang contained one incompletely dominant gene and the symbol Pt_1 was suggested (Mode and Schaller, 1958). C.I. 4797, C.I. 739 and C.I. 4929 contained a single dominant gene designated as Pt_2 , and C.I. 2750 and C.I. 4922 contained 2 dominant genes designated as Pt_2 and Pt_3 . A fourth gene, Pt_a , was later designated by Khan & Boyd (1969b). Utilizing trisomic analysis, Bockelman et al. (1977) found Tifang to contain a single dominant gene for resistance against a Tunisian isolate

of P. teres to be on chromosome 3, and another dominant gene for resistance in C.I. 7584 was located on chromosome 2. C.I. 9819 contained 2 dominant genes on chromosomes 3 and 5 effective against the same isolate of P. teres.

Recent and Current Work

Under the auspices of an AID contract for improving disease control in barley, net blotch has been one of the main barley diseases receiving emphasis. More than 50 isolates of P. teres were collected from Montana and the Middle East (Figs. 1 and 2), and evaluations were first made on some selected barley varieties to obtain some idea of the virulence pool involved. From these tests, 9 virulence groups were designated (Bjarko, 1979) (Tables 1 and 2).

Unitan was resistant to all 9 virulence groups, while many of the other barley varieties tested as differentials were resistant to some virulence types but susceptible to others. Dekap, Mona-Arivat and Arimont were susceptible to all isolates of P. teres. These 9 virulence groups were then used for evaluating resistance of 147 barley lines which were reported to be resistant to net blotch at some place and at some time. Nine barley lines, C.I. 1615, C.I. 4207, C.I. 5298, C.I. 5401, C.I. 5845, C.I. 7208, C.I. 9768, C.I. 13262 and Unitan (MT) were resistant to all of the isolates of P. teres. Twenty-two lines were resistant to 8/9 virulence groups.

In preliminary studies on the genetics of resistance, Unitan was found to contain at least 3 genes for resistance, and many other cultivars contained 2 or 1 resistance genes. It

is not yet possible to say how many different genes for resistance were present in these materials, but there appeared to be at least 6 different genes for resistance to net blotch.

In addition to several major genes conditioning resistance to net blotch, Bjarko (1979) found evidence of minor gene resistance in several barley lines. These lines were generally susceptible as parents and in the F_1 . In the F_2 , however, evidence for minor gene additive action was obvious with certain parents used in crosses. In a follow up of minor gene resistance in barley to net blotch, Bordelon (1981) made 9 different crosses between parents normally susceptible and selected the most resistant appearing plants in each segregating generation up to and including the F_4 (Table 3).

Sixty-nine of 109 F_4 lines showed better resistance than the most resistant parent, and another 15 lines had less disease than the mean of the 2 parents. Often there was very little evidence of resistance in the F_2 or even the F_3 generation, but additive resistance was obvious for many lines by the F_4 . There were obvious differences in combining ability for resistance between the different crosses. C.I. 2330 msg 10 is the main male sterile constituent of several recurrent selection populations for disease resistance, and it was used as the receptor in 4 of the 9 crosses. When used with the barley cultivar Hector, it showed excellent combining ability for additive gene resistance. Firlbecks III, Palliser and Georgie exhibited less combining ability for net blotch resistance in declining order. However, Georgie showed good combining ability for additive resistance with both Betzes

ert-a msg 23 and Tifang used as receptors. F₄ progeny of Tifang x Firlbecks III also showed excellent combining ability for additive gene resistance. These evaluations were first made with one isolate of *P. teres*.

Certain progeny populations tested later with several isolates gave similar results. The results indicated that many barley cultivars contain minor genes which can be combined to give effective resistance. Similar results have been obtained with wheat and stripe rust (Krupinsky and Sharp, 1979), and the resistance has been long-lasting. Since minor genes for resistance often occur in agronomically-suitable types, the breeder's job of selection is less difficult.

Both the major gene resistances and minor gene resistances described in this paper are being combined separately into barley recurrent selection populations for resistance to net blotch.

References

- BJARKO, M.E. 1979. Sources and Genetic Action of Resistance in Barley to Different Virulence Types of Pyrenophora teres, the Causal Organism of Net Blotch. M. Sc. Thesis, Montana State University, Bozeman, Montana, U.S.A., 97 pp.
- BOCKELMAN, H.E., SHARP, E.L, and ESLICK, R.F. 1977. Trisomic Analysis of Genes for Resistance to Scald and Net Blotch in Several Barley Cultivars. Can. J. Bot. 55:(15):2142-2148.
- BORDELON, B.P. 1981. Transgressive Segregation for Resistance in Barley to Net Blotch. M. Sc. Thesis, Montana State University, Bozeman, Montana, U.S.A., 86 pp.
- BUCHANON, K.W. and MACDONALD, W.C. 1965. Sources of Resistance in Barley to Pyrenophora teres. Can. J. Plant Sci., 45:188-193.
- CADDEL, J.L. and WILCOXSON, R.D. 1975. Sources of Resistance to Net Blotch of Barley in Morocco. Plant Dis. Rep. 59:(6) 491-494.
- KHAN, T.N. and BOYD, W.J.R. 1969b. Physiologic Specialization in Drechslera teres. Aust. J. Biol. Sci. 22:1229-1235.
- KHAN, T.N. and BOYD, W.J.R. 1969b. Inheritance of Resistance to Net Blotch in Barley. II Genetics Conditioning Resistance Against Race W.A. - 2. Can. J. Genet. Cytol. 11:592-597.
- KRUPINSKY, J.M. and SHARP, E.L. 1979. Reselection for Improved Resistance of Wheat to Stripe Rust. Phytopathology 69:400-404.
- MODE, C.J. and SCHALLER, C.W. 1958. Two Additional Factors for Host Resistance to Net Blotch in Barley. Agron. J. 50:15-18.
- SCHALLER, C.W. and WIEBE, G.A. 1952. Sources of Resistance to Net Blotch of Barley. Agron. J. 45:174:176.

Table 1. Virulence Groups of Montana Isolates in Relation to 15 Different Barley Varieties (Net Blotch).

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

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

Table 2. Virulence Groups of Middle East Isolates in Relation to 15 Different Barley Varieties (Net blotch).

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

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

Table 3. Relative Net Blotch Disease on Various F₄ Selected Barley Lines in Comparison to Parents.

Barley Cross	Disease Index Lower Than Least Diseased Parent	Total # of Lines*
C.I. 2330 msg 10 x Hector	13 lines	13
Tifang x Firlbecks III	22 lines	24
Betzes ert-a msg 23 x Georgie	7 lines	8
Tifang x Georgie	7 lines	10
Betzes msg- x Firlbecks III	2 lines	3
Georgie x Firlbecks III	8 lines	14
C.I. 2330 msg 10 x Firlbecks III	4 lines	8
C.I. 2330 msg 10 x Palliser	6 lines	20
C.I. 2330 msg 10 x Georgie	0 lines	9
	<u>69 lines</u>	<u>109</u>

* 84/109 lines had less disease than the average of the 2 parents.

Fig. 1 COLLECTION SITES FOR PYRENOPHORA TERES
IN MONTANA

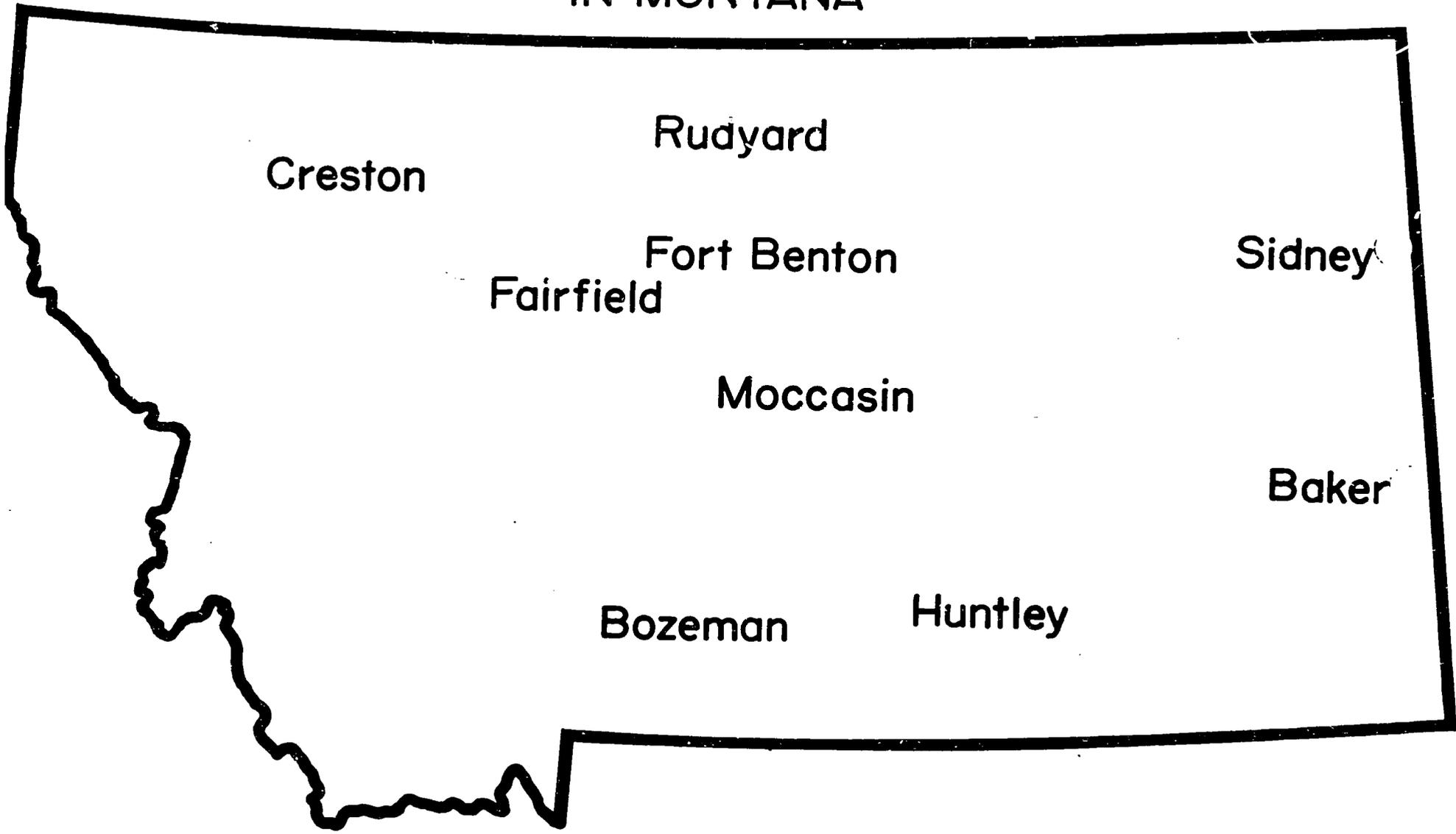
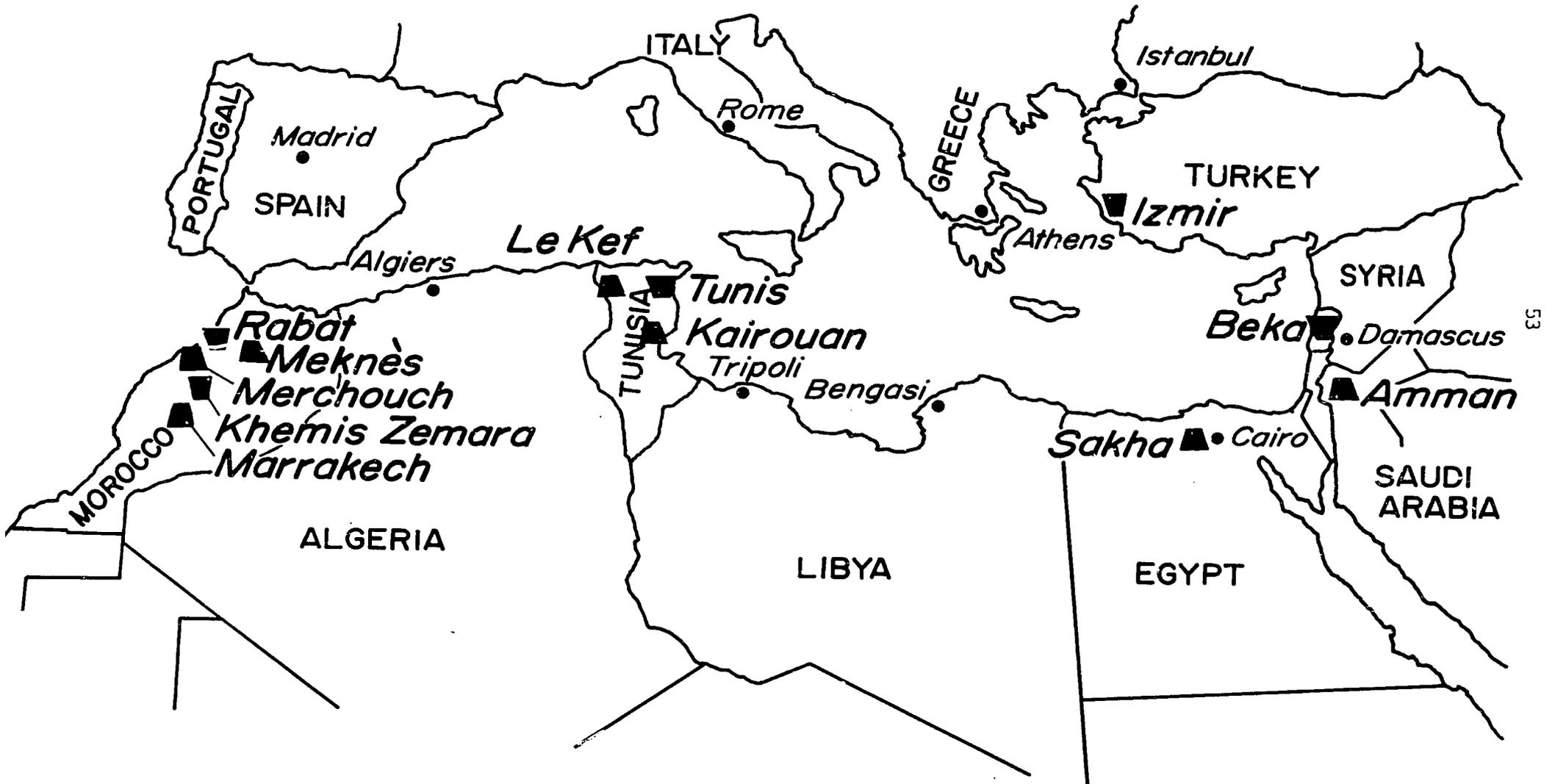


Fig. 2. COLLECTION SITES FOR PYRENOPHORA TERES IN THE MEDITERRANEAN AREA



NET BLOTCH SITUATION IN EGYPT

T. M. Abdel-Hak, E. Ghobrial, A. M. Hammouda*

Barley is attacked by different species of the genus *Helminthosporium* and mainly with *H. teres* (*Pyrenophora teres*) the causal organism of net blotch, *Pyrenophora graminea* causing stripe disease and *H. sativum* incitant of spot blotch." Under Egyptian environmental conditions, net blotch is considered the most important one, followed by stripe disease and spot blotch.

In Egypt, net blotch had been very serious on barley during the fifties and sixties, especially in the cool and humid areas of the northern parts of the Delta Region. In certain localities such as Sakha and Mehalet Mousa (middle of the Delta Region), the percentage of infections used to be as high as 100% due to the continuous planting of barley in large areas every year in the same fields.

There are two main sources of infection with net blotch fungus in barley growing regions; namely (1) the dormant mycelium existing in diseased seeds or barley straw, and (2) the ascospores produced in the ascocarp (the perfect stage) formed at the end of the growing season.

Under Egyptian conditions, the perfect stage has not been detected in the annual surveys of this disease. Thus the perfect stage does not play an important role in initial infection in Egypt.

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The following studies were recently conducted in Egypt:

1. Disease Survey:

The distribution and severity of net blotch are determined yearly by an extensive survey in growers' fields and governmental stations throughout Egypt.

The survey includes the Northern Coast (65,000 hectares grown under rainfall conditions) where net blotch infection is about 5%. In North Egypt, the disease is widespread, and the highest level of infection is found at Damietta, Kafr El-Sheikh, Behira, Menoufia and Kalubia; it then decreases gradually towards middle Egypt. In the far South (Assiout governorate), infection has not been recorded (Table 1).

2. Physiologic Specialization in H. teres:

Race identification of Helminthosporium teres (Sacc.) started in Egypt in 1974 where 60 varieties were selected from the Barley World Collection on the basis of their different reaction to this pathogen. Of these, 6 were found to exhibit clear differential reactions, namely Nepal (CI 475), Gold (CI 1145), Bolivia (CI 1365), Atlas (CI 4118), Lechtaler (CI 6488) and Giza 117 (CI 11190), and thus were chosen as differential hosts for this pathogen in Egypt.

Sixteen physiologic races were identified for the first time in Egypt. The reactions of these races on the differential varieties are shown in Table 2.

Race Ht.₁ was the most virulent, attacking all the 6 differential varieties, whereas race Ht.₁₁ predominated with 20 percent of the total isolates.

3. Epidemiology of Net Blotch in Egypt:

(a) Meteorological factors:

Preliminary studies on epidemiology of net blotch were carried out in 1978 in three governorates: Giza, Behira and Kafr El-Sheikh.

From Table 3, it is obvious that no significant differences were found between temperatures in the 3 governorates. With regard to relative humidities and net blotch development, it was found that at Kafr El-Sheikh, where highest infection occurs, the rainfall was higher than in other governorates. It can be concluded that blotch occurs better at cooler temperatures (7 - 19° C) associated with higher relative humidity and rainfall.

(b) Seeds as source of inoculum:

In this study, seeds taken from fields grown with 4 barley varieties showing different degrees of net blotch infection were planted at Sakha Experiment Station to study the effect of seed infection on net blotch development in the following crop. The results given in Table 4 show that the higher degree of seed infection resulted in a higher infection in the following crop.

(c) Barley debris as sources of infection:

To study the role of barley debris on net blotch development, healthy seeds were grown in soils as is shown in

4. Effect of host on Net Blotch infection:

For this study, 13 barley varieties were tested by detached leaf technique and under field conditions where 3 ages (seedling, middle and adult stages) were studied. It was found

that 2 varieties showed transition of susceptibility to resistance with age, 7 varieties showed increasing susceptibility with age, and 4 cultivars showed seedling and adult resistance with susceptibility in middle life (Table 6).

5. Chemical control:

Preliminary studies were conducted by using 4 fungicides: namely Blastocidin S (4% benzyl amino benzene sulfonate) at the rate of 0.1%; Kitazin (48% E. B. P., S-benzyl diisopropyl phosphorothiolate) 0.1%; Hinosan (50% "EDDP," ethyl-S-S-diphenyl) 0.1%, and Topsin 70-M (70% Thiophanate methyl 1,2-bis "3-methoxy carbonyl-1,2-thioureido" benzene) 0.1% were applied twice at 15 day intervals. The results showed that Blastocidin S and Kitazin gave essentially good control under field conditions and appeared to possess both protective and eradivative properties. Yield response increased by 15% with Blastocidin S and 12% with Kitazin, compared with the unsprayed check (Table 7).

6. Resistance to Net Blotch:

It is generally recognized that successful control of net blotch is through the resistant varieties. Searching for sources of resistance is carried out yearly by testing different varietal collections (including more than 12,000 varieties) of the commercial and promising varieties, new introductions and hybrids, as well as the Barley World Collection, under different climatic conditions where severe infection with the disease is usually present.

A total of 119 varieties showed good resistance and can be used as resistant parents in breeding programs (Table 8).

References

- ABDEL-HAK, T., DESSOUKI S.M., GHOBRIAL E., MANSOUR A.A., and KHALIFA M.I. 1968. Sources of Resistance to Net Blotch, Helminthosporium teres (Sacc.) in UAR. Agric Tech. Bull. No. 10.
- ABDEL-HAK, T., and GHOBRIAL E. 1977. Barley Diseases Situation in the Near East with Special Reference to Sources of Resistance. Proceedings of the Fourth Regional Winter Cereal Workshop, Barley, Vol. II:311-319.
- EL-FAHL, A.M., GHOBRIAL E., IBRAHIM A.N., and HAMMOUDA A.M. 1979. Physiologic Specialization in Helminthosporium teres (Sacc.) Proceedings of the Annual Meeting Egyptian Society of Applied Microbiology, pp. 59-64.
- GHOBRIAL, E. 1977. Multiple-disease Resistance of Barley Varieties with Special Reference to Methods and Terms for Assessing These Diseases Under Egyptian Conditions. The First Arab Biologists Congress. Alexandria, October 26-30.
- GHOBRIAL, E. 1979. Relative Resistance to Barley Diseases Under Egyptian Conditions. Barley Newsletter 22:119-121.
- GHOBRIAL, E. 1979. Varietal Multiple-resistance to Barley Diseases Under Egyptian Conditions. The First Cong. of Agricultural Research Center, Giza, May 22-29.
- GHOBRIAL, E. 1979. Chemical Control of Barley Net Blotch. IX- International Congress of Plant Protection, Washington, D.C. August 5-11 (Res. No. 801).
- GHOBRIAL, E., HAMMOUDA A.M., ABDEL KHALIK R., and MOSTAFA E.E. 1976. Sources of Resistance to Helminthosporiosis of Barley in ARE. In Proceedings of the 2nd Phytopathology Conference, pp 329-340.
- GHOBRIAL, E., HAMMOUDA A.M., IBRAHIM, A.N. and EL-FAHL, A.M. 1979. Epidemiology of Barley Net Blotch, Helminthosporium teres (Sacc.) In Proceedings of the 3rd Egypt pp. 665-674. Phytopathology Congress, Vol 2:665-674.
- GHOBRIAL, E., HAMMOUDA. A.M., IBRAHIM, A.N. and EL-FAHL, A.M. 1980. Epidemiological Studies on Barley Net Blotch, Helminthosporium teres (Sacc.) Barley Newsletter 23:83-84.
- IBRAHIM, A.N., EL-FAHL A.M. GHOBRIAL E., and HAMMOUDA, A.M. 1977. Susceptibility of Barley Plants of Different Ages to Net Blotch "Ontogenetic Predisposition." Agr. Res. Rev. 55:2:13-15.
- MORSI, L.R., MANSOUR A.A., KHALIFA, M.I., GHOBRIAL, E., and SABET, T. 1975. Sources of Resistance to Net Blotch of Barley, Helminthosporium teres (Sacc.) Agric. Res. Rev.53:8.

Table 1. Survey of Net Blotch in Egypt, 1980.

Governorate	% Infected Plant	% Severity
<u>North Egypt</u>		
Alexandria	4	4
Behira	15	4
Damietta	15	7
Kafr El-Sheikh	15	7
Sharkia	5	3
Dakahlia	3	3
Ismaielia	2	3
Gharbia	7	4
Menoufia	10	4
Kaloubia	10	4
<u>Middle Egypt</u>		
Giza	10	6
Fayoum	5	3
Beni-Suef	3	3
Minia	5	3
<u>South Egypt</u>		
Assiout	0	0

Table 2. Identified Races of *H. teres* in Egypt.
Differential Varieties & Reactions. *

Physiologic Race	Bolivia (USA)	Atlas (USA)	Giza 117 (Egypt)	Lechtaler (Portugal)	Gold (Sweden)	Nepa. (USA)
Ht.1	4	4	4	4	4	4
Ht.2	4	4	0	4	4	3
Ht.3	3	4	0	4	4	3
Ht.4	4	4	0	4	4	1
Ht.5	4	4	0	4	4	0
Ht.6	4	0	4	4	4	0
Ht.7	3	4	0	4	4	2
Ht.8	4	3	0	4	4	0
Ht.9	3	4	0	4	4	0
Ht.10	4	2	0	4	4	0
Ht.11	0	4	0	4	4	0
Ht.12	4	0	0	4	4	0
Ht.13	0	0	0	4	4	4
Ht.14	3	0	0	4	4	0
Ht.15	0	3	0	4	4	0
Ht.16	0	0	0	4	4	0

* 0 = immune 1,2 = resistant types; 3,4 = susceptible types.

Table 3. Relation Between Meteorological Factors and Net Blotch Infection in 1978.

Governorate	Temp. Range °C	Rel. Humid.%	Rainfall mm	Infected Plants %	Severity Infect. %
<u>January:</u>					
Giza	6.4-16.9	70.0-80.4	11.2		
Behira	7.7-17.7	77.7-79.0	48.2		
Kafr El Sheikh	8.3-19.0	79.5-82.0	50.8		
<u>February:</u>					
Giza	5.7-19.9	60.6-75.4	6.7		
Behira	7.0-19.6	76.0-82.0	4.4		
Kafr El-Sheikh	7.7-20.1	77.0-82.0	13.4		
<u>March:</u>					
Giza	11.2-23.6	57.8-78.5	-	0	0
Behira	10.6-22.6	79.9-81.4		30	10
Kafr El Sheikh	6.9-19.0	71.0-77.6	7.6	80	50

Table 4. Effect of Infected Barley Seeds on Net Blotch Development in The Following Crop.

Variety	Grain of Previous Barley Crop		
	Infection %	Leaf Infected Area m ²	%Infection Seed in Following Crop
Damazzy	60	300	60
Piast	50	160	40
Nutance 6955	50	100	40
Lubusky	15	100	20

Table 5. The results obtained showed that the highest infection was found in the case of the soil covered with fungus followed by soil mixed with debris or covering it, indicating that debris is considered a source of secondary infection.

Table 5. Infected Debris as a Source of Infection.

Treatment	Mean No. of Blotches on Leaf
Soil mixed with debris	3.00
Soil covered with debris	1.75
Soil mixed with fungus	0.50
Soil covered with fungus	4.75
Untreated soil	0.00
LSD at 5%	2.40

Table 6. Effect of Plant Age of Barley Varieties to Net Blotch Resistance.

Group	Variety	CI No.	Sources	Net Blotch Reaction		
				Seeding	Middle life	Adult
I	Nabawi	10330	Egypt	4	3	0
	Atlas	4118	N.Africa	4	4	2
II.	Numar		RCP	0	0	3
	Yesilkoy		RB	0	1	4
	Orge de Prophet		B	0	3	3
	Esperance	13181	BWC	0	3	3
	Weah		RCB	0	3	4
	Giza 121		Egypt	0	3	4
	Chung Nae 15		LBYT	0	3	4
III.	Dayton	9517	RDISN	0	3	0
	Zehra	5189	PON	0	4	0
	Comp 259		RCB	0	3	2
	Russell "C"		ACSAD	0	4	2

BWC: Barley World Collection

LBYT: Lebanon Barley Yield Trial selections

RDISN: Regional Disease and Insect Screening Nursery

PON: Preliminary Observation Nursery

RCB: Regional Crossing Block

Table 7. Fungicidal Activity Against Net Blotch and on Yield Response.

Treatment Sakha	Av.% Net Blotch Severity	Weight of 1000 Kernel (g)	%Yield Increase over Control
Blasticidin	12.5	47.3	14.1
Kitazin	17.5	46.3	11.5
Hinosan	25.0	47.0	8.5
Topsin 70-M	31.3	45.4	5.6
Untreated	45.5	44.1	-
LSD at 5%	4.2	1.7	
Treatment Bahtim	Av.% Net Blotch Severity	Weight of 1000 Kernel (g)	%Yield Increase over Control
Blasticidin	10.5	50.1	15.3
Kitazin	14.0	49.4	12.6
Hinosan	23.0	48.9	10.1
Topsin 70-M	28.5	48.3	7.2
Untreated	40.0	47.5	-
LSD at 5%	3.9	1.3	

Table 8. Barley Varieties Showing Good Resistance to Ne Blotch.

Variety	CI No.	Source	Variety	CI No.	Source
Coast	276		Ming	4797	Manchuria
Scottish	277	Europe		4918	China
Hannchen	531	Sweden		4974	Morocco
Peru	653	Peru		4976	Morocco
Chile Brewing	657	N.Africa	Rekal	5051	Australia
Hail' Hanna	682	Germany	Rojo	5401	USDA
Trebi	936	Turkey		5422	USDA
Kwan	1016	India	Compana	5438	USDA
Algerian	1179	Algeria		5579	USSR
Oder- brucker	1272	USA		5769	USSR
Vaughn	1367	USA VR		6058	USDA
Manch' a	2330	China	Cebada Capa	6193	N.Africa
Peruvian	2441	N.Africa	Psaknon	6305	Australia
Ariana	2524	Tunis		6307	Germany
Gordon	2674	Canada		6388	Ethiopia
	3211-1	Ethiopia	Sudan	6489	Portugal
Palmella Blue	3609	Egypt	Pallidum 043	6518	USSR
Aim	3737	Egypt		6683	USSR
Delta	4251	Egypt	Kindred	6969	N.Dakota
	4292	Transcaucasia	Stoneman	7112	Arizona
	4294	Transcaucasia	Heitpas 5	7124	USA WI
	4295	Transcaucasia	Freja	7130	Sweden
	4302-1	Transcaucasia	Balder	7131	Sweden

Table 8. (Continued)

Variety	CI No.	Source	Variety	CI No.	Source
Lincoln	4302-2	Transcaucasia	Valentine	7242	Wisconsin
	4303	Transcaucasia	Moore	7251	USA
	4307	Transcaucasia		7457	Japan
	4312	Transcaucasia	Argands	7479	Spain
Tifang	4407-1	Manchuria		7836	Turkey
	7863	Turkey	Rabat x Manchuria (Gaines I)	12253	Florida
	7864	Turkey	B.B.2-21	18080	England
	7870	Turkey		25347	Colombia
	7881	Turkey		25373	Ecuador
	7890	Turkey		25377	Ecuador
	7893	Turkey		25388	Ecuador
	7895	Turkey	Composite Cross	42	
	7897	Turkey	"	"	89
	7929	Turkey	"	"	96
	7937	Turkey	"	"	189
Forrajera			"	"	205
PM.58DIV.2383	8158	Argentina	"	"	243
Forrajera de			"	"	259
Invierno	8159	Argentina			
	8612	Turkey	"	"	291
	8768	Turkey	"	"	612
	8801	Germany	CI 6709 x CI 6695		Egypt
Hispont	8828	Germany		F.6	
Hakata 2	8969	Japan	Sahrawi		Egypt

Table 8. (Continued)

Variety	CI No.	Source	Variety	CI No.	Source
Gospick	9094	Yugoslavia	Giza 24		Egypt
	9157	Turkey	Local Borg El-Arab		Egypt
Traill	9538	N.Dakota	Palestine		Egypt
Prophy	10647	N.Dakota	Local Marsa Matrouh		Egypt
Larker	10648	USA	Munsing		USA
	11288	N.Dakota	Br.Sel. 3962-4		Canada
DIV.6472, 58-12313	11532	Argentina	Moscovicky 121		USSR
San Carlos DIV.5000	11533	Argentina	Union		England
Anoidium x Rabat,a	11540	Canada	Herta		Rotterdam
4805-9-8r		Vola			Rotterdam
Hybernum	115799	Gemany	Geina Khaga		E.Germany
La Estanzuela 75 x	11800	England	Delissa		Holland
Reka I			Pock		Wanderhore
Forrajera Klein	11801	England	Athenais		Cyprus
x Reka 7			Perolina	11805	
Vada	11808	England	Sakiz 66	12056	Turkey

SPOT BLOTCH DISEASE OF BARLEY

A. L. Scharen*

Cochliobolus sativus (Ito et Kurib.) Drechs. ex Dastur (imperfect stage), 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, crown, 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 Gramineae 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 (Tekauz, 1975; Hampton, 1976; Anon., 1979). 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,

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1976). 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 seeds 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 (Anon., 1979; Dickson, 1956). Heavily-infected kernels are often shrivelled.

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, 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, 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 lyophilization or on wheat straw at room temperature.

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 stage 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 USA. (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 2880 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 (1978) in New Zealand found carboxin-thiram best and benomyl-thiram next best as seed treatments to control seedling blight phase of the disease. Musick 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.

References

- Anonymous, 1979. Barley: Origin, Botany, Culture, Winter Hardiness, Genetics, Utilization, Pests. USDA Agriculture Handbook No. 338, 154 pp.
- CHRISTENSEN, J.J., 1922. Studies on the Parasitism of Helminthosporium sativum. Minnesota Agric. Exp. Sta. Tech. Bul. 11, pp. 1-42.
- CHRISTENSEN, J.J. and WOOD, Leon. 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 WALLEN, V.R. 1969. Seed Infection of Barley by Cochliobolus sativus and its Influence on Yield. Can. Pl. Dis. Surv. 49:60-64.
- COUTURE, LUC, and SUTTON, John C. 1978. Efficacies of Fungicides in Controlling Spot Blotch of Barley. Can. J. Pl. Sci., 58:311-317.
- DICKSON, J.G., 1956. Spot Blotch. In Diseases of Field Crops, 2nd ed., McGraw & Hill Book Co, New York. 517 pp. 43-49.
- HAMPTON, J.G., 1976. Spot Blotch of Barley. In Proceedings of the 29th N.S. Weed and Pest Control Conf., pp. 221-224.
- HAMPTON, J.G., 1978. Seed Treatments for the Control of Drechslera sorokiniana in Barley. N.Z. J. Exp. Agric, 6:85-89.
- HAYES, H.K., STAKMAN, E.C., GRIFFEE, F., and CHRISTENSEN, J.J., 1923. Reaction of Barley Varieties to Helminthosporium sativum. Univ. of Minn. Tech. Bul., 21. 47 pp.
- MUSICK, R.R., WILCOXSON, R.D., WARNESS, D., and SMITH, L. 1979. Yield Increases in Resistant and Susceptible Barleys Due to Foliar Fungicides. Phytopathology 69:1040 (abstr.).
- RASMUSSEN, D., and WILCOXSON, R.D. 1977. Yield Losses Due to Spot Blotch. Barley Newsletter, 21:17. (Quoted by permission of R.D.W.).
- ROANE, C.W., 1973. BARLEY. In Breeding Plants for Disease Resistance. R. R. Nelson, (Ed.), Penn. St. Univ. Press, Univ. Park, 401 p., pp 237-252.
- SPRAGUE, R., 1950. Helminthosporium sativum. In Diseases of Cereals and Grasses in North America. The Ronald Press Co., New York, 538 p., pp. 376-381.
- TEKAUZ, A., 1975. In Present Status of Barley Leaf Spot Diseases in Manitoba. Annu. Conf. Manitob. Agron., pp.83-84.

BARLEY STRIPE - ABSTRACT**M. Boulif***

Barley stripe is a frequent disease throughout the world and has been reported from the northern European countries to the tropics.

In Morocco, it is found throughout the barley producing areas with infection rates reaching up to 20 percent. The amount of barley stripe varies from region to region with the highest infection rates being found in the semi-arid and cold areas. Some research workers in Morocco have concluded that only 3 percent of inspected seed-crop fields met their requirement for seed production in Morocco, as far as barley stripe is concerned.

Because of the concern over yield losses in Morocco due to barley diseases, there are efforts being made in relation to barley stripe to develop a systematic approach via various methods to measure these losses, including the use of fungicides.

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HELMINTHOSPORIUM STRIPE IN KOREA**Eun Sup Lee***

The first cultivation of barley, which is the most important human food in Korea and second to rice, was believed to be from around 100 B.C.; the artificial hybridization of barley was begun in 1921. However due to the taste differences, the barley consumption and acreage have been decreased with increasing rice production and economic development.

The current barley cultivation is divided into three areas according to climatic condition: the first area is for covered barley and occupies 35% of the total acreage, the second area is for naked barley and occupies 58%, while the remaining area is for malting barley (Figure 1). Among these, the acreages of naked barley and malting barley are being increased compared with the covered barley. For improving these barleys, there are 4 breeding institutes and 20 places of regional adaptation trials for advanced lines.

Winter barley, fall-sown, is the most prominent in Korea. Therefore, the barley is very seriously affected by the cold temperature during the winter season. As shown in Figure 2, the temperature at fall seeding is usually favorable, but as the growth progresses, plants are subjected to the cold weather which is below zero for about 3 months. Spring regrowth starts in early March with rapidly rising temperatures, and the

*Head of Barley Breeding, Wheat and Barley Research Institute, ORD, Suweon, Korea, 1970.

heading stage is normally reached in early May. The temperature during the ripening stage is usually high with drought. However, due to these conditions in this period, it is believed that the outbreak of helminthosporium stripe may be reduced.

Korea is anxious to increase land utility through the double-cropping system. Approximately one-half of the Korean barley is grown on paddy fields in a double-cropping system with rice, while the other is grown on upland in various double-cropping systems that include soybean. Therefore, if the barley harvest is delayed by cold damage, the double-cropping system is seriously affected by the late harvest of barley.

In the southern part of Korea, the double-cropping system with rice and soybean is comparatively easy because the barley harvest starts in early June, and rice transplanting starts in the middle of June. Therefore, the interval is more than 5 days for the relaxation of the labor competition. On the other hand, in the middle and northern part, the double-cropping system is almost impossible in the paddy field, so it is mostly carried out with soybean in upland fields.

In Korea, the barley should be planted in the fall for the cropping system. If the seeding is in spring, the maturity is delayed more than ten days, and the yield also is markedly decreased. In addition to this, seeding in early spring is very difficult because of frozen soil or excessive soil moisture in the field.

The Breeding Program

According to the above conditions, the current breeding program is concerned with six items.

First is winter hardiness which is the most serious problem. It not only decreases yield, but also delays maturity which makes the difficulties in the double-cropping system with rice and other crops.

Second is earliness, which is very important in the double-cropping system. However, there is a serious problem in breeding for earliness because the relationship between earliness and winter hardiness has a negative trend.

Third is grain quality. Most barley products are consumed in human food by cooking barley with rice. Most people dislike barley compared with rice, and breeding is therefore focused on improving the grain quality.

Fourth is lodging resistance which sometimes causes a 20% yield reduction.

Fifth is tolerance to excessive soil moisture. Approximately one-half of the Korean barley is grown on paddy fields. Due to this condition, the barley is damaged by the excessive soil moisture. Even though there is no major gene in breeding, the research for this problem is being continuously undertaken.

Sixth is disease resistance. Generally speaking, the breeding program on disease resistance has not been strongly worked because it has not been a serious problem on yield.

Diseases

The general diseases affecting barley yield in Korea are barley stripe, powdery mildew, scab and smut. Because of these diseases, barley yields have decreased by 11.4% which is the average from 1972 to 1977. Among the diseases, barley stripe is the most serious by 3.2% compared with powdery mildew by 2.5%, scab by 2.4% and others.

To investigate the infection trend of barley stripe in Korea, we surveyed at three different areas. Usually the occurrence of the disease starts from early April, increases with the growth of barley and maximizes at around heading stage. The occurrence in the mountain areas is generally low, while that of the seashore areas is high from the early stages. At the low land, its occurrence is rapidly increased during the middle of April, probably due mainly to temperature which, in the mountain areas, is comparatively low, but that of the seashore is high in early April (Figure 3).

As shown in Figure 4, the yield reduction caused by *Pyrenophora graminea* ranged from 1.9% to 5.9% for 6 years. Among them, 5.9% in 1972 was the most serious. The reason depended on temperature and precipitation. In 1972, there were comparatively high temperatures and much rainfall from the regrowth stage of barley.

To observe the several physiological characteristics of *P. graminea* isolates in Korea, we have carried out some tests which showed that the fungi grew actively at pH 4-5 at 15°C and at pH 6-7 at 20°C. According to the results, *P. graminea*

also grows in Korea at around the neutral range of pH.

More specific and basic information to control the disease systematically is needed.

For the control of P. graminea in Korea, varieties are being screened for resistance. Of 412 barley varieties tested, 148 were found to be resistant and are being used as a breeding source.

All of these varieties are currently cultivated in Korea (Table 1). They were tested by Army and Shands' technique using the fungus which was isolated from the infected barley plants grown in Korea. Most varieties were proven to be comparatively resistant. However, some varieties including Olbori, which is largely cultivated in Korea, are susceptible. The current varieties are being treated with seed disinfectants before seeding. The newly-improved lines are tested for resistance to barley stripe before being recommended as new varieties.

In the 1978 preliminary and advanced-yield tests with 94 lines, the distribution of resistant lines was much lower than that of the susceptible lines. The 1980 test with 232 lines showed a different trend, which indicates that the resistant lines are being increased.

Regarding chemical control of P. graminea, several seed disinfectants have been tested to observe the inhibition zones of the fungus grown on Potato Dextrose Agar (PDA). Thiram and Orthocide were the best on the fungus inhibition, but this result was a little different from field tests.

Among the seed disinfectants, Vitavax, Vitathiram,

Mercuron and Thiram were proven as the promising chemicals for controlling stripe disease. The current chemicals used in Korea are Vitavax and Vitathiram, excepting Mercuron which was withdrawn by the government due to mercuric pollution.

Table 1. Response of Recommended Varieties to *P. graminea*.

Year	Cultivar	Reaction*	Year	Cultivar	Reaction*
1932	Suweon#18	R	1977	Dongbori#2	M
1963	Beheung	MS	1978	Durubori	M
1967	Yeogi	M	1978	Albori	MR
1973	Kwangseong	M	1978	Sacheon#2	MS
1973	Olbori	S	1979	Oweolbori	MR
1974	Milyang#6	MS	1979	Sacheon#6	MS
1976	Kangbori	MS	1980	Jogangbori	MR
1976	Bunong	MS	1980	Buhobori	M
1977	Dongbori#1	M	1980	Muanbori	M

* M = Medium
 MR = Moderately Resistant
 MS = Moderately Susceptible

R = Resistant
 S = Susceptible

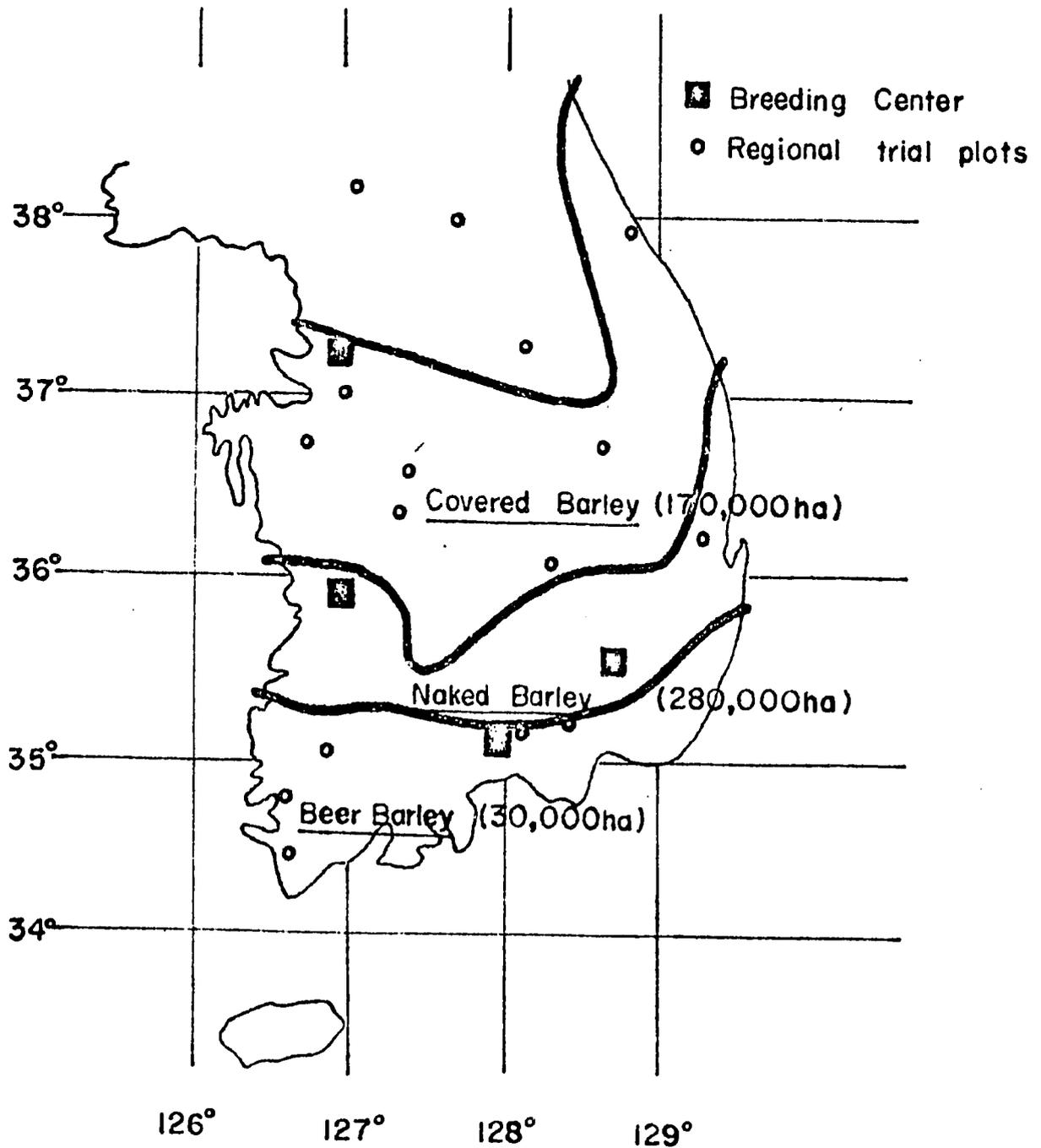


Figure 1. Barley cultivation in Korea.

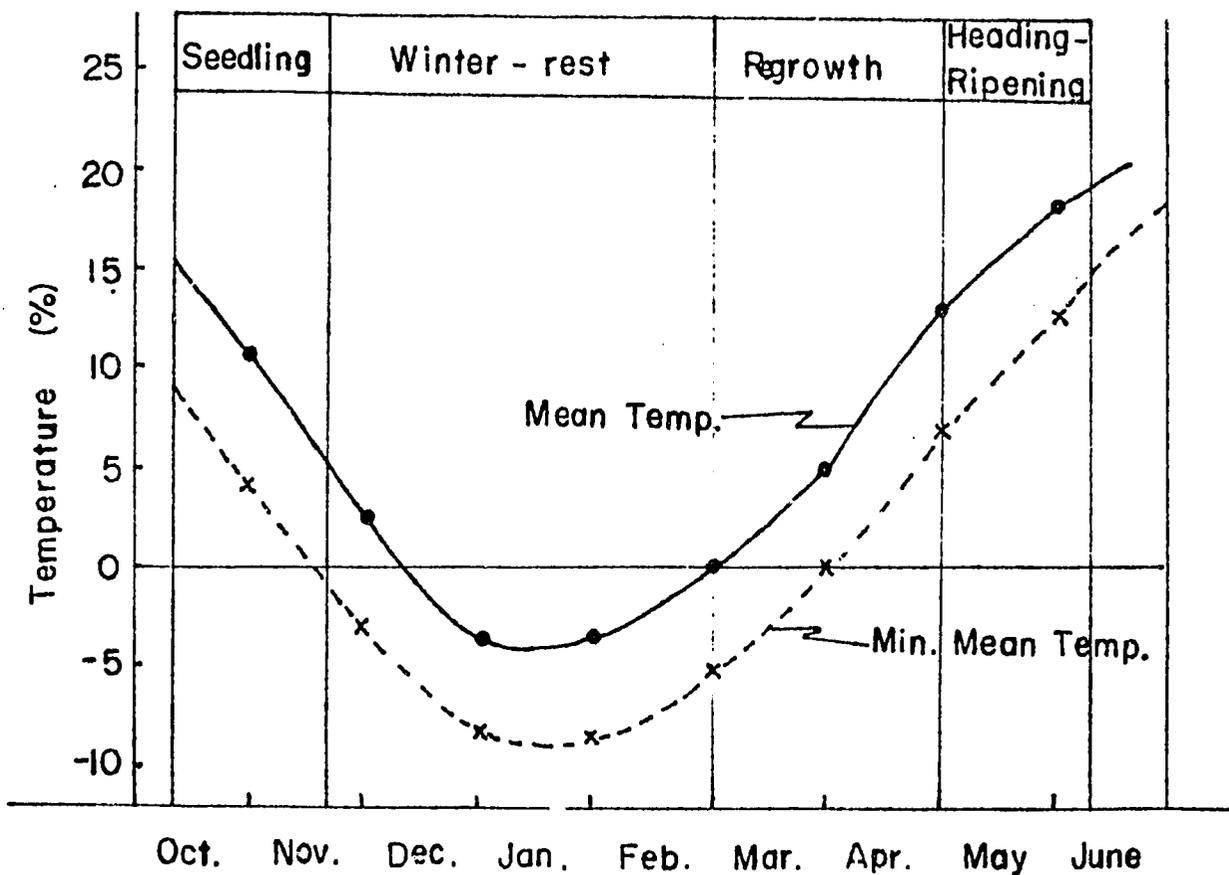


Figure 2. Temperature and barley growth in Korea.

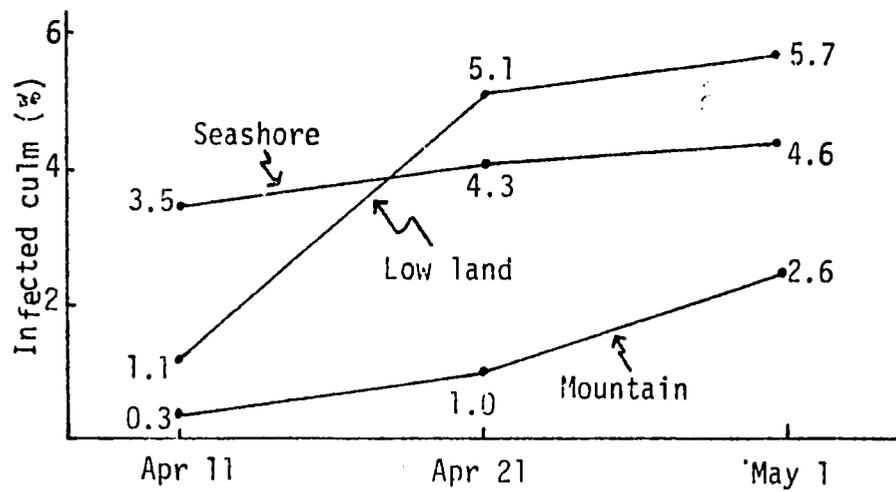


Figure 3. Regional infection trend of barley stripe.

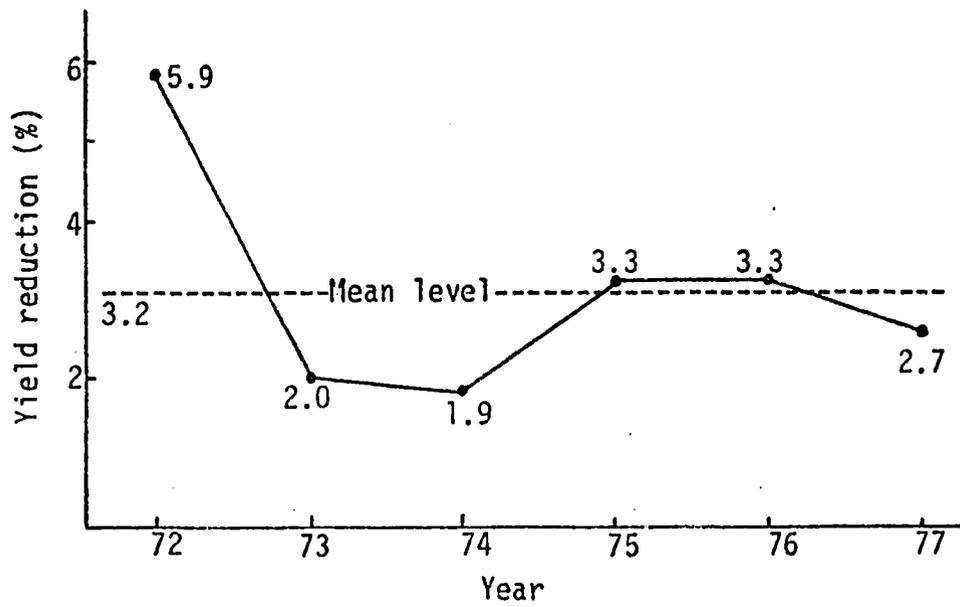


Figure 4. Yield reduction trend caused by *P. graminea*.

REVIEW OF SCALD OF BARLEY

Omar F. Mamluk*

Scald of barley was reported at the end of the last century but not as a disease of significance. However in recent years, the disease has gained in importance. In the past three years, scald has been very severe in Jordan and Syria, and it has been reported from most barley production regions of the world where susceptible varieties are grown.

The disease causes considerable yield losses in Afghanistan, Turkey, Ethiopia and Kenya. In Germany, losses can reach 30% in winter barley and 15% in spring barley.

The scald fungus *Rhynchosporium secalis* attacks barley, rye and many grasses. Several races have been identified - possibly as many as six.

The pathogen survives the off-season as mycelium on dead leaf tissues where it may not persist for more than one year. The pathogen is also found in barley seed, but it is transmitted mainly on infected plant debris.

The conidia are airborne and are also distributed by rain. They germinate from 6-25°C in the presence of relatively-high relative humidity. When the temperature exceeds 24°C and environmental conditions are dry, no more conidia are produced.

When plants become infected, the symptoms first appear as irregular blue-green water-soaked lesions on the leaf blades and sheaths. Later, the symptoms develop into bleached areas with brown margins.

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Crop rotation, elimination of plant residues and the use of resistant varieties are the recommended control measures.

VIRULENCE PATTERNS OF RHYNCHOSPORIUM SECALIS FROM SEVERAL
BARLEY-GROWING REGIONS

H. E. Bockelman*

Twenty barley cultivars were inoculated in seedling tests with, nine isolates of Rhynchosporium secalis collected from several barley-growing regions. The results (Table 1) 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.

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Table 1. Seedling Reactions of 20 Barley Cultivars to 9 Isolates of *Rhynchosporium secalis*.

Cultivars		Isolates**								
		A	B	C	D	E	F	G	H	I
Abyssinia	CI 3940	0*	0	1	0	0	0	0	0	0
Abyssinian 5	CI 4354	0	0	1	0	0	0	0	0	0
Steudelli	CI 2226	1	0	1	1	0,1	1	1	1	0,1
Osiris	CI 1622	0	0	0,1	0	0	0	1	2,3	0
Atlas 46	CI 7323	0	0	0,1	3	0	0	2	0	0
Abyssinian	CI 668	0	0	1	0	0	0	2	2,3	0
Turk	CI 14400	0	0	3	1,2	0	0	3	0	0
Jet	CI 967	0	0	2,3	0,1	0	0	2,3	3	0
Nigrinudum	CI 11549	1	0	3	0	0	0	2,3	3	0
Modoc	CI 7566	0,1	0	3	1	0	0	3	3	0
Beecher	CI 6566	1	0,1	3	2,3	3	0,1	0,1	1	0
Trebi	CI 936	0	0	2,3	0	0	2,3	3	2,3	0
LaMesita	CI 7565	0	0	3	0	0	0,1	3	3	2
Kitchin	CI 1296	0	0	2,3	0	0	0,1	3	3	2
Bey	CI 5581	0	0	3	0	0	0	3	3	2
Unitan	CI 10421	1,2	2	3	1,2	2	0	1	2,3	0
Steptoe	CI 15229	1,2	1	3	1,2	2	1	2,3	2,3	2
Gem	CI 7243	2	0,1	3	2,3	3	2	0,1	1	0,1
Atlas	CI 4118	2,3	1	3	3	3	1,2	1,2	3	0
Betzes	CI 6398	3	3	3	3	3	3	3	3	3

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

**A = LewB77 (Montana)
 B = 79 Ftb (Montana)
 C = 79 Dav-2 (California)

D = 79 Dav-3 (California)
 E = L (Lebanon)
 F = T (Turkey)
 G = Tun 1 (Tunisia)
 H = Mor 25 (Morocco)
 I = Syr 79-58 (Syria)

LEAF SCALD - A MAJOR BARLEY DISEASE IN PORTUGAL

M. T. Barradas*

The average hectarage of barley in Portugal within the last eight years is 84,000 ha (Table 1). This is approximately 10% of the total area sown to winter cereals. Practically all the barley crop is for grain and is cultivated under dry-farming conditions. Barley in Portugal is almost always grown in the southern part of the country where the Mediterranean influence is stronger. The crop is commonly sown in winter. There are large variations in crop management methods. Barley is used mainly for animal feeding, malting and brewing.

The commercial system of growing malting barley is well organized and provides good economic returns. Consequently, that type of barley is cultivated by a comparatively more advanced technique. The system for production of animal feed barley was, on the contrary, quite unprotected; but very recently it has improved significantly. In these two different systems, the grain yield in 1977 for malting barley was 1380 kg/ha and for feeding barley was 680 kg/ha.

Diseases

The most important ones are leaf scald (Rhynchosporium secalis), Helminthosporium spp. (mainly Helminthosporium teres), powdery mildew (Erysiphe graminis hordei), smuts (Ustilago spp.), stripe rust (Puccinia striiformis) and Barley Yellow Dwarf Virus (BYDV).

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Leaf scald is widely distributed throughout the barley crop. The disease aggressively develops in some seasons and locations and results in appreciable yield losses. The most serious effects of that epidemic can be observed in the rich soils of valleys, e.g. the Tagus Valley and the Caia Valley where the National Plant Breeding Station is located. It occurs mainly when high amounts of nitrogenous fertilizers are applied.

In the mild and rainy winters, the disease develops from the earlier vegetative stages of the crop and can persist throughout the spring. When dry weather comes, the pathogen development is blocked.

Scald, in this country, is a disease with high local carry-over on stubble and crop debris. Heavy infections are found in poorly-drained soil areas.

The field reaction at Elvas shows a wider spectrum of races than in Aberystwyth according to a joint breeding project (1966-1971) with the Welsh Plant Breeding Station. In these experiments, only Cb 957 Turk was completely resistant.

Under heavy infections of scald disease at Elvas in 1978 and 1979, resistant lines were observed among material received from several breeding programs. Resistant phenotypes to leaf scald are found more frequently among the six-rowed and winter types (Table 2). Except Arivat, all the barley varieties at present used by the farmers in Portugal are susceptible genotypes. The Plant Breeding Station is using lines in the breeding program with resistance to Rhynchosporium secalis and acceptable performance.

Table 1. Area, Production and Yield of Barley in Portugal, 1973-80.

Year	Area (hectares)	Production (tonnes)	Grain yield (kg/ha)
1973	80,800	56,600	700
1974	93,500	74,500	797
1975	102,900	126,600	1,231
1976	114,000	104,000	912
1977	67,200	39,400	586
1978	72,327	39,361	544
1979	72,058	41,150	571
1980	73,823	49,613	672

Table 2. Two-Rowed Barley Lines Showing Resistance to Scald Disease (*Rhynchosporium secalis*) Under Field Conditions at Elvas, Portugal.

Type of barley	Line	Growth Habit
Two-rowed	Alger - Ceres	Spring
	Alger - Ceres 362-1-1	Spring
	Alger - Union	Spring
	Victoire x Jerusalem - 92	Spring
	62/13 - 6	Spring
	65/55 - 3	Spring
	Alpha	Winter
	Apna	Winter
	Hydra	Winter
	Igri	Winter
	Sonja	Winter

Table 3. Six-Rowed Barley Lines Showing Resistance to Scald Disease (*Rhynchosporium secalis*) Under Field Conditions at Elvas, Portugal.

Type of barley	Line	Growth Habit
Six - rowed	Abyssinian 33	Spring
	Dubois D	Spring
	Beecher	Spring
	Celaya	Spring
	Centinela	Spring
	Cholo	Spring
	CM 67-U.Sask.1800 x Pro-6M 67-CMB 72 A	Spring
	Gv 380 - Maguelone - 1406	Spring
	Herawi	Spring
	Puebla	Spring
	Steptoe	Spring
	Tlaxcala	Spring
	Traill-1038 x DL 7 D - CM 74 A	Spring
	CM 67-Pro/Bco.Mr x DS- Apro-CMB-73	Spring naked
	Pro-Tol 1 x Cer ² - Tol I/5106-CMB-73	Spring naked
	Antares	Winter
	Astrix	Winter
	Copm	Winter
	Gerbel	Winter
	Hop	Winter
Katje	Winter	
Robur	Winter	
Vogel Sanger Gold	Winter	

SEEDLING REACTION OF THE 7TH IBON TO RHYNCHOSPORIUM SECALIS
IN THE GREENHOUSE AND SOURCES OF RESISTANCE

A. M. El-Ahmed*

Introduction

Scald of barley, caused by Rhynchosporium secalis (Oud.) Davis, is a major disease in many regions, particularly in the cooler and semi-humid areas, inciting considerable losses in yield (Ali, 1975; Shipton et al., 1974). Results of the first IBON (CIMMYT, 1974) indicated the importance of this disease in Africa (Ethiopia) and the Andean regions (Ecuador and Peru). It exists also in the Central areas of Mexico (Moreno and Vivar, 1975), in Syria (Bayaa et al., 1978) and most barley-producing areas of the world.

Field screening for scald is difficult when other diseases are present, especially Helminthosporium spp. (Riddle and Briggs, 1950) and Xanthomonas translucens which are also frequent on barley. However, this problem can be eliminated in the greenhouse (Riddle and Briggs, 1950).

The study described in this paper was undertaken to examine the reaction of the 7th IBON (International Barley Observation Nursery) to a mixture of different isolates of R. secalis collected from Mexico, and furthermore, if possible, to identify, the parents responsible for resistance to this fungus in the nursery.

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Materials and Methods

Isolates: Five isolates were collected from barley in different locations of the high plateau, Mexico:

Isolate I: Emiliano Zapata, State of Hidalgo

Isolate II: Calpulalpan, State of Tlaxcala

Isolate III: San Marcos, State of Tlaxcala

Isolate IV: Benito Juarez, State of Tlaxcala

Isolate V: Lagunilla, State of Hidalgo

The isolation of *R. secalis* from infected leaves was done according to the technique used by Schein and Kerelo (1956) on Lima Bean Agar (LBA) and incubated at 20°C.

Hosts: Lines of the 7th IBON were used in this test. Eight to ten seeds of each entry were sown in duplicate carton cups having a mixture of forest soil, river loam, sand at a 3:2:1 ratio and grown in a greenhouse at 20°C \pm 2°. When the first leaf was completely extended, seedlings were fertilized with ammonium sulfate at 1.5 g/cup.

Preparation of Inoculum and Inoculation: Two plates of each isolate (14 days old) were whipped in a blender for 30 seconds, mixed together and adjusted to 10⁶ spores/ml by diluting with distilled water containing 0.5 percent gelatin and filtered through three layers of cheesecloth.

At the time of the appearance of the third leaf, seedlings were sprayed with the spore suspension, dried naturally for one hour and then sprayed again. One liter of inoculum was sufficient to inoculate the entire nursery sets twice. Plants,

after spraying, were incubated for 60 hours in a chamber with two humidifiers and returned to the greenhouse.

Results were scored after 19 days of inoculations according to the scale used by Ali and Boyd (1974) and modified as follows:

Highly Resistant (0):	no visible symptoms
Resistant (1):	small lesions on the tips or on the base of the leaf
Intermediate (2):	one to two small lesions on the blade and/or a narrow band of lesions extending at the margin of the leaf
Susceptible (3):	well-developed lesions on the blade, but without collapse
Highly Susceptible (4):	leaves collapsed

Results and Discussion

The first symptoms started 10 days after inoculation and became completely typical 5 days later. The reaction type was noted on the two lower leaves. Five entries were discarded because of lack of germination or death.

Lines which have the reaction type 0 to 1, and 2, are regrouped in Tables 1 and 2, respectively. Of the 286 evaluated entries, 10 were highly resistant (reaction type 0), 22 resistant (reaction type 1), 29 intermediate (reaction type 2) and 225 entries susceptible or highly susceptible (reaction types 3 and 4).

Parents of the resistant entries (0 and 1) were studied in the same way to evaluate their reaction to the mixture of the above isolates. Table 3 indicates the presence of 6 common parents with reaction type 0 or 1 which might be responsible

for the resistance of 16 entries in the nursery (Table 1). On the other hand, parents with reaction 2 (Table 3) seem to provide resistant reaction to other entries as shown in Table 1. Resistant entries derived from two susceptible parents were observed in this study. The explanation of this observation could be the complementary effects of the two original parents.

Although these parents have given good resistance to 32 entries, some lines derived from these parents were susceptible. However, sister entries of the same parentage but with different pedigrees sometimes reacted differently to the mixture of isolates. For example, Api-CM67 x Mzq (entry 117) was resistant, while the sister (entry 116) was susceptible, and another entry 115 was intermediate in reaction type. This variation in reaction could be due to the lack of uniform natural infection of the line materials by *R. secalis* prior to selection; or it could result from the inclusion in these mixtures of biotypes, one or more of which provide virulence for a resistance gene conferring resistance to biotypes present at time of selection of lines 116 and 115, while line 117 has an additional gene which maintains the resistance of that line.

To overcome at least the first part of this pathogen and considering the worldwide importance of the disease, it is recommended that artificial inoculation of segregating materials should be part of the selection process rather than depending entirely on natural infection. This recommendation is based on the work of the summer of 1979 when all barley F₂'s were inoculated twice with a mixture of the above five

isolates, giving a reaction ranging from extreme susceptibility to high resistance.

References

- ALI, S.M., 1975. Inheritance of Scald Resistance in Barley. I. Resistance of Genes of Group A Barley Cultivars, Aust. J. Agric. Res., 26:243-250.
- ALI, S.M. and BOYD, J.R., 1974. Host Range and Physiologic Specialization in Rhynchosporium secalis. Aust. J. Agric. Res., 25:21-31.
- BAYAA, B., EL-AHMED, A. and BALLAR, M., 1978. Survey on Syrian Plant Diseases. in Plant Protection Newsletter (Syrian Plant Protection Society), No. 3-4, pp. 1-10.
- CIMMYT. Results of the first IBON, 1973-1974. Centro Internacional de Mejoramiento de Maiz y Trigo, Information Bulletin No. 36.
- MORENO, R. and VIVAR, H., 1975. Especializacion Pathogenica de Rhynchosporium secalis en Los Valles Altos de Mexico. Turrialba, 25:223-225.
- RIDDLE, O.C. and BRIGGS, F.N., 1950. Inheritance of Resistance to Scald in Barley. Hilgardia, 20:19-27.
- SCHEIN, R.D. and KERELO, J.W., 1956. Culturing Rhynchosporium secalis. Plant Disease Reporter, 40:814-815.
- SHIPTON, W.A., BOYD, W.J.R. and ALI, S.M., 1974. Scald of Barley. Review of Plant Pathology, 53:839-861.

Table 1. Entries of the 7th IBON Showing Highly Resistant (0) and Resistant (1) Reaction to 5 Isolates of *R. secalis*.

Entry No.	Variety or Cross and Pedigree	Reaction Type
9	Mzq-Egypt 20 CMB-74A-62-7B-1Y-2B-1Y-1B-OY	1
10	Mzq-Egypt 20 CMB-74A-62-7B-1Y-2Y-1B-OY	1
11	Mor-BuRF9 x Pro/loll-Api)Hja C 4179 CMB-74A-76-15B-1Y-2B-1Y-1B-OY	1
31	H251-Choya CMB-74A-1097-4B-1Y-1B-1Y-1B-OY	1
32	H251-11016.2 CMB-74A-1102-6B-1Y-1B-2Y-1B-OY	1
73	Api-CM67 x Oregano CMB-75-94-15Y-2B-1Y-1B-1Y-OB	1
74	Api-CM67 x Oregano CMB-75-94-27Y-1B-2Y-1B-3Y-OB	1
81	U.Sask 1766 x Api-CM67 CMB-75-163-7Y-1B-1Y-2B-1Y-OB	1
83	Clipper x Apam-IB65 CMB-74/A-762-8M-3Y-1B-1Y-1B-OY	1
85	Apam-Gva x Api-CM67 CMB-75-203-1Y-1B-1Y-1B-1Y-OB	0
86	Gaines-Oregano "S" CMB-75-303-1Y-2B-1Y-1B-1Y-OB	0
87	Gaines-Oregano "S" CMB-75-303-1Y-2B-1Y-1B-2Y-OB	0
88	Gaines-Oregano "S" CMB-75-303-1Y-2B-1Y-1B-3Y-OB	0
92	RM1508-H251 CMB-75-362-4Y-1B-1Y-1B-1Y-OB	1
93	RM1508-H251 CMB-75-362-4Y-1B-1Y-1B-2Y-OB	0
117	Api-CM67 x Mzq CMB- X5-413-10Y-1B-1Y-1B-1Y-OB	1

Table 1. (Continued)

Entry No.	Variety or Cross and Pedigree	Reaction Type
134	M67. 18-M14 X Apam-1B65/Bco.Mr-Gva. CMB-75-489-1Y-1B-3Y-1B-1Y-OB	1
139	CM67-U.Sask.1800 x Pro-CM67/Mzq CMB-75-515-1Y-1B-1Y-1B-1Y-OE	1
154	Dubois x Api-CM67 CMB-75-800-4Y-1B-1Y-2B-1Y-OB	0
155	Dubois x Api-CM67 CMB-75-800-44-1B-1Y-2B-2Y-OB	0
156	Ager x Api-CM67 CMB-75-827-1Y-1B-1Y-1B-2Y-OB	1
164	Manker-Bahtim 10 x Api-CM67 CMB-75-1085-A-1Y-1B-1Y-1B-1Y-OB	1
199	CM67-Shikoku Hadaka 47 CMB-74A-186-1B-2Y-1B-1Y-1B-OY	1
227	Api-CM67 x Oregano CMB-75-94-27Y-1B-1Y-1B-2Y-OB	0
228	Api-CM67 x Oregano CMB-75-94-27Y-1B-1Y-1B-3Y-OB	0
234	Api-CM67 x Hul-less Cq CMB-75-406-3B-1B-1Y-3B-1Y-OB	0
258	APAM-RL X F 1014.69 CMB-75-574-12Y-1M-2Y-1B-1Y-OB	1
275	Apam-RL x Ager CMB-75-569-1Y-1M-1Y-1B-1Y-OB	1
279	Apam-RL x F1014.69 CMB-75-574-12Y-1M-1Y-1B-1Y-OB	1
281	Apam-RL x F1014.69 CMB-75-574-12Y-1M-1Y-2B-1Y-OB	1
282	Apam-RL x F1014.69 CMB-75-574-12Y-1M-1Y-2B-2Y-OB	1
291	B45-Nepal CI 593 x 10985.1-Clipper CMB-75-1349-E-1Y-1B-1Y-1B-1Y-OB	1

Table 2. Entries of the 7th IBON Showing Intermediate Reaction Type (2) to 5 Isolates of *R. secalis*

Entry No.	Variety or Cross and Pedigree	Reaction Type
3	CENTINELA	2
4	CM 67	2
27	Api-CM67 x Apam-IB65 CMB-74A-1014-4B-1Y-1B-1Y-1B-OY	2
28	Api-CM67 x Apam-IB65 CMB-74A-1014-4B-1Y-1B-1Y-2B-OY	2
30	Por-EB1053 x CM67/Minn 126-CM67 x DS-Apro CMB-74A-1059-13B-24-1B-1Y-1B-OY	2
34	Pitayo-Cambrinus CMB-74A-84-7B-1Y-1B-1Y-1B-OY	2
103	CENTINELA	2
104	CM67	2
115	Api-CM67 x Mzq CMB-75-413-1Y-3B-1Y-1B-1Y-OB	2
133	Huzache "S" x Api-CM67 CMB-75-450-10Y-1B-1Y-1B-1Y-OB	2
141	CM67-U.Sask 1800 x Pro-CM67/Mzq CMB-74-5Y-1B-1Y-1B-1Y-OB	2
153	Dubois x Api-CM67 CMB-75-800-4Y-1B-1Y-1B-1Y-OB	2
157	Ager x Api-CM67 CMB-75-827-1Y-2B-1Y-1B-1Y-OB	2
165	Manker-Bahtim 10 x Api-CM67 CMB-75-1085-A-1Y-1B-1Y-1B-2Y-OB	2
191	Mzq-DL71 CMB-74A-67-1B-1Y-1B-1Y-OB	2
192	CM67-U.M(evans)4098 CMB-74-20-1Y-1B-1Y-1B-2Y-OB	2
193	TEQUILA "S" CMB-72-189-3Y-1B-2Y-1B-1Y-OB	2

Table 2. (Continued)

Entry No.	Variety or Cross and Pedigree	Reaction Type
197	WI 2137.2 x Apam-1B65 CMB-74A-1117-2B-1Y-1B-1Y-1B-OY	2
198	WI 2137.2 x Apam-1B65 CMB-74A-1117-8B-2Y-1B-1Y-1B-OY	2
203	CENTINELA	2
204	CM67	2
210	Api-CM67 x HBCC XXVIII CMB-74A-967-6M-24-1B-1Y-1B-OY	2
221	M65.94-CI 3909.2 X RM1508 CMB-74A-1796-B-6B-1Y-1B-1Y-1B-OY	2
224	Cadillo x Apam-1B65 CMB-75-28-2Y-1B-1Y-1B-1Y-OB	2
226	Api-CM67 x Oregano CMB-75-94-15Y-2B-1Y-2B-1Y-OB	2
232	RM1503 x Ds-Apro CMB-75-357-5Y-1B-2Y-2B-1Y-OB	2
276	Apam-RL x F1014.69 CMB-75-574-5Y-1M-2Y-1B-2Y-OB	2
283	Apam-RL x F1014.69 CMB-75-574-12Y-1M-2Y-3B-1Y-OB	2
287	Row 31.73-Hja C4715 CMB-75-699-4Y-1M-1Y-1B-1Y-OB	2

Table 3. Reaction of Parents of the Resistant Entries in the 7th IBON to 5 Isolates of *R. secalis*.

Parent	Reaction type
Ager	0
Apam-Godiva	0
Dubois	1
H251	1
Mezquite	1
Gaines	1
CM67	2
Api-CM67	2
Mor-BuRF9 x Pro/Tol I-Api	2
F 1014.69	3
M67. 18-M14 x Apam - IB65	3
Apam-RL	3
U.Sask 1766-Api	3
Choya	3
Clipper	4
11016.2	4
Egypt 20	4
Bco. Mr-Godiva	4
RM1508	4
Manker-Bahtim 10	4
Oregano	4
CM67-U.Sask 1800 x Pro-CM67	4
Apam-IB65	4
Hull-less Cq	4
Shikoku Hidaka	4

BARLEY SCALD IN ETHIOPIA

H. Gebre*

Scald, Rhynchosporium secalis, is the most serious disease of barley in Ethiopia. It occurs mostly in the highlands, with more severity in altitudes between 2200 and 2700 m. Grain yield loss due to scald is estimated to be about 20-30 percent. Races of scald are not identified yet, but there is circumstantial evidence for variation. There is an ongoing breeding program for scald resistance on food and malting barleys, selection commences at Fl. To date, completely-resistant varieties have not been obtained - only some varieties with various degrees of resistance.

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POWDERY MILDEW OF BARLEY (*Erysiphe graminis hordei*)**J. G. Moseman*****Introduction**

The disease powdery mildew of barley, *Hordeum vulgare* L., is one of the most economically-important diseases on barley (Blumer, 1967; Torp et al., 1978). It causes a reduction in malting quality, kernel weight and yield (Brooks, 1970; Sigurbjornsson, 1976). The pathogenic fungus *Erysiphe graminis* DC EX Merat f. sp. *hordei* Em. Marchal, which incites the disease, is present in most areas where barley is grown (Eyal et al., 1973). The fungus is a heterothallic obligate pathogen which can survive and reproduce only on compatible hosts, *Hordeum* species. Two cultures of the fungus with + and - mating types are required to complete the sexual cycle (Myer et al., 1979). In the semi-arid regions, the fungus forms perithecia on barley plants as they ripen in the late spring and early summer. The perithecia remain dormant on dead leaves and plant debris during the dry summer and early fall. When rains occur in the fall, and volunteer plants begin growing, the sexual ascospores are discharged from the perithecia and young seedling plants are infected. During the winter when there is little plant growth, the fungus lives as haustoria or mycelia in those plants. The fungus initiates its growth whenever the plants on which it is living begin growing.

The most effective and efficient method for controlling

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this pathogenic fungus is the use of resistant varieties. It is not possible to eliminate the perithecia in which the fungus survives when plants are not available. After the fungus has infected a compatible or susceptible host plant, it will survive and grow as long as the host plant is alive and growing.

The disease, powdery mildew of barley, is the result of compatible interactions between the pathogen, *E. graminis hordei*, and the host, *Hordeum* species. Characteristics of both the pathogen and host are important in determining if the interactions between the pathogen and host are compatible, and if disease development can progress. Procedures for selecting and developing resistant hosts to control diseases will be discussed by several individuals at this workshop. Therefore, I will discuss the characteristics and use of pathogenic cultures of the pathogen to control the disease, powdery mildew of barley.

Characteristics of Pathogenic Cultures

The primary method of classifying obligate pathogens is by the infection types induced by specific cultures of the pathogens on specific hosts. Two important characteristics of infection types are that they should be discriminate and stable. The infection types should be easily recognized and distinct. Cultural and environmental conditions in which the host is grown should be optimized and standardized as much as possible since the growth of obligate pathogens is determined by the physiological condition of their hosts. Conditions should be avoided in which there are few or poorly developed

pustules since differences in infection types are difficult to distinguish under those conditions.

Some infection types are unstable and easily modified by slight variations in light, temperature and/or other environmental factors. Host-pathogen combinations which produce such infection types should be avoided. An example is the mesothetic reaction in which there are compatible and non-compatible pustules on the same leaf. The relative frequency of the two types of pustules is often influenced more by modifications in one or more environmental factors, such as light and temperature, than by the genotypes of either the host or pathogen.

The most frequently referred-to characteristic of obligate pathogens is the pathogenicity of specific cultures on a specific set of hosts. This characteristic of cultures is referred to as physiologic races. Physiological races are identified by the pathogenicity of cultures of a pathogen on a pre-selected set of host varieties or lines (differentials). The selection of the differentiating hosts is important. Two cultures which induce similar infection types on a set of differentials are classified as the same physiologic race and are often assumed to be the same pathogenically. The assumption that the two cultures have the same pathogenic characteristics is often wrong for obligate pathogens. Cultures originating in different areas in which different varieties or lines of the host are grown will probably differ in pathogenicity on those hosts. If the differentiating hosts have more than one resistance gene (and most hosts have more

than one resistance gene), then different resistance genes in those hosts could be responsible for the resistant infection types, and different avirulence genes would be expressed in the 2 cultures. The number of potential physiologic races of obligate pathogens such as *E. graminis hordei*, which have an effective sexual cycle plus other means of inducing pathogenic variation, is limited only by the number of differential hosts and the number of resistance genes in those hosts.

The relative virulence of two cultures depends on the resistance genes in the hosts being studied. Therefore, a culture could be virulent on only 5 hosts among several hundred; whereas a second culture could be virulent on most of the hosts, but avirulent on those 5 hosts. If only the 5 hosts on which the first culture was virulent were used as differentials, then the first culture would be classified as virulent and the second culture avirulent. Therefore, the differentiating hosts should be identified when cultures are classified for virulence.

I do not classify cultures by physiologic races or relative virulence. I have designated 2 types of cultures, the standard and the special. The standard cultures are those which have been used in many studies and have known genes for pathogenicity or specific virulence characteristics. The genes for pathogenicity may not be known in the special cultures, but they are obtained from plants in field nurseries in certain areas. These cultures are usually virulent on specific resistant hosts being used by plant breeders and other individuals in developing resistant cultivars.

Culture CR3 is an example of a standard culture. That culture has been used as the standard culture in many genetic studies (Ellingboe, 1978; Myer et al., 1979). The genes for pathogenicity in culture CR3 are known with respect to the set of 10 isogenic host lines which have specific resistance genes (Moseman, 1966). The culture is avirulent on most sources of resistance used for cultivar improvement in North America and has been used by many other scientists for studying interactions of *E. graminis hordei* and barley (Ellingboe, 1978; Myer et al., 1979).

Source of Pathogenic Cultures

Cultures with specific pathogenic characteristics can be obtained in 3 types of field nurseries. The nurseries are either mobile, observation or plant breeding.

Mobile nurseries have been used in Israel and other countries to survey the range in pathogenicity and to obtain cultures with new virulence potential (Eyal et al., 1973). In those nurseries, seedlings of the test hosts growing in flats are placed in fields where epidemics are occurring. The seedlings are removed after 24 to 48 hours and placed in a greenhouse or growing room to permit the development of the infections on the hosts. The seedling plants are exposed to several thousand spores while in the field. If one of those spores has a new gene for virulence on a previously resistant host, that spore may infect the seedling of that host, and a compatible or susceptible type pustule will develop. A culture with the new virulence gene is then obtained by transferring

spores from the susceptible type pustule.

Observation nurseries have been used by many individuals to obtain cultures with new virulence genes. Those nurseries are useful in areas where epidemics are sporadic or not very severe. Ellingboe and his colleagues (Ellingboe, personal communication) have used these nurseries in Michigan. He has obtained cultures with genes for virulence corresponding to most of the known resistance genes to E. graminis hordei and E. graminis tritici in barley and wheat, respectively. Each year for several years, varieties and selections of barley and wheat with the known resistance genes have been planted at several locations in Michigan. The plants in those nurseries are examined carefully several times during the growing season for susceptible or compatible type pustules. When a compatible pustule is observed, the spores from that pustule are transferred to a susceptible host plant to develop a culture with the new gene for virulence.

In plant breeding nurseries, the barley varieties and selections which have previously been resistant to pathogenic strains of E. graminis hordei in those nurseries should be observed. If a compatible or susceptible pustule develops on plants of those varieties and selections, spores from that pustule should be transferred to plants of a susceptible variety. By limiting the collections to only those from previously-resistant varieties or selections, the number of cultures tested is greatly reduced. The chances of obtaining cultures with new genes for virulence on the varieties now being grown and those being developed for growing in the future

is also greatly increased.

Selection of Pathogenic Cultures

The number and type of cultures used in a test depends on the objective and purpose of that test. For each test, the relationship of the resistance of the host varieties and selections and the virulence of the pathogen cultures must be considered. The following are examples of the type and number of cultures used in various studies.

Large collections of barley germplasm are available in which the accessions are being evaluated for their reactions to the pathogen E. graminis hordei. An example of such a collection is the Regional Disease and Insect Screening Nursery which is assembled and distributed annually by individuals at ICARDA. The accessions in that nursery are being tested to identify accessions with potential as germplasm for barley improvement programs in many countries. The purpose of the test is to identify accessions possessing one or more resistance genes which will be effective against the pathogenic strains of the pathogen in many countries. In those tests, a composite of cultures having most of the known virulence genes should be used to identify resistant accessions. Accessions resistant to all of the cultures in the composite must have one or more new resistance genes which do not correspond to any of the virulence genes in the cultures in the composite. Such accessions should be useful as new sources of resistance to the pathogen E. graminis hordei in breeding programs.

Accessions in plant breeding programs, in which the objective is to develop productive new cultivars resistant to

the pathogen *E. graminis hordei*, should be evaluated for their reaction to that pathogen. When possible, those accessions should be evaluated in the field with a composite of cultures which possess all of the pathogenicity in cultures occurring locally or in the region in which the new cultivar may be grown. If reliable tests are not obtained in the field, then the accessions can be evaluated in controlled conditions for their reactions to such a composite of cultures. As indicated previously, attempts should be made to isolate cultures of new pathogenic strains occurring in the area which are virulent on the resistant germplasm being used in the plant breeding programs. Those cultures should be included in the composite to identify those accessions with new resistance genes or combinations of genes which are effective against the new pathogen strains.

Standard cultures with specific pathogenic characteristics are required to study the genetic, physiologic and other aspects of the disease powder mildew of barley. The cultures used depend on the objective of the research. Culture CR3 has been used by many individuals in their research (Ellingboe, 1978; Myer et al., 1979). The genes conditioning the avirulence of culture CR3 correspond to the resistance genes in the 10 special isogenic lines and to other resistant sources. Individuals, although in different laboratories, have been able to cooperate and compare their results by using culture CR3 and the same host lines (Ellingboe, 1978; Myer et al., 1979).

Source of Resistant Hosts

I have discussed characteristics of the pathogen *E.*

graminis hordei, and how to obtain and use cultures of that pathogen with specific characteristics to identify resistant hosts. Many participants in this workshop are involved in developing productive cultivars which should be resistant to E. graminis hordei in your country or region. For such programs, cultures of the pathogen which occur in that country or region and hosts resistant to those pathogenic cultures are needed. The cultures of the pathogen needed are those which occur in your country or region. However, hosts which are resistant to those cultures can be obtained from other sources. The following is information regarding barley varieties and lines resistant to the pathogen E. graminis hordei.

Three H. spontaneum and 51 H. vulgare accessions in the barley collection at Gatersleben have been shown to be resistant to several pathogenic strains of the pathogen (Hirata, 1966).

Sigurbjörnsson (1976) identified eight varieties in which resistance to the pathogen was induced by a mutation.

Ten isogenic lines each with at least one distinct gene for resistance have been developed (Moseman, 1966).

Torp et al., (1978) have analyzed the genes for resistance to E. graminis hordei in 106 spring barley varieties grown in Northwest Europe.

References

- BLUMER, S., 1967. Echte Mehltaupilze (Erysiphaceae). G. Fischer Verlag., Jenga, 436 pp.
- BROOKS, D.H., 1970. Powdery Mildew of Barley and its Control. Outlook on Agriculture, 6:122-127.
- ELLINGBOE, ALBERT H., 1978. A Genetic Analysis of Host-Parasite Interactions. The Powdery Mildew (D. M. Spender ed) Academic Press, New York & London, 565 pp., pp. 159-181.
- ELLINGBOE, ALBERT H. Personal Communication.
- EYAL, Z., RUTH YURMAN, J.G. MOSEMAN and I. WAHL., 1973. Use of Mobile Nurseries in Pathogenicity Studies of *Erysiphe graminis hordei* on *Hordeum spontaneum*. Phytopath. 63:1330-1334.
- HIRATA, K., 1966. Host Range and Geographic Distribution of the Powdery Mildews. Niigata Univ., Japan.
- MEYER, HOST and CHRISTIAN O. LEHMENN., 1979. Resistenzeigenschaften in Gersten-und Weizensortiment Gatersleben. 22. Prufung von Sommergersten auf ihr Verhalten gegen zwei neue Rassen von Mehltau (*Erysiphe graminis* Dc. f. sp. *hordei* MARCHAL). C. Kulturpflanze XXVII, pp. 181-188.
- MOSEMAN, J.G., 1966. Genetics of Powdery Mildew. Ann. Rev. Phytopathol., 4:269-290.
- MOSEMAN, J.G., 1972. Isogenic Barley Lines for Reaction to *Erysiphe graminis* f. sp. *hordei*. Crop Sci., 12:681-682.
- SIGURBJORNSSON, B., 1976. Methods of Mutation Induction, Including Efficiency and Utilization of Induced Genetic Variability. In Barley Genetics III, Proc. Third Int. Barley Genet. Symp., Garching, 1975, pp. 84-95.
- SLOOTMAKER, L.A.J., 1974. Aims and Objectives in Breeding Cereal Varieties. Outlook on Agriculture, 8:133-140.
- TORP, J., JENSEN, H.P., JORGENSEN., J. HELMS. 1978. Powdery Mildew Resistance Genes in 106 Northwest European Spring Barley Varieties. in Royal Veterinary and Agricultural University Yearbook, 1978, pp. 75-102.
- YARWOOD, C.E., 1973. Pyrenomycetes: Erysiphales. in the Fungi (G.C. Ainsworth, F.K. Sparrow, H.S. Sussman, eds.) Vol. IV, Academic Press, New York and London, 621 pp., pp. 71-86.

POWDERY MILDEW OF BARLEY (ERYSIPHE GRAMINIS HORDEI) IN GREECE

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Barley diseases are a major limiting factor of the Greek crop. The diseases caused by *Helminthosporium* spp. were considered most important some years ago. However, more recently, the changes in cultural practice and the identification of barley growing coupled with the widespread use of susceptible cultivars has led to mildew becoming an increasing problem. It may even persuade growers to increase the hectarage of this crop (Table 1).

Factors Affecting Powdery Mildew Severity

The cultivation of barley in Greece has swung over almost entirely to fall sowing. Following mild winters, the first signs of infection of mildew (*Erysiphe graminis*) occur on seedlings at the 3 to 5-leaf stage by conidia blown from infected fields. Volunteer barley plants or grasses are opportune hosts and support the pathogen between summer and autumn-sown crops. Ascospores may also infect barley.

Mildew is widespread in Central and Northern Greece due to higher moisture than in the dryer southern barley-growing regions of the country. Dense stands, because of high-seed rates and heavy nitrogen fertilization, favor disease development.

High humidity during winter and beginning of spring favors the early development of the diseases. In most years, however,

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the hot, dry, windy weather that usually prevails during the boot stage is unfavorable for mildew development. In these years, the loss due to mildew is limited to early infection on the first 4-6 leaves of barley plants. This early seedling infection has a greater potential effect on yield than does infection on the flag leaf, as happens in northern European countries.

Resistant Varieties

The most economic control of mildew is through the use of resistant varieties. Much attention has been paid to mildew resistance in our breeding program. However, the varieties grown in Greece are not resistant to mildew (Table 2). More than 10,000 barley cultivars and lines, including the World Barley Collection, have been evaluated in the last three years. Among 1321 varieties tested in 1978 with heavy infection, only nine were highly resistant and out of these, two varieties were nearly immune (Table 3). Resistant varieties are defined as those having an average field disease score of 3 or less on a 0-9 scale.

There is a continuing need to evaluate alternative procedures of breeding for resistance to mildew because major genes are easily overcome by the pathogen and hence do not offer good protection. So far, mildew in Greece is a disease situation which requires an alternative approach to the use of major genes. Most cultivars show susceptibility to new races or shifts in pathogen virulence if grown continuously. A significant activity of the sexual stage is the production of new genetic combinations of factors for pathogenicity.

Fungicide Evaluation

Owing to the frequent and severe losses, there is a trend toward employing chemicals to combat the mildew organism on barley.

Since 1969, trials for controlling mildew by fungicides have been conducted at the Cereal Institute using the chemicals as seed dressing, dust on furrow or foliar spray.

Fungicide treatment of barley in Greece as a seed dressing or foliar spray against mildew gives yield increases up to 50% and improves grain quality. However, there are many factors affecting recommendations for control in each situation.

Mildew infection varies between seasons and varieties. The effectiveness of fungicides, and the yield response also varies. This may be due to cultivar susceptibility, response to chemicals, differences associated with crop structure, different weather conditions, the presence of other diseases and early or late disease incidence.

When mildew appears early in winter, control with ethirimol and benomyl as seed dressings was over 95% until the end of winter (Skorda, 1972 and 1975). In later assessments, control with both fungicides was less, although ethirimol seed dressing still gave better control than the other chemicals.

The control of mildew in early winter with seed dressing chemicals gives an improvement in crop color, growth and vigor compared with the untreated plots which remain yellow and stunted. This effect persists well into spring and in some years, also until harvest.

Foliar sprays with most products give satisfactory results when applied soon after the start of the epidemic, which normally occurs before stem extension.

The seed dressings tend to give better mildew control than the other treatments tested, but this is not consistently reflected in yield increases, particularly when late mildew infection occurs. Under these conditions, the most effective foliar sprays gave the best yield increase. However, when infection started in early winter, which is usual in Greece, the seed dressing and best sprays gave similar yield results (Table 4). Good results were obtained with benomyl as dust in furrow (Table 5).

Although the disease could not be fully controlled in some years, treatment with effective fungicides resulted in yield increases (Table 6).

In Greece, there are two main factors to consider: (1) early application as seed dressing, or (2) foliar spray treatment with a wide-spectrum of disease control. Where mildew appears with other diseases, the best yield results have been obtained with wide spectrum foliar chemicals which, in addition to controlling cereal powdery mildew, have a marked effect against other pathogens such as brown rust, Helminthosporium spp., etc. With wide-spectrum sprays, it is not possible to relate yield effect to individual disease levels and, consequently, the extent of mildew infection and yield loss is rather conflicting. However, using one chemical against mildew only, there was a very close correlation between the percentage loss in yield and amount of mildew recorded.

The results suggest that the new protectant and systemic fungicides so far tested in Greece can offer effective and economical means of control.

Under potential conditions, proper timing of protectant foliar fungicide applications will prevent rapid development and spread of mildew within local barley growing areas. Also, an application of fungicides as seed dressings or foliar sprays at the 3 to 5-leaf stage has a greater potential for controlling mildew and of preventing yield loss than the universally accepted recommendation of spraying to protect the flag leaf.

The use of effective chemicals against foliar diseases of barley could change cultural techniques, intensify cereal cropping and increase yields if the cost of chemicals is not too high. It represents a fast solution of the mildew problem if the resistance of grown varieties breaks down.

Table 1. Area of Barley Grown in Greece, 1974-80

<u>Year</u>	<u>Area (ha)</u>
1974	414,518
1975	404,681
1976	397,971
1977	393,250
1978	366,558
1979	373,301
1980	330,100

Table 2. Mildew Infection (Scale 0-9) on Cultivars Grown in Greece

<u>Variety</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>Mean</u>	<u>% Area</u>
Beka	8	4	4	5.3	42
Carina	6	5	5	5.3	10
Clipper	8	6	4	5.7	10
Rivale	7	6	3	5.3	14
Elassona	9	7	6	7.3	7
Attiki	7	8	5	6.6	3

Table 3. Frequency Distribution of Barley Cultivars of World Collections for Mildew Severity in Greece

	0	1	2	3	4	5	6	7	8	9	Total No. of Cultivars
1978	3	0	2	4	14	46	73	52	66	1031	1321
1979	15	5	18	64	84	142	192	247	210	76	1053
1980	188	10	71	271	317	125	15	3	0	0	1000

Table 4. Effects of Fungicide and Application Methods on Mildew and Yield of Clipper Barley Variety

Fungicide	Application Method	Rate g.a.i./ha	Mildew Infection (0-9)	Grain Yield % of Control
Untreated		0	4.0 d	100.0 (3080)
Ethirimol	seed dressing	750	1.3 a	112.0
Ethirimol	seed dressing	1500	1.3 a	107.0
Ethirimol	foliar spray	750	2.2 b	104.0
Ethirimol	foliar spray	1500	3.7 cd	107.0
Tridemorph	foliar spray	225	4.0 d	116.0
Tridemorph	foliar spray	450	3.5 cd	105.0
Tridemorph	foliar spray	450	3.3 c	89.0
LSD	5%			12.5
LSD	1%			16.6

Table 5. Effects of Fungicide and Application Methods on Mildew and Yield of the Kenice Barley Variety.

Fungicide	Application methods	Rate g a.i./ha	Mildew Infection (0-9)	Grain Yield % of control
Untreated		0	6.8 d	100.0 (3500)
Benomyl	Seed dressing	150	5.3 c	102
Benomyl	Seed dressing	300	5.0 bc	112
Benomyl	Furrow dust	250	1.4 a	119
Benomyl	Furrow dust	500	1.4 a	113
Benomyl	Foliar spray 1	125	4.6 bc	110
Benomyl	Foliar spray 2	250	4.3 b	108
Benomyl	Foliar spray 3	375	4.3 b	113
Benomyl	Foliar spray 1	250	4.3 b	115
Benomyl	Foliar spray 2	500	4.6 bc	
LSD	5%			8.5
LSD	1%			11.4

Table 6. Effects of Fungicide on Mildew and Grain Yield of G 88082-8 Barley Variety.

Treatment	Rate g a.i./ha	Mildew Infection(0-9)	Grain Yield	
			Kg/ha	% of control
Untreated		4.5 a	1460	100
Fenarimol	40	1.3 de	1795	123
Fenarimol	90	2.2 d	1673	115
Carbenda- zime + Mancozeb	180 1600	4.2 ab	2138	146
Triadimefon	125	1.2 e	1702	117
Triadimefon	150	1.2 e	1457	100
Pyracarbolid	800	3.7 ae	1848	127
Pyracarbolid BCM	1000	3.2 c	2097	144
Carbendazime + Pyrazophos	360 88	4.2 ab	1763	121
LSD	5%		373	
LSD	1%		498	

**BARLEY PROGRAM IN TUNISIA
FOR IMPROVING RESISTANCE TO POWDERY MILDEW**

A. Ghodbane, A. El-Ahmed, F. Laribi and H. Ketata*

Tunisia grows nearly 600,000 ha of barley, two-thirds of which is in southern Tunisia. Almost all the production consists of Martin (6 row) or Ceres (2 row). Because of the agro-climatic extremes and variables in the barley region, different varieties are needed for the south, central and northern areas.

Barley yield can be reduced by a range of diseases and pests. The principal ones are root and foot rot, *Helminthosporium* spp., BYDV, powdery mildew, wireworms and birds.

In the barley breeding program initiated in 1972, resistance to powdery mildew has been one of the objectives.

Powdery Mildew

In the northern cereal regions, the incidence varies from year to year according to the nature of the environmental conditions. In the 1979-80 crop season, it was serious in Motem, Le Kef and Tunis. In the semi-arid regions (center and south), it seldom occurs except in irrigated fields.

The heaviest infections usually occur during tillering, with recovery at the adult stage. Most of the cultivars tested in the northern area were susceptible at the tillering stage.

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Screening for resistance is carried out at the adult growth stage.

Varieties and lines showing resistance to powdery mildew are listed in Table 1, and those found to be highly susceptible are listed in Table 2.

Table 1: Varieties and Lines Resistant to Powdery Mildew (*Erysiphe graminis*) in 1977-78 and 1979-80, Regional Crossing Block (RCB).

A. 1977-78 RCB	
Entry No.	Variety/Cross or Pedigree
B 69	Alger/Union, 385-2-2
B 70	Composite Cross 89
B 74	Zypher/WI 2197
	Tc 73-44-OSK
B 75	Impala/Julia
	Tc 73-8-CSK
B 81	Arivat/Local D8 (Deiralla 106)

B. 1979-80 RCB	
Entry No.	Variety/Cross or Pedigree
24	Pro/Arivat CMB 72A-9-4L-2L-4AP
25	Aurore/Esperance, LB-2L-9L
93	Masurka
122	Alger/Ceres
131	Impala/Ceres
133	Arimar/2763, 6L-OSK
135	Impala/Magnif 102

Table 2. Powdery Mildew (*E. graminis*) Susceptible Lines in the 1979-80 RCB and Regional Disease and Insect Screening Nursery (RDISN).

A. 1979-80 RCB	
Entry No.	Variety/Cross or Pedigree
132	CM67/Sv. Mari CMB-72-140-8Y-1B-3Y-1B-OY
135	FB (E) NYT/72
B. 1979-80 RDISN	
Entry No.	Variety/Cross or Pedigree
156	Nopal x Apam-IB65 CMB-75-A-976-10S-4AP-OAP
211	Pro-109M x CM67-Gva CMB-75-50-1S-OAP
214	Nepal Barley x Apam-IB65
256	WI2173/2 x Apam-IB65 CMB-74A-95-1B-1Y-1B-1Y-OB
357	CM67-Apam CM-72-21-5Y-2B-5Y-1B-1Y-OB
491	Sv. Mari-CM67 CMB-72-140-4Y-1B-3Y-3B-OY
504	Calhoun ³
514	CM67-U. Sask 1800 x Pro/CM67
515	CM67-Bza CMB-72A-3Y-16B-1B-1Y-OB
568	291-3 Barley Germplasm, Izmar
569	297-1 Barley Germplasm, Izmar
589	CM67-U.Sask 1800 x Pro-CM67, 1AP-OAP

THE BARLEY LEAF RUST PATHOSYSTEM

J. E. Parlevliet*

Biology and Ecology of Leaf Rust

Leaf rust or brown rust of barley caused by Puccinia hordei, mainly affects the leaves, although stems and awns can be affected as well. In most areas where barley is grown, leaf rust occurs; often it causes some damage - sometimes the damage is severe (Kamel, 1981).

It is the repeating phase, the urediosorus, that occurs on the Hordeum species. After several cycles of urediospore formation on Hordeum, the fungus produces telia in the maturing leaf tissue. These telia remain with the plant debris on the surface of the soil. When the autumn rains have started, the teleutospores in the telia produce a promycelium in which meiosis occurs, followed by the production of basidiospores. The basidiospores infect leaves of Ornithogalum species, the alternate host, to produce pycnia. The monocaryotic pycniospores merge (+ and - forms must unite) into the dicaryotic phase, which produces aecidia. The aecidiospores have to infect barley again to complete the cycle.

When a urediospore germinates, the germination hypha grows until a stoma is found, over which an appressorium is formed. From this appressorium, an infection peg is brought into the substomatal cavity where a cigar-shaped vesicle is formed. From both ends of the vesicle, secondary hyphae are formed, which form haustoria in the host cells they contact.

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The leaf rust of cultivated barley seems to be restricted to this host and its wild progenitor, Hordeum spontaneum. This creates special problems for the pathogen to bridge the period when barley is not grown. Within the growing season of the crop, the rust population grows from an initial low level, x_0 , to sometimes damaging levels, the rate of increase being described by the apparent infection rate, r , (Van der Plank, 1968). The principal components that affect r are the infection frequency (IF), the proportion of uredospores resulting in sporulating lesions, the latent period (LP), measuring the time from infection to first spore production, and spore production (SP), the number of spores produced per uredosorus (Van der Plank, 1968; Parlevliet, 1979).

In the Mediterranean and Near East areas, spring barley is grown as a winter crop. The leaf rust bridges the host-less summer through the telia in the plant debris. In the autumn and early winter when the rains start, barley can become infected again through the alternate host, Ornithogalum. In the other barley-growing areas, the alternate host does not play a role. Here the pathogen has to survive the year around on barley. In temperate climates, the leaf rust cycles through winter barley, spring barley, volunteer barley plants to winter barley again (Parlevliet and Van Ommeren, 1976). In other areas, the leaf rust moves from areas where the barley is grown as a winter crop (plains of India) to areas where it is grown as a spring-summer crop (foothills of Himalayas, India).

Resistance of Barley to Leaf Rust

Resistance of barley to leaf rust can be distinguished

into two types, i.e., the hypersensitive or low-infection type resistance and the partial resistance.

Hypersensitive Resistance

The growth of the pathogen is reduced or even blocked, accompanied with host cell collapse. This host cell collapse is expressed as necrosis or chlorosis around the infection court. If there is only necrosis, the infection type (IT) is described with a fleck (0); when the necrosis or chlorosis goes together with some sporulation, the IT is a 1 or a 2. An IT of 3 represents a larger pustule surrounded by clear chlorosis, while a 4 describes the susceptible IT, a smaller or larger pustule without any chlorosis or necrosis.

Partial Resistance

Here, too, the growth of the pathogen is reduced or even blocked, but this is not accompanied with host cell collapse. As with hypersensitive resistance, the pustules may be smaller, but there is no essential reaction of the host tissue; the pustules, although smaller and fewer in number, are not surrounded by necrosis or extensive chlorosis. The IT is a susceptible one. Table 1 tries to describe this.

In both types of resistance, the interaction between host and pathogen, resulting in a reduced or even blocked growth of the pathogen, starts as soon as the secondary hyphae make contact with the host cells. In both types of resistance, the LP is increased, the SP decreased. Both types of resistance, therefore, may result in a reduced rate of epidemic development, i.e., in slow rusting (Farlevliet, 1979).

Hypersensitive resistance is genetically controlled by major genes of which nine are identified at present (Pa1 to Pa9). This resistance is typically of a race-specific nature and easily neutralized by the pathogen. None of the resistance genes are effective everywhere, but Pa3, Pa7, and Pa9 are effective in many areas. In the few cases where they have been used commercially, the resistance ~~did~~ not last long (Parlevliet, 1981).

The partial resistance is polygenically controlled (Parlevliet, 1978a) and more or less race-non-specific. Small race-specific effects do occur though (Parlevliet, 1978b), but the resistance seems durable. The partial resistance, due to a reduced IF, a longer LP and a reduced SP, is expressed by a lower rate of epidemic development (Table 2), but not all slow rusting is of this nature. Intermediate resistance (Table 1) of the hypersensitive type is slow rusting too, but contrary to the slow rusting caused by partial resistance, it is not durable.

The difference between the two types of resistance is not to be found in the slow rusting character. Vada, Varunda, Lofa Abed, Menuec, Miranda, Georgie, Julia, Armelle and several other cultivars show slow rusting of a durable nature based on partial resistance, while Triumph Simon and Nadja are slow rusters based on a hypersensitive reaction of the intermediate type. This slow rusting is race-specific and not durable. Triumph and Nadja lost this slow rusting character within four years in East Germany (Walther and Thiele, 1979). So partial resistance can only be discerned from the hypersensitive one by

looking at the infection type. If there is slow rusting, despite a susceptible infection type (little or no necrosis or chlorosis), then one deals with partial resistance.

The expression of partial resistance varies with the development stage; it is most pronounced at heading, being less so before and after heading; at the seedling stage the expression is least pronounced.

Selection for Resistance to Leaf Rust

Resistance of the hypersensitive type can be selected for with high efficiency and great reliability in the seedling stage. This is, in fact, often done with the stem rust (Sr genes), the leaf rust (Lr genes) and the yellow rust (Yr genes) of wheat. Although the selection is easy, the resistance obtained rarely lasts long.

Partial resistance, on the other hand, is often thought to be difficult to handle in a breeding program. For barley against leaf rust, this is certainly not true. It is neither difficult to select for, nor is it rare. On the contrary, absence of partial resistance is rare. Among 40 West European barley cultivars, one (Akka) was considered extremely susceptible, a few very susceptible, while about half the cultivars showed a considerable level of partial resistance (Parlevliet et al., 1980). In the same study, it was shown that selection for partial resistance could be done with a fair-to-good degree of efficiency at all stages of the plant breeding program, such as in the greenhouse in the seedling stage and in the field in the single plant and small plot

stages.

With the selection in the field, one should realize that with a pathogen-like leaf rust that is easily spread by wind, the rust levels found in the breeder's plots do not represent the levels experienced in the farmer's fields. In the latter, the rust epidemic develops depending on the partial resistance of the cultivar grown; while in the former, partially-resistant cultivars receive the greater part of their inoculum from susceptible cultivars on adjacent or nearby plots. In small adjacent plots, the differences in rust levels, and so in apparent partial resistance, are considerably smaller than in the true commercial situation. This is depicted in Table 2. The isolated plots represent the farmer's situation, the adjacent plots the breeder's plots. The difference between Vada and L94 on the one hand, and Vada and Julia on the other, was nearly 3000x in the former and only 17x in the latter. The ranking order of the cultivars, however, remained the same, enabling a good selection (Parlevliet and Van Ommeren, 1975).

The partial resistance of cultivars like Vada and Julia is sufficient for the conditions met in Western Europe, and as Habgood and Clifford (1981) stated, this resistance appears to be durable and easily transferred.

Summary

The cultivated barley is the predominant host of *P. hordei*. Other *Hordeum* species, although they can be infected, play no role of any significance in the epidemiology of this rust, except the wild barley *H. spontaneum*.

In some growing areas, except the Mediterranean areas.

Near Middle and Far East, the pathogen over-winters or over-summers in the uredial stage in the living host tissues.

In the Mediterranean area, the alternate host, *Ornithogalum* species, plays a role of importance. The teleutospores, after over-summering, germinate in the autumn to infect the leaves of *Ornithogalum* from where the wild and cultivated barley again become infected. Leaf rust occurs in most growing areas and can be damaging in several areas.

Two forms of resistance occur; (1) the hypersensitive type, characterized by major genes (Pa1 to Pa9 now known, of which Pa7 is the only one fully effective except in the Near-East), race-specificity and lack of durability, and (2) the partial resistance, characterized by a reduced amount of leaf rust despite a susceptible infection type. It is a polygenic, durable form of resistance. It occurs in many cultivars and can be brought to a level sufficient to prevent damage without much effort.

References

- HABGOOD, R.W. and CLIFFORD, B.C., 1981. Breeding Barley for Disease Resistance: The Essence of Compromise. In Strategies for the Control of Cereal Diseases, Ed. J.F. Jenkin and R.T. Plumb, Blackwell Scient. Publ., pp. 15-25.
- KAMEL, A.H., 1981 Barley Diseases in the Dry Areas. Proc. Workshop Barley Diseases and Associated Breeding Methodology, Rabat., April 1981.
- PARLEVLIET, J.E., 1978a. Further Evidence of Polygenic Inheritance of Partial Resistance in Barley to Leaf Rust, *Puccinia hordei*. *Euphytica*, 27:369-379.
- PARLEVLIET, J.E., 1978b. Race-specific Aspects of Polygenic Resistance of Barley to Leaf Rust, *Puccinia hordei*. *Netherlands Journal of Plant Pathology*, 84:121-126.
- PARLEVLIET, J.E., 1979. Components of Resistance That Reduce the Rate of Epidemic Development. *Ann. Rev. of Phytopathology*, 17:203-222.
- PARLEVLIET, J.E., 1981, Stabilizing Selection in Crop Pathosystems: An Empty Concept or a Reality? *Euphytica*, 30:(2), in press.
- PARLEVLIET, J.E., LINDHOUT, W.H., VAN OMMEREN, A. and KUIPER, H.J., 1980. Level of Partial Resistance to Leaf Rust, *Puccinia hordei*, in West European Barley and How to Select For It. *Euphytica*, 29:1-8.
- PARLEVLIET, J.E. and VAN OMMEREN, A., 1975. Partial Resistance of Barley to Leaf Rust, *Puccinia hordei*. II. Relationship Between Field Trials, Micro-plot Tests and Latent Period. *Euphytica*, 24:293-303.
- PARLEVLIET, J.E. and VAN OMMEREN, A., 1976. Overwintering of *Puccinia hordei* in the Netherlands. *Cereal Rusts Bull.*, 4(1):1-4.
- VAN DER PLANK, J.E., 1968. Disease Resistance in Plants. Academic Press., New York/London., 206 pp.
- WALTHER, U. and THIELE, M., 1979. Zur Rassensituation beim Zwergrost, *Puccinia hordei* Otth., in der DDR. Tag. Ber. Akad. Landwirtsch. Wiss. DDR. Berlin. 175:67-71.

Table 1. Infection Types in the Seedling and Adult Plant Stage of Barley Infected By *Puccinia hordei*.

Type of Resistance	Stage	
	Seedling	Adult
seedling resistance	0 - 1	0 - 1
Hypersensitive resistance:	intermediate resistance	2 - 3
	adult plant resistance	0 - 2
Partial resistance:	4	3 - 4

Table 2. Partial Resistance in Plots Isolated from One Another by Winter Wheat and in Small Adjacent Plots of Five Barley Cultivars to *Puccinia hordei*, its Components, Infection Frequency (IF), Latent Period (LP) and Spore Production (SP), Relative to the Most Susceptible Cultivar, and the Estimated Number of Polygenes Governing LP (Parlevliet, 1979).

Cultivar	No. of Sori per Tiller		Components			No. of Polygenes for LP
	Isolated Plots 3.0 x 4.0 m	Adj. Plots 0.25 x 1.0 m	IF at Heading	LP	SP	
L94	2800	1700	100	100	100	0
Sultan	750	750	65	130	80	3
Volla	115	440	70	130	110	3
Julia	17	270	65	160	50	5
Vada	1	100	40	190	50	6

LEAF RUST SITUATION IN EGYPT

Emal Ghobrial*

Leaf rust of barley, incited by Puccinia hordei (Otth.) occurs annually in Egypt, especially in the northern parts of the Delta Region where high humidity is favorable for its development, causing heavy losses in terms of quality. Infection decreases gradually towards the south where the geographical distribution of the causal organism in this area is apparently governed by prevailing temperature and humidity factors that control urediospore germination.

The following studies have been made on this disease:

1. Disease Survey

The distribution and severity of leaf rust are determined yearly by an extensive survey of growers' fields and governmental experiment stations throughout Egypt. The survey includes the Northern Coast (65,000 hectares grown under rainfall conditions) where the disease occurs to a level of 50% infection.

At Delta and Middle Regions, the disease is widespread, and the highest level of infection is recorded in the Kafr El-Sheikh, Behira and Alexandria governorates; it then decreases gradually towards the south where it is less-frequently distributed in the Southern Region (Table 1).

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2. Rust Race Spectrum

The race survey revealed the existence of 13 physiologic races during the period from 1967 through 1980. From 1967 to 1971, ten races (races 2, 8, 14, 21, 23, 30, 32, 43, 46 and 51) were found; race 2 was the most common and widely distributed, followed by races 21 and 14. However, during the six-year period (1972-77), only 5 races of those previously isolated were observed (races 2, 14, 21, 30 and 51). Recently (1978-80), 9 physiologic races were isolated; the races 2, 10, 21 and 23 were found during these three seasons, three races were identified in two seasons (race 51 in 1978 and 1979, and races 11 and 49 in 1979 and 1980), while races 14 and 30 were identified in 1978 only (Table 2).

3. Effect of Environmental Factors on Rust Infection

a. Studies on the effect of temperature on spore germination showed that the optimum temperature was found to be 22°C after three hours of incubation; followed by 25°C, and that the percentage of spore germination dropped below or above these degrees. When counting the total number of germinated spores after 24 hours, it was found that the highest percentage was at 16°C, followed by 22°C (Table 3). Moreover, the minimum and maximum temperatures were below 5°C and above 35°C, respectively.

b. Urediospores failed to germinate except when placed in free water. The spores placed at 90% relative humidity or lower became shrunken and darker in color, but those kept at 95-100% maintained their turgor and color.

c. It was found that pH 6.4 was optimal for spore

germination (maximum 7.1) and then sharply dropped (Table 4).

4. Longevity of Urediospores on Barley Leaves

The viability of leaf rust urediospores on barley leaves was studied by using the common and widespread physiologic race 2 of *P. hordei* for inoculating seedlings of the two susceptible varieties, Oderbrucker and Speciale, and transferred to moisture chambers after the lapse of different periods, then to an air-conditioned greenhouse. After two weeks, the developing pustules were counted. Results showed that the number of pustules per leaf gradually decreased as the time between inoculation and placement of the seedlings in the moisture chamber increased. After 6 days, the spores failed to germinate (Table 5).

5. Effect of Host Age on Rust Infection

Thirty-nine barley varieties were tested in the seedling stage under greenhouse conditions and in the adult stage in the field under artificial infection. Results indicated that host age appears to play an important role in barley resistance to leaf rust. The behavior of these cultivars showed the following two cases:

(1) Plant age has no effect on the varietal resistance or susceptibility, where 7 varieties were resistant and 15 were susceptible in both seedling and adult plant stages.

(2) Plant age has an important effect on the varietal resistance or susceptibility (Table 6), where 7 varieties showed increasing resistance with age (Nos. 1-7), 8 varieties showed a transition from susceptibility to resistance with age (Nos. 8-15) and two varieties showed increasing susceptibility with age

(Nos. 16-17).

6. Host Range of Puccinia hordei

Fourteen species (11 genera) of cereals and wild or cultivated grasses of Gramineae were tested for their relative susceptibility. Results indicated that P. hordei has a narrow host range in Egypt, where Avena fatua, A. sativa, Cynodon dactylon, Oryza sativa, Panicum colonum, Phragmites communis, Polypogon monspeliensis, Setaria viridis, Sorghum sudanense, S. vulgare and Zea mays were immune. Triticum compactum (variety Little Club) and T. durum (variety Daker 52) were highly resistant (showing necrosis), while Hordeum vulgare (variety Giza 117) was highly susceptible.

7. Chemical Control of Leaf Rust

Recently, it was estimated that annual losses from barley leaf rust in Egypt ranged from 10-15% of the yield, and that 20-30% of these losses could have been avoided by using specific fungicides, where reduction in rust and associated increase in yield were observed.

Trials for controlling the disease were conducted by using Saprol (0.2%), Indar (0.27%), Vigil (0.2%), Bayleton (0.2%), and Calixin M (0.2%). One or two applications were sprayed during the growing season; the first when rust appeared, and the second two weeks later.

Results showed that Saprol and Indar reduced rust infection from 65% in the untreated plots to 28.5% and 32.0%, respectively, at Sakha Experiment Station by using one application, resulting in an increase of 21.6% and 17.2%. At Bahtim Experiment Station, results were parallel with those obtained at

Sakha. Vigil and Bayleton gave approximately the same effect.

Although one spray with any of these fungicides was sufficient for controlling rust and for increasing yield, excellent disease control and higher yield response were recorded by using two sprays, compared with the findings obtained when one spray was applied (Table 7).

8. Resistance to Leaf Rust

The search for sources of rust resistance started in Egypt in 1962 to assist barley breeders in choosing suitable material for breeding programs, where the ultimate means for controlling this disease is through the use of resistant varieties. To breed cultivars exhibiting a high level of resistance to all or the most common physiologic races, even under adverse climatic conditions, various varietal collections (including more than 12,000 cultivars) of the commercial and promising varieties, introductions through USDA, FAO, CIMMYT, ICARDA, Ford Foundation and the Barley World Collection were tested for their behavior.

Varietal resistance to single races of *P. hordei* showed different reactions among 47 varieties to races 10, 23 and 49. Some of these cultivars were resistant to only one race, others showed good resistance to two or three races. These varieties could be arranged into three classes (Table 8), while the other varieties were susceptible:

Class I - Five varieties resistant to race 49 (Nos. 1-5).

Class II - Three cultivars showed resistant reaction to races 23 and 49 (Nos. 6-8).

Class III - Thirteen varieties showed resistance to the three races (Nos. 9-21).

It is evident from studying the varietal resistance at different locations representing different climatic conditions, where severe infection with rust is usually reliable that only 110 cultivars maintained a highly-resistant reaction and could be used in breeding programs for developing new resistant varieties (Table 9).

References

- ABDEL-HAK, T. and GHOBRIAL, E., 1968. Sources of Resistance to Leaf Rust, Puccinia hordei Otth. in UAR. Min. Agric. Tech. Bull. No. 17.
- ABDEL-HAK, T. and GHOBRIAL E., 1977. Barley Disease Situation in the Near East with Special Reference to Sources of Resistance. in Proceedings of the Fourth Regional Winter Cereal Workshop Barley, Vol. 11, pp. 311-319.
- ABDEL-HAK, T., GHOBRIAL, E. and SABET, T., 1975. Physiological Races of Puccinia hordei Otth., the Causal Organism of Leaf Rust of Barley. in ARE. Agric. Res. Rev., 53:2:1-7.
- GHOBRIAL, E., 1977. Multiple-disease Resistance of Barley Varieties with Special Reference to Methods and Terms For Assessing These Diseases Under Egyptian Conditions. The 1st Arab Biologists Congress, Alexandria, October 26-30.
- GHOBRIAL, E., 1979. Relative resistance to Barley Diseases Under Egyptian Conditions. Barley Newsletter, 22:119-121.
- GHOBRIAL, E., 1979. Varietal Multiple-resistance to Barley Diseases Under Egyptian Conditions. The First Cong. of Agricultural Research Center, Giza, May 22-29.
- GHOBRIAL, E., 1981. Effect of Environmental Factors on Leaf Rust Infection. (in press).
- GHOBRIAL, E., HAMMOUDA, A.M., ABDEL-KALIK, R. and MOSTAFA, E.E., 1976. Chemical Control of Leaf Rust of Barley. in Proceedings of the 2nd Phytopathology Conference, pp. 805-813.
- GHOBRIAL, E., MORSI, L.R. and SABET, T., 1976. Sources of Resistance to Leaf Rust of Barley, Puccinia hordei Otth. in ARE. In Proceedings of the 2nd Phytopathology Conference, pp. 671-682.
- GHOBRIAL, E., EL-SHEHEDI, A.A. and MASARAT EL-GHAMRY., 1981. Effect of Host Age on Leaf Rust Reaction, (in press).

Table 1. Distribution of Leaf Rust Throughout Egypt.

Governorate	Infection %	Severity %	Governorate	Infection %	Severity %
Delta Region			Menoufia	35	15
Alexandria	50	30	Kalubia	40	20
Behira	55	30	<u>Middle Region</u>		
Damietta	35	20	Giza	30	20
Kafr El-Sheikh	55	40	Fayoum	20	10
Sharkia	25	20	Beni-Suef	20	10
Dakahlia	25	20	Minia	15	10
Ismailia	25	15	<u>Southern Region</u>		
Gharbia	20	15	Assiout	10	3

Table 2. Frequency Distribution of Physiologic Races of *Puccinia hordei* During 1967-1980.

Physiologic races	Frequency distribution of specific physiologic races				
	1967-71	1972-77	1978	1979	1980
2	23.63	38.10	30.30	25.66	12.26
8	7.41	-	-	-	-
10	-	-	4.55	7.08	7.10
11	-	-	-	12.39	10.32
14	14.82	19.05	13.64	-	-
21	22.23	28.57	21.21	12.39	7.74
23	3.70	-	13.64	21.24	42.58
30	7.41	9.52	9.09	-	-
32	3.70	-	-	-	-
43	3.70	-	-	-	-
46	3.70	-	-	-	-
49	-	-	-	14.16	20.00
51	3.70	4.76	7.57	7.08	-

Table 3. Effect of Temperature on Urediospore Germination.

Temperature °C	% Spore germination	
	After 3 Hrs.	After 24 Hrs.
5	10.0	18.0
10	17.0	60.0
16	20.0	90.0
22	60.0	72.0
25	45.0	55.0
30	25.0	24.0
35	8.0	8.0

Table 4. Effect of pH Value on Urediospore Germination.

%Spore germination		pH		%Spore germination	
pH	After 3 hrs	After 24 hrs	pH	After 3 hrs	After 24 hrs
4.4	3.5	3.5	7.1	63.0	66.0
5.7	13.0	16.0	8.0	1.5	1.5
6.4	65.5	68.0	9.0	0.0	0.0
Sterile distilled water		72.0	77.0		

Table 5. Longevity of urediospores on affected barley leaves.

Time before transference to moisture chambers (Days)	Average number of pustules/leaf	
	Oderbrucker	Speciale
0	85	53
1	30	24
2	16	20
3	7	10
4	3	6
5	1	2
6	0	0
7	0	0

Table 6. Effect of Plant Age on the Varietal Resistance.

No.	Variety	CI No.	Source	Reaction to Seedlings	Leaf Rust* Adults
1	-----	4974	Morocco	MR	R
2	Cebada Capa	6193	N.Africa	MR	R
3	Forrajera PM.58 DIV. 2383	8158	Argentina	MR	R
4	Forrajera de Invierno	8159	Argentina	MR	R
5	DIV.6472.58-12313	11532	Argentina	MR	R
6	Hybernum Hor.728	11577	Germany	MR	R
7	Forrajera Klein x Reke 7	11801	England	MR	R
8	Weider	1021	Australia	S	R
9	Club Mariout	2334	Egypt	S	R
10	Bahtim 52	3240	Egypt	S	R
11	Estate	3410	Egypt	S	R
12	-----	3624	Egypt	S	R
13	Aim	3737	Egypt	S	R
14	Husky	9537	Canada	S	R
15	San Carlos DIV 5000	11533	Argentina	S	R
16	Odessa	2228	USSR	MS	S
17	Bonus	11308	Sweden	MS	S

*R = Resistant

MR = Moderately resistant

MS = Moderately susceptible

S = Susceptible

Table 7. Efficiency of Different Fungicides in Controlling Leaf Rust and Yield Response.

Treatment		Sakha		
		Av. % leaf rust	Av. % leaf rust control	% yield increase over control
Saprol	1 spray	30.0	53.8	21.6
"	2 sprays	26.0	60.0	24.4
Indar	1 spray	35.0	46.1	17.2
"	2 sprays	31.0	52.3	20.0
Vigil	1 spray	37.5	42.3	15.0
"	2 sprays	32.5	50.0	18.4
Bayleton	1 spray	40.0	38.5	9.0
"	2 sprays	34.0	46.9	13.0
Calixin M	1 spray	48.5	26.1	6.0
"	2 sprays	45.0	30.8	9.7
Untreated		65.0	-	-
L.S.D. at 5%		3.7		

Treatment		Bahtim		
		Av. % leaf rust	Av. % leaf rust control	% yield increase over control
Saprol	1 spray	27.5	50.0	23.1
"	2 sprays	22.5	59.1	26.8
Indar	1 spray	32.5	40.1	20.0
"	2 sprays	27.5	50.0	23.3
Vigil	1 spray	31.0	43.6	16.7
"	2 sprays	26.0	52.7	20.0
Bayleton	1 spray	35.0	36.4	10.0
"	2 sprays	30.0	45.4	13.3
Calixin M	1 spray	40.0	27.3	6.7
"	2 sprays	35.0	36.4	
Untreated		55.0	-	
L.S.D. at 5%		4.1		

Table 8. Reaction of Barley Cultivars to Individual Races of *P. hordei*.

No.	Designation	CI No.	Source	Reaction to		
				Race 10	Race 23	Race 49
1	Brutus	1011	Peru	3	4	0
2	Cape	557	S.Africa	4	4	0
3	----	4249-2	China	4	4	0
4	Hanna	226	Czech.	4	3+	2
5	Golden Pheasant	2488	Scotland	4	4	2
6	Callas	2440	N.Africa	3	1	0
7	Libia	2484	N.Africa	3	1	1
8	Peruvian	2441	N.Africa	3	2	0
9	----	4975	Africa	0	0	1
10	Recardo	6306	Uruguay	1	1	1+
11	Ariana	2524	Tunisia	1	1	2
12	H-2211	12202	Germany	1+	1+	1
13	La Estanzuela 75 x Reka 1	11800	England	1+	2	0
14	H-2212	12203	Germany	2	1	1
15	H-2210	12201	Germany	2	1+	1
16	Hybernum Hor. 728	11577	Germany	2	1	2
17	Forrajera Klein x Reka7	11801	England	2	2	1
18	Forrajera de Invierno	8159	Argentina	2	2	1
19	Forrajera P.I. DIV. 2383	8158	"	2	2	2
20	DIV.6472, 58-12313	11532	"	2	2	2
21	Cebada Capa	6193	N.Africa	2	2	1

Table 9. Barley Varieties Showing Good Resistance to Leaf Rust.

Variety	CI No.	Source	Variety	CI No.	Source
Hannchen	531	Sweden	Weider	1021	Australia
Peru	653	Peru	Quinn	1024	"
Chile Brewing	657	N.Africa	Chevron	1111	Switzerland
Hail's Hanna	685	Germany	Algerian	1179	Algeria
Monte Cristo	1017	India	Bolivia	1257	N.Africa
Oderbrucker	1272	USA	C.C.sel. from CI 4116	5334	Pl. Sel.
Osiris	1622	Kandara	Long Glume	6168	USDA
Manchuria	2330	China	Cebada Capa	6193	N.Africa
Modia	2483	N.Africa	Psaknon	6305	Australia
Ariana	2524	Tunis	Ricardo	6306	Uruguay
Gordon	2674	Canada	Lechtaler	6488	Portugal
Batna	3391	Algeria	Sudan	6489	"
Main Wali	3400	India	Pallidum 043	6518	USSR
Multan	3401	India		6683	"
Estate	3410	Egypt		6713	Egypt
Palmella Blue	3609	"	Heitpas 5	7124	USA WI
Aim	37378	"	Balder	7131	Sweden
Vagabond	3933	India	Valentine	7242	Wisconsin
	4220-1	Ethiopia	Anoidium	7269	Argentina
Delta	4251	Egypt	Argands	7479	Spain
	4292	Transcaucasia		7836	Turkey
	4293	"		7863	"
	4294	"		7864	"
	4298	"		7870	"
	4299	"		7890	"
	4299--2	"		7893	"
	4303	"		7895	"
	4307	"		7897	"
	4309	"		7929	"
	4310	"	Forrajera		
	4311		PM.58 DIV.2383	8158	Argentina
	4974	Morocco	Forrajera de		
	4976		Invierno	8159	Argentina
	5051	Austral.	Marocaine 021	8330	France
Marocaine 071	8334	France	Commander	8338	"
	8559	Turkey	Composite		
			Cross	138	
	8612	"	"	169	
	8768	"	"	205	
	8769	"	"	235	
	8801	German	"	240	
Sangatsu Nadaka					
No. 1	8931	Japan	"	243	
Traill	9538	USA(ND)	"	251	
Larker	10648	USA	"	268	
DIV.6472, 58-12313	11532	Argentina	"	279	
San Carlos DIV. 5000	11533	"	"	612	

Table 9. (Continued)

Variety	CI No.	Source	Variety	CI No.	Source
Anoidium x Rabat					
a-4805-9-8r	11540	Canada	CI 6709 X CI 6695 F6		Egypt
Hybernum	11579	Germany	Local Marsa Matrouh		"
La Estanzuela	11800	England	Cambrinus		Sweden
75 x Reka 1					
Forrajera Klein					
x Reka 7	11801	England	Weihenstephan		"
			C.P. 127422		
Perolina	11805	"	Herta		Rotterdam
Vada	11808	"	Vola		"
Sakiz 66	12056		Union		England
Rabat x Manchuria					
(Gaines I)	12253	Florida	Semsky		Czech.
Composite Cross	10		Athenais		Cyprus
"	"		Composite Cross	11	
	136				

LEAF RUST OF BARLEY

E. L. Sharp*

Isolates of *Puccinia hordei* which causes leaf rust of barley were collected from several locations in the Mediterranean area and in Montana, U.S.A., and evaluated on the standard differential host cultivars plus a number of barley cultivars reported as being resistant to leaf rust (Table 1 and 2). Of the known Pa genes for resistance, Pa₃ and Pa₇ were resistant to all isolates. Several cultivars with unknown resistance genes were also resistant to all isolates (Table 3). The resistance gene Pa₉ was effective against all but two virulence groups of *P. hordei*. One of these virulence groups originated from the alternate host, *Ornithogalum* spp.

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Table 1. Reaction of Differential Varieties to Several Isolates of Puccinia hordei.

Differential Varieties	Isolates*							
	1	2	3	4	5	6	7	8
Sudan Pa	-	+	+	+	-	+	+	-
Peruvian Pa ₂	-	+	+	+	-	+	+	-
Batna Pa ₂ +	+	+	+	-	-	-	-	+
Reka Pa ₂ +	-	-	-	+	+	-	+	-
Ricardo Pa ₂ +	-	+	+	+	-	+	-	+
Quinn Pa ₂ + Pa ₅	-	+	-	+	-	+	-	+
Bolivia Pa ₂ + Pa ₆ +		+	-	+	+	+	+	-
Estate Pa ₃	+	+	+	+	+	+	+	+
Gold Pa ₄	-	-	-	-	-	-	-	-
Cebada Capa Pa ₇	+	+	+	+	+	+	+	+
Egypt Pa ₈	-	-	+	-	-	-	-	-
CI 1243 Pa ₉	+	+	+	+	+	-	+	+

+ = Resistant
- = Susceptible

Isolates*

1 = Creston

2 = San Antonio

3 = Merchouch

4 = Fretissa

5 = Sakha

6 = Tel Aviv

7 = Homs

8 = Izmir

Table 2. Resistance Spectrum of Several Barley Varieties to *Puccinia hordei*.

Isolates resistant against	Isolates*											
	1	2	3	4	5	6	7	8	9	10	11	12
7/12 Sudan	x		x		x	x	x		x			x
Peruvian	x				x	x	x		x	x		x
Ricardo	x				x	x	x		x	x		x
Modjo		x		x	x	x			x			x
San Carlos		x	x	x	x			x				x
CI 4974		x			x	x	x	x		x		x
8/12 Batna	x	x	x	x	x	x				x		x
CI 11577	x	x			x	x	x		x	x		x
Weider	x	x			x	x	x			x	x	x
9/12 Bolivia	x	x	x	x		x	x	x	x			x
10/12 CI 1243	x	x	x	x	x	x	x	x		x		x
11/12 Ford 1203	x	x		x	x	x	x	x	x	x	x	x

*1 = San Antonio 2 = Creston 3 = Sidney 4 = Rabat
 5 = Merchouch 6 = Marrakech 7 = Fretissa 8 = Sakha
 9 = Tel Aviv 10 = Tel hadya 11 = Homs 12 = Izmir

x = resistance

Table 3. Barley Varieties Resistant to all Isolates Tested.

Variety	Pa-Gene
Aim	Pa3
Estate	Pa3
Cebada Capa	Pa7
La Estanzuela	Pa7
CI 11801	Pa7
Forrajera Klein x Reka	Pa7
CCIM-13	?
Cr 386-16-2	?

STRIPE RUST OF BARLEY

R. W. Stubbs*

Stripe (yellow) rust is caused by *Puccinia striiformis*. Regarding the world distributiton of this rust, it was absent in Australia until 1977. It is present in China and Japan, and it also occurs in India where it survives in the Himalayas and moves down to the foothills every year. It is also important in Pakistan and Nepal.

Research has been carried out at Wageningen by a Nepalese scientist to determine whether the biotypes found in Bangladesh, Nepal, India and Pakistan differ from each other, and whether the virulence has changed in the last six years. These investigations showed no difference in the yellow rust in those countries and no change in virulence either. Therefore, it can be said that virulence has been stabilized in the region embracing those countries.

Although stripe rust occurs in Iran, Iraq and Turkey, it is not ranked as the most important disease. The question arises as to whether it is because of its life cycle, or the resistance of the barley varieties being grown that there are no serious epidemics.

It is present in East Africa, but it is not very important in Kenya nor Ethiopia. It never develops into any serious epidemics, and this same situation also applies in North Africa.

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Our analysis of infected barley samples in Tunisia has shown that the spores came from a race prevalent in Western Europe. The same race has also been found in Southern France on barley, so presumably it had moved from the north to the south and ended up in North Africa.

In South America, a very virulent race was introduced into Columbia in 1975. This race is identical to the one that is present in Western Europe. From Columbia, it moved down through Ecuador, Peru, Bolivia and now into Chile. It has caused a 100% yield loss--the heads are completely shrivelled. It will not be long before it enters Argentina and Brazil.

In Europe, we experienced a serious epidemic in 1961. It was caused by a race which possessed this virulence and against which barley varieties did not have any resistance. There is now a downward curve in the survival of this race in Western Europe because of the lack of winter barley.

In Europe, a lot of research, especially on the identification of resistance genes, is being conducted in East Germany. There it has been found that there are three genes effective against races 23 and 24. In my own virulence survey work, I have found that these three genes are still effective throughout the whole world.

ICARDA has requested me to undertake a virulence survey for its region, and recently I received an excellent collection of material from that Center to examine for virulence. I was surprised to find some sources of resistance, especially in the barley cultivar called Belfort which has shown a complete immunity to cultures from different parts of the world. We are

now investigating the reason for this immunity. We have covered the whole leaf surface with spores, but the cultivar has still given an immune reaction.

Dr. Stubbs concluded his presentation by showing and describing color slides.

BARLEY YELLOW DWARF VIRUS AND APHIDS**T. W. Carroll***

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 species 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.

According to Rochow, BYDV is actually a group of related viruses. The viruses 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

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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-non-specific, 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. For the sake of simplicity of discussion, BYDV will be referred to as a single virus.

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 provide 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-non-specific 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 RPV 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 10-20°C 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 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 26 nm in diameter.

Control

The most effective control measure is to use barleys tolerant to BYDV. These barleys contain the Yd₂ gene or allele. The source of Yd₂, and the genetic background into which it is placed seem to determine the level of tolerance conditioned by the gene. The Yd₂ 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 the effect of BYDV on six cultivars of barley grown in Montana, in comparison with 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 XXXIII-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 population 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 Pirolina was the most susceptible barley, and it suffered a yield loss of over 90% (Table 1). By comparison, Hector only had a yield reduction of about 48% (Table 1).

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.

References

- A'BROOK, J. and DEWAR, A.M., 1980. Barley Yellow Dwarf Virus Infectivity of Alate Aphid Vectors in West Wales. *Ann. Appl. Biol.*, 96:51-58.
- BOULTON, R.E. and CATHERALL, P.L., 1980. The Effect of Increasing Dosage of Barley Yellow Dwarf Virus on some Resistant and Susceptible Barleys. *Ann. Appl. Biol.*, 94:69-75.
- BRUEHL, G.W. and DAMSTEEGT, V.D., 1964. Degree of Resistance to Barley Yellow Dwarf in Selected Ethiopian Barleys. *Plant Dis. Rep.*, 48:470.
- CATHERALL, P.L. and HAYES, J.D., 1966. Assessment of Varietal Reaction and Breeding for Resistance to the Yellow Dwarf Virus in Barley. *Euphytica*, 15:39-51.
- CATHERALL, P.L., JONES, A.T. and HAYES, J.D., 1970. Inheritance and Effectiveness of Genes in Barley that Condition Tolerance to Barley Yellow Dwarf Virus. *Ann. Appl. Biol.*, 65:153-161.
- DAMSTEEGT, V.D. and BRUEHL, G.W., 1964. Inheritance of Resistance in Barley to Barley Yellow Dwarf. *Phytopathology*, 54:219-224.
- JONES, A.T. and CATHERALL, P.L., 1970. The Relationship Between Growth Rate and the Expression of Tolerance to Barley Yellow Dwarf Virus in Barley. *Ann. Appl. Biol.*, 65:137-145.
- JONES, A.T. and CATHERALL, P.L., 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.
- LISTER, R.M. and ROCHOW, W.F., 1979. Detection of Barley Yellow Dwarf Virus by Enzyme-linked Immunosorbent Assay. *Phytopathology*, 69:649-654.
- PALIWAL, Y.C., 1977. Rapid Diagnosis of Barley Yellow Dwarf Virus in Plants Using Serologically Specific Electron Microscopy. *Phytopath. Z.*, 89:25-36.
- 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., QUALSET, C.O., and RUTGER, J.N., 1964. Inheritance and Linkage of the Yd² Gene Conditioning Resistance to the Barley Yellow Dwarf Virus Disease in Barley. *Crop Sci.*, 4:544-548.
- SCHALLER, C.W., RASMUSSEN, D.C. and QUALSET, C.O., 1963. Sources of Resistance to the Yellow-dwarf Virus in Barley. *Crop Sci.*, 3:342-344.
- THOMPSON, R.K. and CRANDOCK, J.C., 1979. Registration of Barley Composite Crosses XXXIII-A and B. *Crop Sci.*, 19:931-932.
- YOUNT, D.J. and CARROLL, T.W., 1980. Identification of Three Distinct Barley Yellow Dwarf Virus Strains in Montana by Aphid Transmission and Enzyme Immunosorbent Assay. (Abst.) *Phytopathology*, 71:267.

Table 1. Effect of Barley Yellow Dwarf Virus (BYDV)¹ on Barley Growth and Yield. Percentage Reduction of Plant Characters Due to Virus Infection in Comparison with Noninfected² Controls.

Spring barley cultivar	Plant Height	Tillers/Plant	Seeds/Head	Yield/15 Plants	1000 Kernel Wt.
1. Pirolina	26.1%	16.7%	21.7%	90.7%	61.9%
2. Klages	26.1%	14.3%	13.6%	84.9%	55.5%
3. Compana	19.7%	14.3%	26.3%	69.1%	38.6%
4. Unitan	20.5%	0.0%	21.4%	51.2%	21.4%
5. Steptoe	19.2%	0.0%	18.8%	48.8%	27.9%
6. Hector	11.8%	14.3%	9.5%	47.6%	26.7%
7. Sutter	8.9%	+20.0%	0.0%	+32.9%	7.7%

¹ The PAV isolate, or variant of barley yellow dwarf virus, was inoculated into barley seedlings in 3-5 leaves by infective aphids of the species *Rhopalosiphum padi*.

² Controls were uninoculated.

BARLEY YELLOW DWARF VIRUS IN THE U.S.A.**C.W. Schaller***

Annual losses from Barley Yellow Dwarf Virus (BYDV) have been reported from various areas of the U.S.A. and Canada since it was first described in 1951. Losses to the California barley crop, resulting from the first recorded outbreak of the disease in 1951, were estimated at 10 percent. Subsequent studies have placed the annual loss in the neighborhood of 15 percent, and it is now regarded as the most serious barley disease in California. Resistant cultivars (Yd₂ gene) are now available for production throughout California.

The disease rose to national prominence in the United States in 1959 when its economic impact on oat production was equated to the losses from Victoria blight and crown rust in the years when those diseases were the most serious. Numerous research activities and breeding programs were initiated in the early 1960's. Research in the areas of epidemiology, vector transmission, strain identification, etc. received attention in many laboratories. Interest in BYDV appeared to decline in the late 60's and early 70's, except for basic studies on the virus and vector-strain interactions. However, screening programs for resistance in oats and barley were continued in Illinois and California, respectively.

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Renewed interest in BYDV occurred in the late 70's. Participants at the BYDV Workshop held in Urbana, Illinois, in June 1977 estimated annual losses of one to three percent of the total wheat, barley and oat production in the U.S.A. and Canada, with losses of 20 to 30 percent in some areas. Dr. Gill reported the occurrence of three major epidemics in Canada in 1964, 1969 and 1974. Losses were heavy in each of those years. Dr. Jedlinski reported that farmers in Illinois stopped growing winter barley because of BYDV. Similar experiences were reported for Virginia and other states.

The importance of this disease was again stressed by the cereal virologists at a meeting in Dallas, Texas, in 1979. They rated it as the most serious virus disease of cereals in the U.S.A. Barley researchers attending the Barley Workshop at Saskatoon in 1978 expressed concern regarding the apparent increase in prevalence of BYD and suggested the establishment of a central testing site where materials could be screened for resistance. These examples are indicative of the importance given to BYDV by the small grain workers in the United States.

Thus far, only one major gene conditioning resistance or tolerance to BYDV in barley has been identified. The YD₂ gene, found to be present in a number of Ethiopian entries in the USDA world collection, has been used in breeding programs throughout the world with good success. However, a sufficient number of reversals have been reported to suggest that resistance may be conditioned by a series of alleles at this

locus. Drs. Schooler and Franckowiak, North Dakota State University, Fargo, recently announced the release of two barley selections possessing tolerance to BYDV. ND 497 was derived from the inter-generic cross *Hordeum vulgare* L. (4x)/*Elymus mollis* Trn. (4x) and ND 586 from the inter-specific cross *H. brachyantherum* L./*H. bogdanii* Wilensky//*H. vulgare* (4x). Neither selections were as resistant as lines having the Yd₂ gene. An attempt is underway at Davis, California, to transfer the Yd₂ gene from barley to wheat.

XANTHOMONAS LEAF STREAK OF BARLEY**David C. Sands, Hee Kyu Kim, Valerie Hall***

Bacterial leaf streak is a disease caused by Xanthomonas translucens. It is found wherever barley is grown. The seedling stage of this disease is an important phase, but is inconspicuous.

Symptoms

They consist of greasy, water-soaked streaks on the primary leaf, and a key diagnostic feature is the presence of bacterial slime on the surface of the leaf. Obvious symptoms are observed at the boot stage and later. The lesions on the leaf begin as small, water-soaked areas which enlarge to yellowish or brownish, somewhat translucent blotches or irregular stripes. Similar lesions may appear later on the glumes giving a symptom referred to as black chaff.

Etiology

Bacterial blight of barley is a widespread disease especially in high-moisture areas and under sprinkler irrigation. The primary lesions may appear on seedling plants very early in their development and secondary lesions when the plants are 8 to 10 inches high. It attacks not only the barleys of all three main groups, i.e., 2-row, common 6-row and erect 6-row (Jones et al., 1917), but also other cereals,

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usually wheat and sometimes oat and rye (Hagborg, 1942) (Table 1). The organism is a monotrichous rod, yellow in culture, and it can invade the plant through natural openings such as stomata. Seed transmission is the main source of dissemination, but it can also over-winter in temperate climates in the straw from infected plants.

History

In 1912, bacterial leaf blotch was observed for the first time. In 1917, Jones et al., described this organism causing bacterial blight of barley as Bacterium translucens. The hosts of this organism were Hordeum distichum group (2-row barley), H. vulgare group (common 6-row barley) and Hordeum hexastichum group (erect 6-row barley). Two years later, Smith, Jones and Reddy described a variety B. translucens var undulosum, which was like the original species except that it was capable of attacking wheat, barley and rye. In 1924, Reddy, Godkin and Johnson described a second variety, B. translucens var secalis, which was essentially like the other two except that it was virulent only on rye (Table 1).

In 1939, Dowson transferred the original species to his newly-created genus Xanthomonas as X. translucens (J.J. and R.) Dowson. Hagborg (1942) amended this species to include five closely-related forma speciales which are distinguishable chiefly by differences in virulence on wheat, oats, barley and rye.

Identification

Xanthomonas translucens belongs to the *Xanthomonas campestris* group and can be identified by a battery of relatively simple tests including the Gram stain, the positive hypersensitivity test on tobacco, the negative oxidase test and the test for virulence. A pathologist working in a poorly equipped laboratory can perform these tests on any orange-pigmented isolates. Most will be xanthomonads.

Isolation

Samples from the field should be soaked in sterile water for 2-4 hours in order for the bacteria to ooze out into the water, then take out a loopful of water suspension and streak on Wilbrink's medium (Dowson, 1957). Its contents per liter of water are sucrose (10 g), Bacto-peptone (5 g), K_2HPO_4 (0.5 g), $MgSO_4 \cdot 7H_2O$ (0.25 g), $NaSO_3 \cdot 7H_2O$ (0.1 g), Bacto-agar (15 g) and cycloheximide (100 mg). This medium serves as a very good nutrient source, and typical yellow colonies will appear in 2-3 days at 28°C. However, this medium has no selectivity for *Xanthomonas translucens*. The other media that have been developed as selective media, i.e., D-5 (Kado et al.), SX agar, are not suitable for isolating this organism. Research on a selective medium is currently underway in our laboratory with promising results.

Inoculation

To prepare inoculum, 3-day-old fresh culture from Wilbrink's medium should be used to make bacterial cell suspensions and adjusted to give 10-50 Klett units (10^7 to 5×10^7 CFU/ml), or OD 0.04-0.08 at 640 nm in any spectrophotometer. If such equipment is not available, a slightly turbid suspension will suffice. Infect the bacterial suspensions by sterile hypodermic syringe at the base of the 3-4-week-old seedling and observe symptoms about 2 weeks later. For hypersensitivity, inject the same suspension into a tobacco leaf, and the necrotic reaction will occur overnight. For field inoculation, the plot can be mowed with a lawn mower and immediately sprayed with a heavy suspension of cells. Symptoms appear in 10-14 days.

Marking Strains with Antibiotic Resistance

Strains of bacteria resistant to antibiotics were used in a field experiment in which the spread of the pathogen was monitored. These were obtained as spontaneous mutants using the following steps.

Bacteria were spread on a plate of Wilbrink's agar, and an antibiotic assay disc containing a low level (10-15 ppm) of erythromycin or rifampicin was placed in the center. The plates were incubated at 27° for 2 days. The colonies of the bacteria which were growing closely to the antibiotic-soaked disc were re-isolated and spread on another plate. A disc which was treated with a higher level of antibiotic than was

previously used was then placed onto this plate. The same procedure was repeated until colonies of *X. campestris* pv *translucens* had been isolated which were resistant to erythromycin or rifampicin at a level of 200 ppm.

Spread of Pathogen

As seed treatments are not 100% effective, it was important to know how far the bacteria could spread from a single locus. A plot 15m x 30m was inoculated in 2 small areas, 15 cm each, with a suspension of the "marked" pathogen resistant to erythromycin or rifampicin at a level of 200 ppm. Inoculation was carried out when the plants were at the three-leaf stage, and symptoms began to show ten days later. The plot was observed periodically, and leaf samples were taken of any new symptoms of the pathogen, and the location from where the sample was taken was mapped. Each sample was soaked in 1 ml of sterile water and then streaked onto 2 plates: one of Wilbrink's agar and one of Wilbrink's agar + 200 ppm erythromycin or 200 ppm rifampicin. Using this method, it was possible to distinguish between the inoculated strain and any naturally-occurring xanthomonads. The disease spread in the directions of prevailing wind and driven rain, and from the single-infection locus, it covered 30.5 square meters (Table 2).

Survival of X. Campestris Pathovar Translucens

Survival of X. campestris pv translucens from one season to the next is accomplished in several ways with seed transmission of the disease being the most important. Although the actual rate of transmission is low (<2% of 95% infected seed lot), it is sufficient to cause a severe outbreak of the disease if the weather conditions are favorable during the growing season. Our recent work indicates that X. campestris pv translucens may over-winter on range grasses. The bacterium was isolated from several grasses common in Montana. In host range tests, many of the isolates were found capable of causing disease symptoms on barley, wheat and sometimes oats and/or rye in addition to the original grass host.

It is possible that this disease over-winters on straw and chaff left in the field, although this was not found to be the case in Montana. Heavily-infested straw was added to test plots during the fall of the year and left to over-winter. These plots were seeded the following spring and failed to show any significant increase in the rate of infection over plots which were not amended with straw. In addition, several nylon mesh bags of infested straw were buried in September and failed to yield the pathogen when recovered in May of the following year.

Seed Treatment

No seed treatment for control of X. translucens was found to be 100% effective (Table 3) however, there were several

which reduced the level of seedling infection on rates considerably (eight-fold decrease). The most effective seed treatments proved to be antibiotics and copper hydroxides. A routinely-used fungicide consistently aggravated the situation as seedlings from seed treated with the fungicide showed a far greater incidence of the pathogen than untreated seeds. Since no seed treatment was found to be completely effective, and due to the fact that the pathogen can spread a considerable distance from one infection locus, it was calculated that the break-even point for seed treatment is a 1% infestation of the seed lot. (Seed lots used in our research ranged from 0-95% infestation, and transmission occurred in about 2% of infested seeds). Seed with a rate lower than 1% infestation can be found usually from a dry-land field. We have concluded that this disease cannot be controlled by currently available seed treatments alone.

Resistance

No potential sources of resistance have been found yet. In 1977, a recurrent selection population was developed at Montana State University. Last year after 2 complete cycles of recombination, a low level of field resistance was observed. A few F_2 lines taken from this population appear to have some tolerance, indicating that these plants were not escapes, but contained some resistance.

References

- DOWSON, W.J., 1939. On the Systemic Position and Generic Names of the Gram Negative Bacterial Plant Pathogens. Zentralblatt fur Bakt. II. Abt. Bd. 100., No. 9/13:176-193.
- DOWSON, W.J., 1957. Plant Diseases Due to Bacteria. Cambridge, England, University Press, 2nd edition, p. 48.
- HACBORG, W.A.F., 1942. Classification Revision in Xanthomonas translucens. Can. J. Res., 20:C:312-326.
- JONES, L.R., JOHNSON, A.G., and REDDY, C.S., 1917. Bacterial Blight of Barley. J. Ag. Res., 11:12:625-643.
- KING, E.O., WARD, M.K., and RANEY, D.E., 1954. Two Simple Media for the Demonstration of Pyocyanin and Fluorescin. J. Lab. Clin. Med., 44:301-307.
- SANDS, D.C., SCROTH, M.N., and HILDEBRAND, D.C., 1980. Genus Pseudomonas: Laboratory Guide for Identification of Plant Pathogenic Bacteria. Bacteriological Committee of Phytopathological Society, St. Paul, Minnesota.

Table 1. Known Special Forms of Xanthomonas campestris
Pathovar translucens.

	Barley	Wheat	Oat	Rye
<u>F. sp hordei</u>	+	-	-	-
<u>F. sp undulosa</u>	+	+	-	+
<u>F. sp secalis</u>	-	-	-	+
<u>F. sp hordei-avenae</u>	+	-	+	-
<u>F. sp cerealis</u>	+	+	+	+

From Hagborg (1942)

*Indicates that the organism has been isolated from host.

Table 2. Spread of Xanthomonas from a Single Infection Locus.

Post-inoculation Day Number	Total Area Showing Symptoms (m ²)
10	
12	2.35
15	3.93
16	5.58
22	6.18
36	11.86
39	30.50

Table 3. Seed Treatments and Control of X. Translucens

Treatment (per 100 g seed)	% Seed Transmission	% Germination of Check
Pfizer 4//30 mg 50% oxytetracycline	.50	79.10
Pfizer 5//10 mg 50% streptomycin	.50	80.85
Pfizer 4//30 mg+ Pfizer 5//10 mg	.75	85.00
Juglone 3.0 ml of 300 ppm solution	1.00	89.98
Kocide SD+ .5 g+ Juglone 3.0 ml	2.25	84.20
Vitavax	6.00	94.57
Check	4.00	100.00

SYMPTOMS AND ETIOLOGY OF BACTERIAL LEAF BLIGHT OF BARLEY**Hee Kyu Kim, Valerie N. Hall and David C Sands***

The causal agent of bacterial leaf blight, *Pseudomonas syringae*, is a cool-moist weather pathogen. It can grow as an epiphyte on the surface of leaves through most of the growing season with few or any visible symptoms. In moisture, especially in cool rain lasting two or three days without dryness, it flourishes with an increase in bacteria to as high as 10^5 /sq. cm. In subsequent dryness, its numbers can decline even more rapidly. The symptoms appear suddenly, usually after a two or three day rainy period with cool nights followed by a dry day. The symptoms range from small, white streaks and flecks on the flag leaves and awns to severe and confluent water-soaking and bleaching of most leaves of the mature plant. Isolations of bacteria during this period of symptom development reveal high counts of these bacteria in water-soaked leaves. As the leaves dry and bleached necrosis appears, the bacteria are difficult to isolate. For this reason, the symptoms are often attributed to physiological disfunctions or at best, a hypersensitive reaction caused by epiphytic bacteria.

Isolation

These bacteria will grow well on almost any standard bacteriological medium. We have found that medium B of King et al. (1954) is used most often because the bacteria produce a

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tell-tale yellow-white fluorescent pigment when grown on it as viewed with long wave length ultraviolet light. Almost no other bacteria, especially contaminants, produce such fluorescent pigments.

The first five components of BCBRVB medium constitute the non-selective Medium B of King et al. (1954). The additional components render this medium its high selectivity. Either medium can be used for detection of the fluorescent pigment (Table 1).

This selective medium enables us to detect and isolate these bacteria even when they are greatly outnumbered. We have found them in aphids, on weeds, on barley seeds, on smut and rust spores, and in rainfall. Our methods for tissue isolation include direct plating of tissue onto the selective medium and suspending the tissue in a few drops of sterile water, subsequently streaked onto the medium after one and four hours. Grinding the tissue immediately kills the bacteria.

Pseudomonas: Taxonomic Problems in the Genus

Probably the most common bacteria to attack plants are the leaf-spotting pseudomonads. These bacteria, distinct as a group because they are slow growing as compared with all other fluorescent pseudomonads, can be found on most crops in the temperate regions of the world. This group of fluorescent bacteria is called the syringae group because *Pseudomonas syringae* was the first accurately-described species. The syringae group consists of more than 40 nomen-species including *Pseudomonas pisi*, *Ps. phaseolicola* and *Ps. tabaci*, named largely on the basis of host range. These pea, bean and

tobacco "species" have been temporarily demoted to the rank of pathovar, i.e., Pseudomonas syringae pathovar pisi, Ps. syringae pathovar phaseolicola and Ps. syringae pathovar tabaci, until enough distinct characteristics are discovered to render them a specific rank again. To insure success in bacterial identification, some known isolates with known reactions should be included, and secondly, isolates should be sent to another laboratory for confirmation analysis. Regardless of their taxonomic disarray, these bacteria are an interesting group of bacteria including some strains capable of attacking only a few varieties of one crop plant. How these very closely-related bacteria can attack one plant and not another will baffle biochemists and physiologists for years to come.

Identification

Pseudomonas syringae can be identified by the tests in Table 2 where it is compared with Pseudomonas fluorescens, a saprophyte.

Inoculation

Any fluorescent pseudomonad from the syringae group will cause some kind of symptom including a hypersensitive reaction if enough bacteria are infected into a barley leaf. The key criterion of pathogenicity appears to be in the relatively-low numbers of bacteria involved, with the most virulent strains capable of multiplying in the leaf to high numbers. Inoculum can be prepared from a fresh culture, suspended in water and adjusted to 10^4 , 10^5 and 10^6 cells per ml by use of turbidity

readings set to a standard curve (set previously by dilution plating). Either pressure inoculation or needle infection will achieve water-soaking and reproducible results. Critical to success is the use of growth chambers or mist chambers capable of sustaining cool, moist conditions for two days (ca 16°C in 99% humidity), after which the plants are placed in a greenhouse with temperatures below 30°C. The hypersensitive reaction occurs in 2-3 days, whereas the susceptible plant will show symptoms of water-soaking or necrosis in 7-14 days. We note that a high percentage (30% or more) of isolates taken from tissue fail to infect when inoculated by these methods. As strains are kept in culture, they tend to lose virulence.

Resistance

Few tolerant or resistant barley plants have been observed in years of severe epidemics of Pseudomonas syringae. At this time, the less said about resistance the better. Recurrent selection populations are being used in search for a combination of genes showing some resistance, but few plants have escaped this pathogen. These bacteria, as evidenced by our numerical taxonomic work, display a great diversity of physiological types, presenting a difficult problem for a breeder.

Control

The best control procedures for these bacteria is avoidance of frequent sprinkler irrigation and avoidance of the most susceptible varieties. Seed treatment with Kocide SD, a copper hydroxide formulation, at 4 oz./100 lbs. seed (1 g per

400 g seed) will prevent seed transmission in greenhouse tests. Nonetheless, fields planted with such treated seed still develop the disease. Yield losses in winter wheat have been estimated to be in the range of 15% in severe years.

References

- DOWSON, W.J., 1939. On the Systemic Position and Generic Names of the Gram Negative Bacterial Plant Pathogens. Zentralblatt fur Bakt. II. Abt. Bd. 100., No 9/13:176-193.
- DOWSON, W.J., 1957. Plant Diseases Due to Bacteria. Cambridge, England, University Press, 2nd edition, p 48.
- HAGBORG, W.A.F., 1942. Classification Revision in Xanthomonas translucens. Can. J. Res., 20:C:312-326.
- JONES, L.R., JOHNSON, A.G., and REDDY, C.S., 1917. Bacterial Blight of Barley. J. Ag. Res., 11:12:625-643.
- KING, E.O., WARD, M.K., and RANEY, D.E., 1954. Two Simple Media for the Demonstration of Pyocyanin and Fluorescin. J. Lab. Clin. Med., 44:301-307.
- SANDS, D.C., SCROTH, M.N., and HILDEBRAND, D.C., 1980. Genus Pseudomonas: Laboratory Guide for Identification of Plant Pathogenic Bacteria. Bacteriological Committee of Phytopathological Society, St. Paul, Minnesota, USA.

Table 1. BCBRVB Medium (Sands et al., 1980).

Protease Peptone	20.0 g
Glycerol	17.0 ml
$K_2HPO_4 \cdot 3H_2O$	2.5 g
$MgSO_4 \cdot 7H_2O$	6.0 g
Nobel Agar	12.0 g
Distilled Water	12.0 g

Autoclave at 15 lb. for 15 minutes. Cool to 45°C, then add a mixture of the following antibiotics in 70% ethanol:

Bacitracin	10.0 mg
Vancomycin	6.0 mg
Rifampicin	0.5 mg
Cyclheximide	75.0 mg
Benomyl	250.0 mg

Table 2. Key Diagnostic Test Reaction of Fluorescent Pseudomonads.

Test	Reaction Pathogen <i>Pseudomonas syringae</i>	Saprophyte <i>P. fluorescens</i>
Growth rate on King B medium	2 days	1 day
Maximum temp. of growth	29-30° C	37° C
*Hypersensitive reaction on tobacco	yes-except pv <i>tabaci</i>	no
*Oxidase test	no or very slow	yes, rapid
Toxins produced on PDA against <i>Geotrichum</i>	yes (over 50% of strains)	no-few
Ice nucleation	50% of strains	few or none
Growth on B-alanine as carbon source	no	yes
Arginine dihydrolase	no	yes

*Diagnostic tests most commonly used.

The exact methods used and many more are reported by Sands et al. (1980).

REVIEW OF SMUT DISEASES OF BARLEY - ABSTRACT**M. Besri***

Smut diseases occur all over the world, and their importance varies from one country to another. In Morocco, some research is being conducted on wheat smut; however, a research effort is required on barley smuts. The relative importance of the different barley smut species and their impact on yield should be investigated.

Smut diseases of barley are more important to farmers than any other barley disease because the reduction in yields is direct, and the quality of the remaining yield is reduced due to the presence of the black heads.

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REVIEW OF SMUT DISEASES IN JORDAN*

Omar F. Mamluk**

In Jordan, 70.5% of the total cultivated area is planted to field crops. The area planted to barley fluctuates around 450,000 dunums and makes up 12.8% of the total cultivated area (Anon., 1980a).

Barley is planted in three physiographic regions of the country. The first region is the Jordan Valley (Ghor Areas) which is of no significance for barley production in Jordan. The main region is the Easter Rainfed Upland; next in importance are the Desert Areas in El Mafraq, Ramtha, Wadi-Dlail, Sail el Zarka and Hasa (Table 1).

Smuts and Smut Disease Survey

The three smut diseases on barley found in Jordan are covered smut, *Ustilago hordei* (Pers.) Lagerth., loose smut, *U. nuda* (Jens.) Rostr., and semi-loose smut (black smut), *U. nigra* Tapke. (Table 2).

These diseases are among the major barley diseases in Jordan (Vestal, 1954; Qasem, 1970; Shaw et al., 1979; Mamluk et al., 1981). To quantify the prevalence of smuts and other diseases of field crops, a field survey was conducted in 1979. This was mainly carried out to estimate the crop losses due to the attack of several economically-important diseases.

*Portion of a study: "Survey of Plant Diseases in Jordan" supported in part through a research grant from the University of Jordan and conducted by Omar F. Mamluk, Associate Professor, University of Jordan (1976-February 1981).

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The survey was carried out at different stages of the growth period, i.e., from March 19 - June 26, 1979. A total of 47 barley fields from the different growing areas were inspected for disease incidence (Table 1).

Disease incidence was recorded as percentages of infected ears in the field. The sampling unit was 100 ears checked in each field. The ears checked were from 10 different spots selected at random on two diagonals of the field. Smut diseases were diagnosed in the field, and some samples were brought into the laboratory to investigate spore morphology.

To estimate crop losses resulting from the attack of covered, loose and/or black smut, the formula "incidence x 1" was used since these diseases cause total infection of the ears (Anon., 1971; Mamluk et al., 1980). Thus, losses are equated to the percentage of disease incidence.

The survey year was, unfortunately, a drought year with low rainfall all over the country (Table 1).

Out of the 18 barley fields checked in the Jordan Valley, 11 were attacked by covered smut, 2 by loose smut and none by black smut. The incidence of covered smut varied between 1% and 38%, with the highest incidence in the location of Muaddi. The incidence of loose smut was high (8%, 17%) in two locations of Muaddi. Crop losses due to both diseases in this region varied between 1% and 38%.

In the Eastern Rainfed Upland, covered smut attacked more frequently than in the Jordan Valley; 19 out of the 21 fields checked exhibited covered smut. In addition, one field showed attack by loose smut and six by black smut. The incidence of

covered smut varied between 1% and 16%, whereas the incidence of black smut was only 1% to 2% in the different locations. Crop losses in this region can be equated to the percentages of incidence of each disease.

Eight fields checked in the Desert Areas were free from any smut disease.

The number of fields checked during this survey was determined by the size of cultivated area of barley. However, the presentation of the fields checked in the Desert Areas has not been properly justified because of the low precipitation in 1979 and needs further investigation.

In the different barley-growing areas, the frequency of fields showing attack by covered smut was higher than the attack by the other smut disease. The incidence of covered smut was also high in most cases.

The frequency and incidence of loose smut may not reflect the true situation of this disease. The survey was carried out in a relatively-late stage, and the disease could have been overlooked and underestimated.

The three smut diseases in Jordan cause total infection and crop losses which can be equated to the percentages of incidences. Accordingly, crop losses due to all these smut diseases can be as high as 38%, 17% and 2%, respectively, for covered, loose and black smut in the different fields.

Covered smut and black smut are soil-borne as well as seed-borne pathogens. Their chlamydospores survive in the surface of the soil and can be transmitted on seed surface. The loose smut causes embryo-infection and can be transmitted

within the seed. Chemical treatment of seeds with non-mercuric, systemic compounds is very effective against these three smuts and can reduce the losses to a large extent.

Acknowledgement

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References

- ANON., 1971. Crop Loss Assessment Method, FAO & CAB, Alden and Mowbrary.
- ANON., 1980a. Agriculture Statistical Year Book. Dept. of Statistics (1976-1979), Amman.
- ANON., 1980b. Climatological Data. Ann. Rept., Meteorological Dept., Amman.
- MAMLUK, O.F., QASEM, S., and SKARIA, M., 1980. The Distribution and Prevalence of Fungal and Bacterial Diseases on Vegetables in Jordan. Dirasat, 7:59-92.
- MAMLUK, O.F., ABU-GHARBIH, W.I., and SHAW, C.G., 1981. Checklist of Plant Diseases in Jordan (in preparation).
- QASEM, S., 1970. Occurrence and Distribution of Plant Diseases in Jordan. Res. Bull. No. 1. Jordan Scientific Res. Council, Amman.
- SHAW, C.G., KHALIF, H. and ABU-BLAN, H., 1979. Parasitic Fungi found in Jordan. Res. Repr. Fac. of Agric., University of Jordan, 24 pp.
- VESTAL, E.F., 1954. Some Plant Disease Problems in Jordan. Pl. Dis. Repr., 38:226-237.

Table 1. Area of Barley Cultivation (dunums), Number of Fields Checked and Annual Precipitation in Jordan.

	Ghor Areas	Eastern Rainfed Upland	Desert Areas	Total
Dunums	20,460	229,818	216,062	466,340
	4.4%	49.3%	46.3%	100%
Number of fields checked	18	21	8	47
	<u>Precipitation (mm)</u>			
Long term (1923-63)	120-180	325-450	200-225	
(1979)	93	250-310	104	

Source: Anonymous, 1980a. Agricultural Statistical Year Book, Dept. of Statistics, (1976-1979), Amman.

Anonymous, 1980b. Climatological Data, Ann. Rept., Meteorological Dept., Amman.

Table 2. Area, location and prevalence of covered smut (*Ustilago hordei*), loose smut (*U. nuda*) and semi-loose smut (*U. nigra*) on barley in Jordan (1979).

Area and Location	Row Type	Growth Stage	Month of Survey	Incidence %		
Ghor Areas:		10.5-11.4	III-V	Cov. smut	Loose smut	Semi-loose smut
Waggas				8	-	-
Kreiymeh				10	-	-
Mashare				5	-	-
Abu Ubeida	6			24	-	-
Muaddi	2			38	-	-
Muaddi				4	8	-
Muaddi				6	17	-
Ghor Kabed				5	-	-
Ghor Kabed				1	-	-
El Karama				15	-	-
El Karama				1	-	-
Number of fields checked		18				
Number of fields attacked				11	2	0
Eastern Rainfed Upland:		11.1-11.4	IV-VI			
Um Qais	2			11	-	2
Irbid	6			1	-	-
T. El Ali	6			7	-	-
T. El Ali	6			9	-	1
Swalleh	6			11	-	-
Hisban	6			1	2	-
Hisban	6			6	-	-
Jadudeh	2			16	-	1
Jadudeh	2			4	-	1
Qaser	2			8	-	-
W. Mujeb	2			4	-	-
El Karak	2			3	-	2
El Mazar	2			1	-	1
Tafile	2			7	-	-
Tafile	2			6	-	-
Tafile	2			3	-	-
Tafile	2			6	-	-
Shoubak	2			6	-	-
Shoubak	2			2	-	-
Number of fields checked		21				
Number of fields attacked				19	1	6
Desert Areas:						
Number of fields checked		8				
Number of fields attacked				0	0	0

ROOT ROTS OF BARLEY

D. E. Mathre*

Root rots of barley are a complex of diseases that have long been known from many regions of the world. They are called different names, but the two most common are "dryland or common root rot" and the "Take-All" disease.

Dryland-Common Root Rot

Cochliobolus sativus (Helminthosporium sativum), Fusarium culmorum and Fusarium graminearum are the fungi usually associated with dryland-common root rot. In most regions, C. sativus appears to be the most prevalent of the three pathogens. Losses in the Canadian provinces have been estimated to range from 10-20% annually (Piening et al. 1976). Losses are greater when the plants are under drought or moisture stress.

Losses have been estimated in several ways. The Canadian studies (Piening et al., 1976) were based on random samples taken from numerous fields. The individual plants were scored for root rot severity and then the grain harvested from each separate plant. This yield was then compared to the yield from plants in the same field showing no root rot symptoms. In Montana, Grey (1981) utilized the Canadian system and compared the results with those obtained from tests where yields were compared between plots fumigated with methyl bromide (to kill

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all soil-borne organisms) and unfumigated plots. He also inoculated plots with the various root rot organisms and compared the yield of inoculated vs. uninoculated plots. In the latter tests, yield reduction from *C. sativus* varied from 19% with cultivar Piroline to as high as 61% for the very susceptible cultivar Gateway. In the fumigation tests in grower fields in Montana, fumigation increased yields by 23-30% averaged across six cultivars. Using the Canadian survey method, Grey (1981) observed losses from 8-10% in Montana.

The main effect on yield components of root-rot-infected plants is a reduction in tillering, i.e., fewer heads per unit area. Seed size and seed number do not seem to be seriously affected (Uoti, 1976; Whittle and Richardson, 1978; and Grey, 1981).

For *C. sativus*, infection is primarily seen on the sub-crown internode. Under severe disease pressure, the fungus causes dark brown discoloration. In advanced stages of infection, the tissue will be almost completely decayed (Huang and Tinline, 1976).

Infection by either *Fusarium culmorum* or *F. graminearum* is often accompanied by a red-to-pink discoloration of infected tissue. Infection can occur from the seedling stage to mature plants. If seedlings are severely attacked, they may be killed; however, if the plants survive, they may be stunted and exhibit white heads.

Survival of *F. culmorum* appears to be primarily as chlamydospores in the soil, while *F. graminearum* probably survives as mycelium in infected plant residue. In the state

of Washington, *F. graminearum* occurs in the warmer, drier areas, while *F. culmorum* is more prevalent in the higher rainfall areas (Sitton and Cook, 1981).

Infection by the common root rot organisms is favored when small-grain cereals are grown continuously in one field (Chinn, 1976; Ledingham, 1961). Seeding into warm soil (above 20°C) also favors infection (Fenster et al., 1972), while crop rotation with non-susceptible crops will reduce inoculum levels. Long rotations of five or more years out of cereals are necessary to obtain significant disease reduction (Ledingham, 1961). Soil nutrient status does not greatly affect disease severity, except that recent studies indicate that use of fertilizers containing the chloride ion (e.g., KCl) do tend to reduce disease severity (V. Haby, personal communication). Seed treatment with certain systemic fungicides, particularly those that inhibit ergosterol synthesis (e.g., imazilil, CGA-64251, triadimenol) can reduce common root rot severity (Chinn, 1978; Mathre, unpublished data). However, effects on yield are unknown at this time.

The control measure of choice would be the use of resistant cultivars. A number of workers, particularly those in Canada, have identified a number of sources of resistance to seedling blight caused by *C. sativus* (Clark, 1966; Cohen et al., 1969; Hamilton et al., 1960; Loiselle, 1965). In addition, Piening (1973) has studied the reaction of 10 barley cultivars under field conditions, and found that some cultivars were more productive than others under conditions of fairly

severe root rot. The lines listed as resistant to seedling blight include CI 1343, CI 2355, CI 2550, CI 5435, CI 6617, CI 7269, CI 7622, CI 8969, CI 10241 and CI 11542. In wheat, there seems to be little correlation between seedling resistance and mature plant resistance. Whether this is true for barley is unclear.

Little work seems to have been done on locating sources of resistance in barley to the two Fusarium species.

A variety of screening techniques has been used to search for resistance to root rot. For seedling reactions, use of a sand-cornmeal inoculum appears to work well (Cohen et al., 1969). In Montana, Grey (1981) studied a variety of screening techniques under field conditions. Oat kernels infested with C. sativus sown with the seed appears to work better than soaking the seed in conidial suspensions. For F. culmorum and F. graminearum, soaking seed in suspensions of macroconidia for 2 hours followed by a 1-7 day drying period prior to sowing allowed severe disease development to occur (Grey, 1981; Uoti, 1976). Oat kernel inoculum of these Fusarium species failed to induce enough disease to allow screening of cultivars or segregating populations.

Take-All

Take-All is caused by Gaeumannomyces graminis (Ophiobolus graminis). It is a disease of wet soils and, therefore, is rarely found in areas where common-dry-land root rot is a problem. The pathogen survives from one growing season to the next as mycelium in plant residue. Seedlings become infected

via their roots growing in the vicinity of infected residue. The initial symptoms are light-to-dark brown lesions on the roots. As infected plants reach the boot stage, most of the roots may be dead. Plants not killed by this time may produce heads that turn white prematurely. Any seed produced is usually shrivelled. Plants showing symptoms can be easily pulled from the soil since their roots are highly decayed. A black, scurfy mycelium, which can be scraped off, is often observed near the base of the culms. Take-All is most severe where soils are alkaline and remain wet for long periods of time. Continuous cropping with members of the grass family also accentuates the damage from this disease.

No resistant cultivars are known. Long rotations (3-4 years or more) out of a grass crop will provide some control. However, a decline in severity is often observed if cereals are grown for long periods of time (e.g., 7-10 years). This decline is believed to be due to a build-up of antagonistic organisms when grass crops are planted continuously. Recent work indicates that species of the bacterium Pseudomonas or the fungus Phialophora radicicola are involved in this antagonism.

References

- CHINN, S.H.F., 1976. Cochliobolus sativus Conidia Populations in Soils Following Various Cereal Crops. *Phytopathology*, 66:1082-1084.
- CHINN, S.H.F., 1978. Influence of Seed Treatment With Imazilil on Common Root Rot and the Size of the Subcrown Internode of Wheat. *Phytopathology*, 68:1662-1666.
- CLARK, R.V., 1966. The Reaction of Barley Lines to Root Rot, Leaf Spot, and Head Blight. *Can. J. Pl. Sci.*, 46:603-609.
- COHEN, E., HELGASON, S.B., and MCDONALD, W.C., 1969. A Study of Factors Influencing the Genetics of Reaction of Barley to Root Rot Caused by Helminthosporium sativum. *Can.J. Bot.*, 47:429-443.
- COOK, R.J. and PAPENDICK, R.I., 1970. Soil Water Potential as a Factor in the Ecology of Fusarium roseum f sp cerealis 'Culmorum.' *Plant and Soil*, 32:131-145.
- COOK, R.J. and CHRISTEN, A.A., 1976. Growth of Cereal Root Rot Fungi as Affected by Temperature-Water Potential Interactions. *Phytopathology*, 66:193-197.
- FENSTER, C.R., BOOSALIS, M.G., and WEIHING, J.L., 1972. Date of Planting Studies of Winter Wheat and Winter Barley in Relation to Root and Crown Rot Grain Yields and Quality. *Univ. of Nebraska Res. Bull.* 250.
- GREY, W.E., 1981. The Effects of Common Root Rot on Yield Components of Spring Barley in Montana. M.Sc. Thesis. Montana State University, Bozeman, Montana, USA.
- HAMILTON, D.G., CLARK, R.V. HANNAH, A.E. and LOISELLE, R., 1960. Reaction of Barley Varieties and Selections to Root Rot and Seedling Blight Incited by Helminthosporium sativum. *Can. J. Pl. Sci.*, 40:713-720.
- HUANG, H.C. and TINLINE, R.D., 1976. Histology of Cochliobolus sativus Infection in Subcrown Internodes of Wheat and Barley. *Can.J. Bot.*, 54:1344-1345.
- LEDINGHAM, R.J., 1961. Crop Rotations and Common Root Rot in Wheat. *Can. J. Pl. Sci.*, 41:479-486.
- LOISELLE, R., 1965. Inheritance of Resistance to Root Rot and Seedling Blight of Barley Caused by Helminthosporium sativum. *Can. J. Pl. Sci.*, 45:238-242.

- PIENING, L.J., 1973. Differential Yield Response of Ten Barley Cultivars to Common Root Rot. *Can. J. Pl. Sci.*, 53:763-764.
- PIENING, L.J., et al., 1976. Barley Losses Due to Common Root Rot in the Prairie Provinces of Canada, 1970-72. *Can. Plant Dis. Surv.*, 56:41-45.
- SITTON, J.W. and COOK, R.J., 1981. Comparative Morphology and Survival of Chlamydospores of *Fusarium roseum* 'Culmorum' and 'Graminearum.' *Phytopathology*, 71:85-90.
- STACK, R.W., 1977. A Simple Selective Medium for Isolation of *Cochliobolus sativus* from Diseased Cereal Crowns and Roots. *Plant Dis. Rep.*, 61:521-522.
- NOTI, J., 1976. The Effect of Five *Fusarium* Species on the Growth and Development of Spring Wheat and Barley. *Ann. Ag. Fenniae*, 15:254-162.
- WHITTLE, A.M. and RICHARDSON, M.J., 1978. Yield Loss Caused by *Cochliobolus sativus* on Clermont Barley. *Phytopath. Z.*, 91:238-256.

THE REGIONAL DISEASE SURVEILLANCE PROGRAM
AND THE RUSTS OF BARLEY

J. M. Prescott*

The Regional Disease Trap Nursery (RDTN) program was initiated in the early 1970's, and it covers countries in the region that is bounded by Morocco in the west, Thailand in the east, Zambia in the south and The Netherlands in the north. Currently, the RDTN is grown in 187 locations in 52 countries. The nursery is comprised of bread wheat, durum wheat, barley and triticale, and it is divided into spring-habit and winter-habit sections. Each section is further divided into (1) principal commercial varieties which are grown within the area, (2) varieties/lines with known virulence characteristics and (3) potential new cultivar/varieties.

Initially, the RDTN was designed as a rust-monitoring nursery for bread wheat and durum wheat. However, over the past ten years, the number of barley entries has been increased from about one percent of the nursery to about 11 percent now. In the current nursery, there are 16 barley entries, and in the forthcoming nursery which will be set out in September 1981, there will be about 25 entries of barley. The nursery will have a total of approximately 200 entries. Currently, eight disease categories are being examined, namely leaf rust (barley), leaf rust (wheat), stripe/yellow rust, stem rust, powdery mildew,

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Septoria tritici, scald and the *Helminthosporium* leaf spot complex.

In the 1981-82 nursery, there are plans to add material for the detection of Barley Yellow Dwarf Virus (BYDV).

In addition to returning disease data, the cooperators are also requested to send in samples of diseases they might find, particularly rusts for laboratory/greenhouse virulence analysis. Assisting in this effort are Dr. R. W. Stubbs who does the yellow rust work for the region and Dr. T.M.A. Hak in Egypt who looks after stem rust. CIMMYT in Turkey makes the leaf rust analysis in Ankara. In the past, Dr. M. Bosbovic in Yugoslavia has looked after the leaf rust virulence analyses, but at present is unable to assist. Mr. M. Raemaekers in Zambia assists in identifying and doing limited virulence analyses for foliar diseases other than rusts. He is interested particularly in spot blotch which is a very severe disease in Zambia.

The objective of all this effort is to detect changes in the virulence at an early date so that there is an early warning available to the various national programs to make them aware of a potential epidemic and to make the necessary changes in the varieties grown.

This entire disease surveillance activity has been supported financially by the Dutch Government through its Ministry for Technical Foreign Assistance and by CIMMYT. There is a tremendous amount of data generated each year by this monitoring effort. It has become impossible to analyze the data by manual means. A computer-based program was developed

to handle the data. The program, which is partly funded by the Dutch Government, is called EPIDAT, i.e., a Data Base Management System for the Evaluation of International Cereal Disease Data.

The computer system is now loaded with seven years of data from the RDTN. Information from the South American disease surveillance program is being entered into the computer and is known as the ELAR program. The European Yellow Rust nursery data is also being entered. Data entry is being accomplished in Ankara by means of a dual-drive floppy disk unit.

Figures 1, 2 and 3 show data which are coming from a current analysis of the three rust diseases of barley, namely leaf rust, stem rust and stripe/yellow rust, respectively. These figures show the average coefficient of infection for each disease over five regions and seven years.

Figure 1 clearly shows that leaf rust of barley over the period 1974-1980 was very important in all regions except the Indian Sub-continent. The variation probably reflects more on the environmental conditions each year than any other factor since all commercial varieties are susceptible.

The case of stem rust of barley, Figure 2, is not as dynamic as with leaf rust. Stem rust is prevalent in all five regions but is consistent only in East Africa and Southern Europe. It can be quite severe in North Africa also, but seems to be much more erratic in its appearance than in other regions. When the average coefficient of infection is greater than 10.0, then damage and loss in production can be expected.

Stripe/yellow rust, Figure 3, does not appear to be much

of a problem in the Middle East and East African regions. However, in the other three regions, it appears to pose a real threat. In the Sub-continent area, this disease seems to cause damage every year.

During the development phase of EPIDAT, it became evident that although there was considerable data available, it was not being fully utilized. There was a need to have a better linking-up of the seedling/field (adult) responses and for a means of looking at specific genes or gene combinations in both host and pathogen. So within EPIDAT, large matrix analysis programs were developed following the gene-for-gene system of Person.

The following programs have been developed:

- DBMSLL - loading and listing of data;
- DBMS - correction of errors within the data base and retrieval of lists with users defined, varieties and locations;
- SCANDT - error screening of all data files;
- VARTST - error screening of variety conversion tables;
- PRIFIL - production of tables by lineprinter;
- DIFFER - assigns the minimum number of differential varieties which will recognise the maximum number of races or biotypes present;
- NODE - conversion of mathematical test on the minimality of the result of DIFFER;
- GENEALOGY - Person Analysis of genetic components of virulence and resistance, this program is utilized in (1) the description of the geographic distribution of virulence components, (2) as a test on zonal classification, (3) for the description of resistance components of varieties and lines in the material and (4) for a test on the usefulness of new lines/varieties for introduction into commercial production.

The other major aspect of the Disease Surveillance Program involves the use of disease-screening nurseries such as the International Bread Wheat Screening Nursery (IBWSN), the Regional Disease and Insect Screening Nursery (RDISN), the International Barley Observation Nursery (IBON), the International Durum Screening Nursery (IDSN), etc. They are all screening nurseries dealing with national program and CIMMYT derived material.

The Surveillance Program is now planning to develop even more extensive analyses via a new computer program, namely EPISEL. A proposal for financial support for EPISEL has been submitted to The Netherlands Government and is now approved.

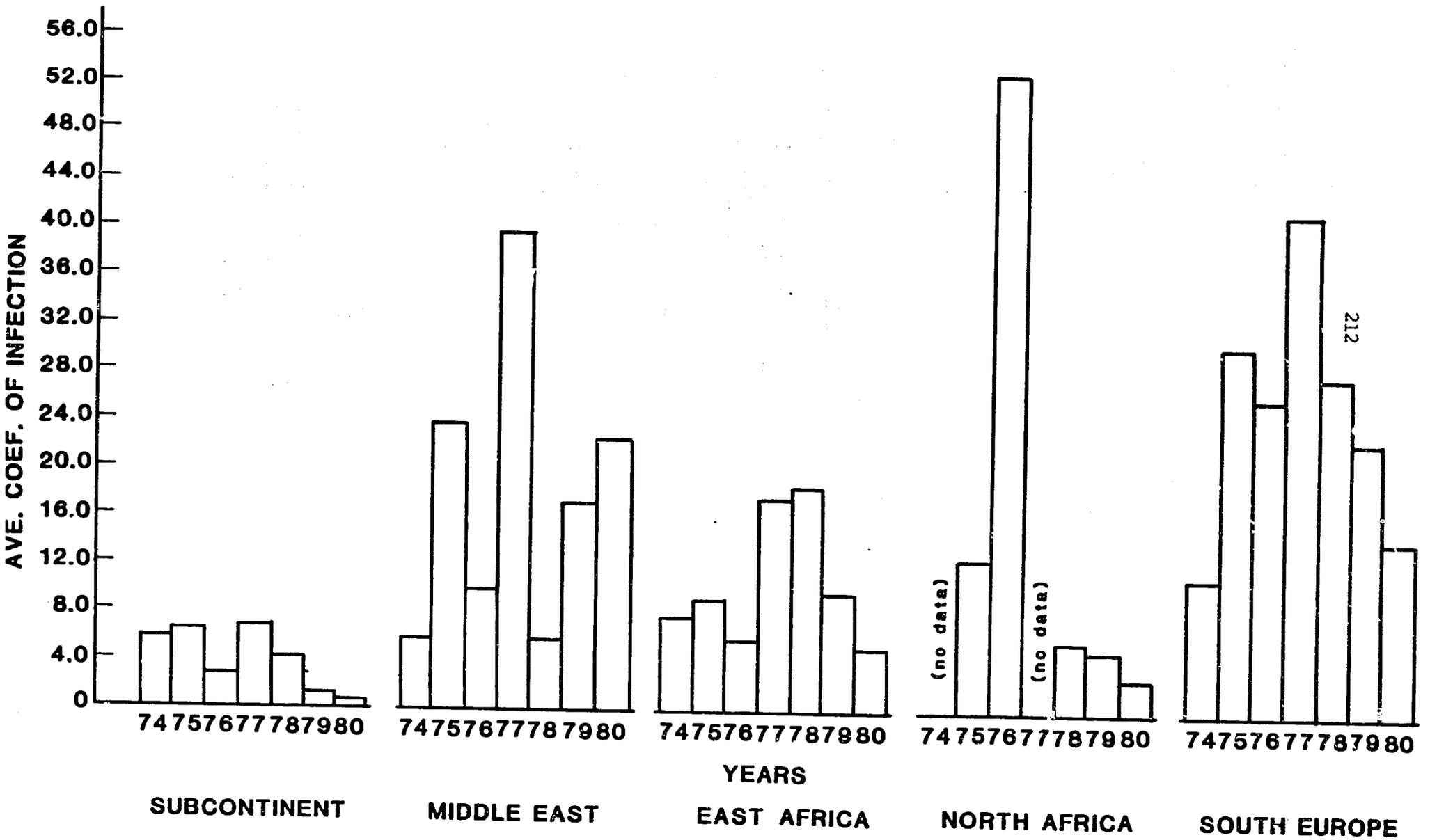
This new program will create capabilities for the following:

1. Preparation of standard tables involving;
 - a. variety/location for each disease,
 - b. comparison of adult (field) and seedling (greenhouse) reaction for each disease,
 - c. sorting and listing all entries (up to 2400/location) for disease severity, coefficient of infection and/or relative infection as compared with checks at each location,
 - d. perform statistical analysis,
 - e. review choice of testing locations against the known virulence genes as determined by EPIDAT;
2. Development of a pedigree analysis system to check for common parents, common genes, etc. leading to a genetic formula for each variety or line. A good check on this program will be the use of EPIDAT's GENEALOGY program;
3. Because screening nurseries are grown in many locations

around the world from which there is a huge return of data, a critical examination of it will be made for other types of resistance, minor genes, etc;

4. The capability to map the various components of virulence will be developed. The mapping program has already been developed with EPIDAT. It is intended to include genes of the host varieties. Inputs will be MAP, DIFFER and GENEALOGY from EPIDAT, plus the new program developed by EPISEL.

As our awareness of barley diseases and their importance increases, plus the addition of more barley varieties to the RDTN or other nurseries, our capability to understand the effects on barley production will become stronger. Hopefully, in the near future, we will be able to do a much better job of disease monitoring.



Importance of barley leaf rust from 1974-80.

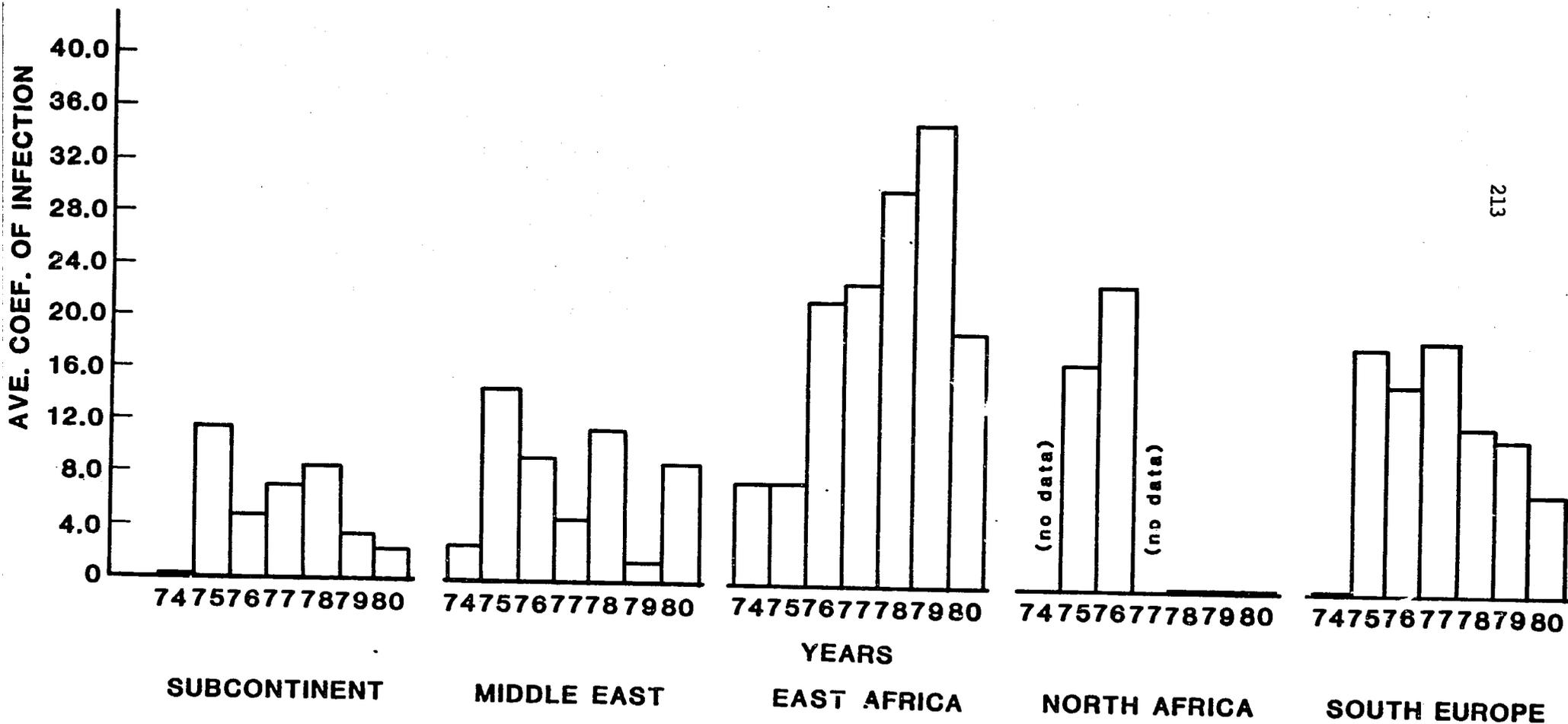


Figure 2. Barley stem rust by region, 1974-80

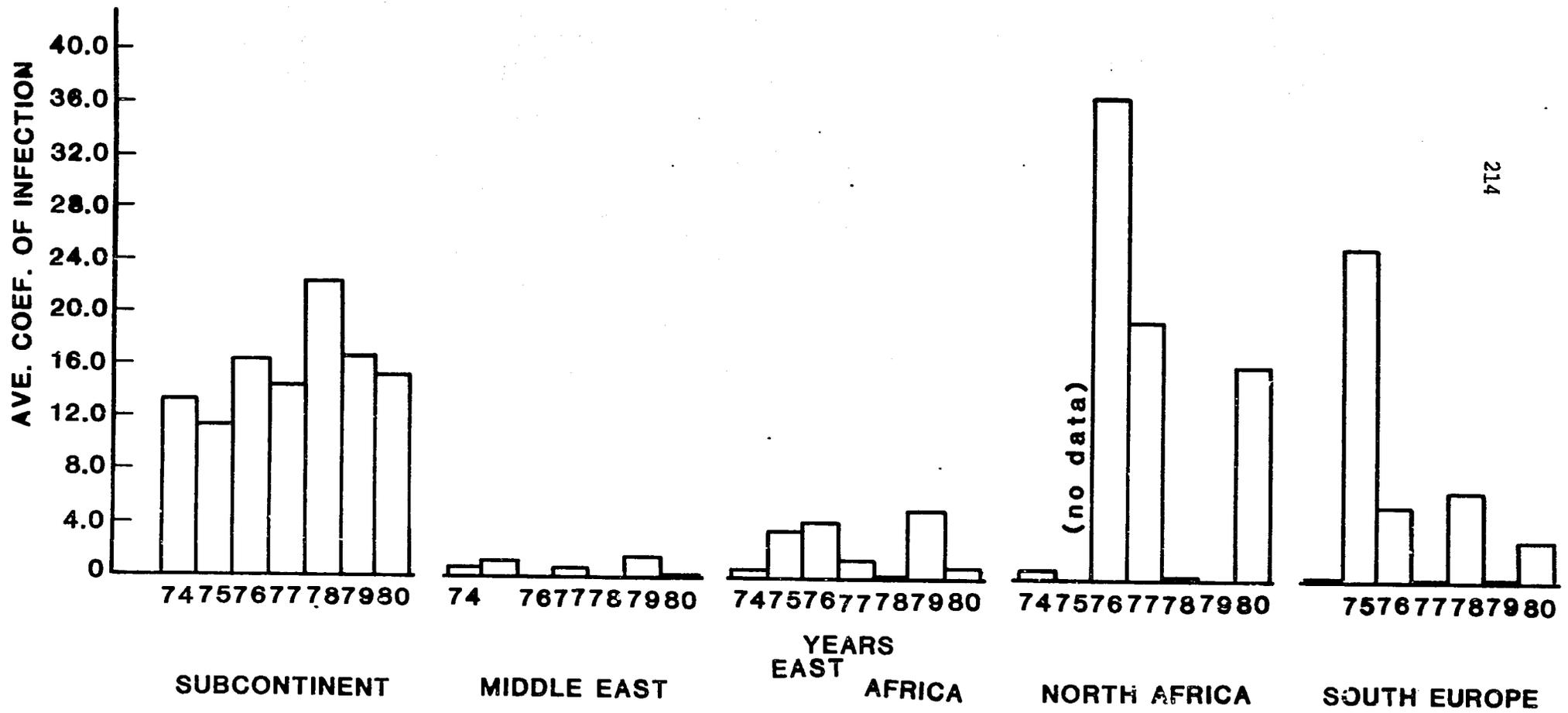


Figure 3. Barley yellow rust by region 1974-80.

BARLEY SITUATION AND IMPROVEMENT IN JORDAN**M.F. Al Zughbi and A.M. Tell***

Jordan, one of the smallest countries (approximately 37,500 sq. miles) in the Middle East, has a Mediterranean climate characterized by a warm, dry summer and mild winter. It is located between 29°-33°N. latitude and 35°-39°E. longitude.

Based on annual rainfall, the East Bank of Jordan can be classified into five agricultural zones:

1. The Arid Zone (Badia): The average annual rainfall is less than 200 mm. This zone is considered as natural ranges and occupies an area of 84569 thousand dunum (dunum equals 0.1 hectare).
2. The Marginal Zone: The average annual rainfall ranges from 200-350 mm. The area receiving 200-250 mm is devoted to barley production, while that receiving 250-350 mm is mainly for wheat and legume crops. This zone occupies an area of 5634 thousand dunums.
3. Semi-Arid Zone: The average rainfall is between 350-500 mm. This area is cultivated for wheat, legume and summer crop production. The area is 1359 thousand dunums.
4. Semi-Humid Zone: It receives more than 500 mm rainfall and is utilized for production of field crops, summer vegetables,

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fruit trees and forestry tree production, depending on land slopes. The area in this zone is 989 thousand dunums.

5. The Ghor Zone (Jordan Valley): This zone lies between 200-350 meters below sea level resulting in hot summers and warm winters. It covers about 10,000 dunums; the largest part of this zone is under irrigation. Vegetables are the dominant crops produced in this zone.

Barley is grown mostly in marginal rainfall land (100-300 mm) where no other crops can be competitively grown. This area exceeds 600,000 dunums. Jordan's domestic barley production (40,000 - 50,000 tonnes) does not meet its consumptive needs (Jordan imports yearly about 50,000 tonnes for feeding purposes). Barley grain yield is about 50-65 kg/dun (Table 1), which is very low as compared with about 329 kg/dun in France and 216 kg/dun in Korea.

Barley Diseases

They are considered to be a minor problem in Jordan; however, leaf rust, stem and yellow rust are observed in wet seasons. Both loose and covered smuts occur as minor diseases.

Barley Improvement Project

Barley is one of the most important feed crops and is the staple diet for the majority of livestock. This fact is a justification for improving barley and barley production.

Objectives of the Project

The improvement project has been planned as follows:

1. to introduce genotypes from other countries that might give high yields under Jordanian conditions;

2. to evaluate the local germplasm in order to increase the average yield per unit area;
3. to select and breed varieties able to resist drought and to increase water-use efficiency;
4. to study hybridization and selection.

Jordanian barley research is particularly concerned with identifying varieties which are adapted to drought conditions. Local genotypes and genetic material from ICARDA, CIMMYT and FAO will be tested.

Table 1. Area (dunums), Production (tonnes), and Average Yield kg/dunum of Barley Grown in Jordan, 1970-1980.

Year	Area (dunums)	Production (tonnes)	Average Yield (kg/ha)
1970	359130	8080	88
1971	538611	39999	74
1972	657923	38708	58
1973	409815	5725	13
1974	585335	55669	95
1975	396337	13783	35
1976	518052	13122	25
1977	440741	13640	30
1978	550680	15220	28
1979	401507	6700	17
1980	670641	58042	86

Source: Ministry of Agriculture, Department of Agricultural Economics.

BARLEY DISEASES IN INDIA

S.C. Atheya, N.N. Dikshit, and Lakhi Ram*

Barley is an important cereal crop in India. It occupies fourth place in world hectarage and third in total production. In India, barley is grown on 2.22 million hectares with a production of 2.3 million tonnes.

Previously, rusts, smuts and stripe were the main diseases of barley, but with the introduction of new varieties, diseases like net blotch, spot blotch, brown leaf spot, molya and cereal yellow dwarf virus, etc. are assuming serious proportions in certain areas of the world.

Fungus Diseases

I. Rusts

1. Yellow Rust (Puccinia striiformis West.):

This is the most prevalent and destructive rust of barley. Until 1968, 12 races of this rust (namely 13, 19, 20, 24, 31, 57, A, D, E, F, G & H) were known in India (Swaminathan et al., 1968). Recently, two more (14 and 38) were reported by Prasada (1965). Races 24, 57 and G are exclusively barley races, whereas race 19 attacks both wheat and barley.

The work done on seedling and adult resistance tests of barley varieties has been reported by various workers (Anon., 1954, 1955, 1956, 1957, 1958 and 1960); Vasudeva et al., (1962), Lele et al., (1965) and Singh (1968) reviewed the work

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done on seedling and adult resistance tests of barley varieties to yellow rust in India. Gulati (1966) tested the sources of resistance for yellow rust and some other important diseases of barley. Sinha et al. (1969) reported the results of seedling resistance tests of 183 barley varieties to three races (24, 57 and G) of yellow rust. Khanna et al., (1968) and Atheya and Saksena (1976) tested a number of varieties from Kanpur, and sources of resistance are listed in Table 1.

Chemical Control:

Atheya and Singh (1971) reported 4 sprays of Plantex (5,6-dihydro-2 methyl-1, 4 oxathin 3-carboxaninide-, 4 dioxide), or cosan (wettable sulphur) or Dithane M-45 (Zince ion + Manganese ethylene bisdithiocarbamate, 80% W.P.) each (0.2%) reduced yellow rust of barley with a corresponding increase in yield.

2. Black Rust (*P. graminis* Pers. f. sp. *tritici* Eriks. and Henn.):

It is the next important rust of barley, which occurs in warmer regions of India late in the season. To date, 19 races and biotypes (11, 14, 15, 15C, 17, 21, 21-A, 24, 34, 34-A, 40, 42, 42-B, 72, 75, 117, 117A, 122 and 194) and 4 sub-biotypes (21-A-1 and three sub-biotypes of 42-B) of this rust have been reported in our country (Swaminathan, 1968). In 1965, Prasada reported the prevalence of races 17 and 21-A on barley rust (Anon., 1956, 1957, 1958, 1959, 1960). Khanna et al., (1969) and Atheya and Saksena (1974) tested 400 and 165 varieties, respectively, at Kanpur, and the sources of resistance are listed in Table 1.

3. Brown Rust (*P. hordei* Otth.):

This rust is very irregular in occurrence and of comparatively less importance in India. So far, only four races and biotypes (H_1 , H_2 , H_3 and H_1-A) are known to occur in India (Joshi et al., 1965).

II. Smuts

1. Loose Smut (Ustilago nuda (Jens.) Rostr.):

This internally-seed-borne disease is quite prevalent in India. Various workers (Anon., 1955, 1956, 1957, 1958), Mathur et al., (1960, 1964), Prasad (1965, 1968), Tandon et al., (1966), Yalava et al., (1969) and Atheya (1974c) tested a number of varieties against this pathogen, and the sources of resistance are listed in Table 1.

Chemical Control:

This disease is effectively controlled by treating the seed with Vitavax (Carboxin; 2 hydro-2-methyl-1, 4 oxathin carboxanilide), or Benlate (Methyl-1 butylcarbamoyle-2-benzimidazole-carbamate) at 2 g/kg of seed.

2. Covered Smut (U. hordei [Pers. Lagerh.]):

This is also an important disease and is externally seed borne. Srivastava (1969) reported 7 races and biotypes (5, 7, 8, 14, 2-A, 8-A and 14-A) of this pathogen from Bihar.

Various workers (Anon., 1955, 1956, 1957, 1958 and 1960), Mehta et al., (1953); Mathur et al., (1960, 1964), Atheya (1974c) and Gupta (1979) tested a number of varieties against this disease, and the sources of resistance are listed in Table 1.

Chemical Control:

Mehta (1951), Grewal and Dharamvir (1964) and Nene (1964) recommended Agrosan GN (phenyl mercury acetate and ethyl mercury chloride) or Ceresan (phenyl mercury acetate 1% mercury) or sulphur at 3 g/kg of seed.

Mathur et al., (1969) and Atheya (1974) found that covered smut of barley was considerably reduced by treating the seed with mercurials such as Agrosan GN (phenyl mercury acetate and methyl mercury chloride) or Ceresan (phenyl mercury acetate 1% mercury) and non-mercurials such as Phygon (XL-2, 3 dichloro-1-4 naphthoquinone), or Thiram (tetramethylthiuram disulphide); Flit (406[-n-] trichloro methyl-mercapto)-4 cyclo-hexene-I, 2-dicarboximide); or Spergon (tetrachloro-benzoquinone) or Dithane M-45 (zinc ion + manganese ethylene bisdithiocarbamate, 80 W.P.)

Leaf Spot and Blights**1. Barley Stripe (Helminthosporium gramineum Rabh.):**

It is a major disease of barley and is prevalent in all the barley-growing areas of India. Mehta et al., (1953), Singh and Atheya (1970), Atheya (1974b), Atheya et al., (1979) and Pillai and Suryanarayan (1979) carried out resistance tests against this pathogen. The sources of resistance are listed in Table 1.

Chemical Control:

Seed treatment with Agrosan GN (phenyl mercury acetate and ethyl mercury chloride) or Ceresan (phenyl mercury acetate 1% mercury) partially controlled this disease.

2. Net Blotch (H. teres (Sacc.) Shoemaker):

It is a minor disease of barley which has assumed importance in the Eastern states of India. Several workers, namely Om Prakash and Misra (1976), Verma (1977) and Atheya (1980), screened a number of varieties against this pathogen. The varieties showing resistance are listed in Table 1.

Chemical Control:

Atheya (1980) carried out seed treatments with Agrosan GN (phenyl mercury acetate and ethyl mercury chloride) and Ceresan (phenyl mercury acetate 1% mercury) which partially controlled this disease.

3. Leaf Spot of Barley (H. sativum (P.K. & B):

Misra and Prakash (1972) reported the occurrence of leaf spot of barley from Bihar. Recently, this disease has been observed from Uttar Pradesh and Himachal Pradesh, but it is a minor disease.

4. Brown Leaf Spot (H. catenarium):

Misra and Prakesh (1972) reported the occurrence of this minor disease in Bihar.

5. Leaf Spot of Barley (Alternaria alternata f hordei):

Dhanraj (1971) reported the occurrence of this disease in Delhi and found that it is seed borne.

Chemical Control:

Spraying the barley crop with 0.2% Vitavax (Carboxin) effectively controlled the disease.

6. Downy Mildew (Sclerophthora macrospora):

Joshi (1971) reported the occurrence of this minor disease

from New Delhi.

Mildew

Powdery Mildew (Erysiphe hordei Marchal):

It is a disease of major importance in the northern hilly regions and foothills of India. Singh and Katiyar (1970) reported the results of testing 44 varieties of barley against this disease. The varieties found resistant are listed in Table 1.

Seedling Diseases

Seedling Blight and Root Rot (Sclerotium rolfsii):

Prasad and Singh (1972) from Kanpur (Uttar Pradesh) and Misra and Rath (1975) from Orissa reported seedling blight due to S. rolfsii. This disease is also of minor importance and occurs in light soil.

Nematodes

Molya Disease (Heterodera avenae):

This is a major disease of barley in certain areas of Rajasthan. Mathur (1971), Dalela and Mathur (1972) and Handa and Mathur (1979) carried out varietal resistance tests against this disease. The varieties showing resistance are listed in Table 1.

Chemical Control:

The above authors found that the application of Nemagon (dibromochloro propene) or Dasanit (Fensulfothein) or DD (1, 3 dichloropropene, 1, 2-dichloropropene to soil at 2 kg/ha reduced the nematode population and increased yield.

Cultural Practices:

Crop rotation and deep ploughing with a view to minimizing

disease incidence has given encouraging results.

Virus Disease

Nagarich and Vashishth (1963) reported the occurrence of cereal yellow dwarf virus from the Simla hills. Dhanraj (1968) and Singh (1972) reported that this disease is prevalent in Punjab, Delhi, Haryana and Simla. Atheya and Singh (1972) recorded the incidence of cereal yellow dwarf virus from Majhera (Nainital) on varieties K 317-4 and K 572/11 (Vijaya) barley.

Barley Improvement Program:

The work on the improvement of barley in Uttar Pradesh was initiated in 1916 and was confined to the development of improved varieties by selection from the indigenous material. The first variety to be isolated was C 251 in 1926 from the Bahraich collection. Besides good yielding capacity, it is a high-quality malting barley and is still widely grown. It has also been found to be tolerant to saline/alkaline soil conditions. Varieties recommended on a regional basis were C 84 (1945), C 50 (1950), K 12 and Ballia Barley (1956), K 14 (1959), CN 292 and CN 294 hull-less.

The hybridization program was intensified using K 12 as the agronomic base, with the result that K 18 and K 19 were evolved in 1963. Two very good combiners for a number of desirable traits are K 12 and K 18 which are being used as donors by breeders throughout India.

The major diseases which reduce barley yield are rusts, smuts and stripe. In 1964, germplasm was enriched from 225 to 425 strains which were screened for disease resistance under

natural conditions and EB 410, EB 438, EB 675, Orge-4, Kn 26, and EB 2556 were found resistant to yellow rust; EB 675 resistant to black rust (MR); and EB 873, EB 928, EB 438, KN 12, K 14, K 64/24 resistant to loose smut. An intensive hybridization program was commenced, and straight crosses between K 12, K 18 agronomic bases and donors' single-plant selections were made in segregating generations. The pedigree method was followed for subsequent study. Varieties K 24 and K 70 were recommended for late-sown conditions and flooded areas, respectively. K 24 is resistant to stripe disease.

The All India Coordinated Barley Improvement Project came into operation in 1967 with Kanpur (Uttar Pradesh), Durgapura (Rajasthan) and Delhi as the major research centers; Pusa (Bihar), Hissar and Ludhiana were sub-centers. More emphasis was laid on resistance and quality breeding under stress conditions. The genetic material was screened thoroughly under natural and artificial conditions for yellow rust, black rust, stripe, powdery mildew, loose smut, covered smut and leaf spots. The best types possessing resistance were isolated for use in breeding programs. These strains are listed below.

<u>Strains/Variety</u>	<u>Desirable Traits</u>
1. EB 438	Resistant to yellow rust, stripe & powdery mildew
2. EB 873	Resistant to yellow rust, stripe & powdery mildew
3. EB 921	Tolerant to yellow rust, resistant to aphids and stiff-straw
4. EB 2856	Resistant to yellow rust and loose smut.
5. EB 1881	Resistant to yellow rust, stripe.
6. EB 2501	Resistant to brown rust, loose and covered smut.
7. EB 1470 EB 1556	Resistant to yellow rust, brown rust, loose and covered smut.
8. K 12	Resistant to covered smut and stripe.
9. K 24	Resistant to stripe.
10. C251	Tolerant to saline/alkaline soil; good malting quality.

In the hybridization program, straight, back, three-way and multiple crosses were attempted between desirable agronomic bases and donors, and the segregating progenies were studied.

Selections from the various crosses were evaluated by standard breeding methods under rain-fed, irrigated and late-sown conditions. The promising strains were included in initial Evaluation and Uniform Regional Trials under different agro-climatic conditions in India for the first time in 1966-67. As a result of the above test, for a number of years, the varieties Jyoti (1969) irrigated, Amber (1969), Vijaya (1972), Azad (1974), K 141 and K 169 (1977) rain-fed, K 252, K 273 (1978) Diara land areas, K 226 (1979) rain-fed and K 257 (1980) for the irrigated tract of Central India were released for general cultivation. The varieties K 141, K 169, K 252, K 273, K 226, and K 257 are moderately resistant to yellow rust and

highly resistant to black rusts and stripe disease, and possess a stiff straw, whereas the earlier varieties were lacking in these attributes.

Much success has been achieved in the incorporation of disease and pest resistance; while previous varieties were highly susceptible to yellow rust and aphids, the present strains which are under test in various coordinated trials have shown TS-LS reaction to yellow rust and possess good yield potential. The variety K 198 (6-row hulled) is highly resistant to yellow rust and is being used as a donor in breeding programs throughout the country. Similarly, K 730-35 (K 1107) a hull-less type developed at the Kanpur Centre, possesses a high degree of resistance to yellow rust and has good yield.

Two-row strains such as K 1010, K 1011, K 1012 developed by using EB 921 as a donor for aphid resistance have shown a high degree of resistance to aphids, tolerance to yellow rust and possess a stiff-straw.

Net blotch is now an important disease of barley in India. Crosses have been attempted between existing agronomic bases and donors, and segregating and advanced generations are under study with a reasonable hope that some good lines will be selected in the near future.

Conclusion:

Some sources of the major diseases of barley are known in India, but keeping in mind the frequent shifts in the race flora of the pathogens, particularly the rusts, work on the screening of varieties for new sources of resistance should be

continued. Some research should also be initiated to determine sources of the other important diseases namely net blotch, spot blotch, malya disease and less-important diseases such as cereal yellow dwarf virus.

References

- Anonymous, 1954. Rep. Div. Mycol. Pl. Path., Sci. Rep. Agric. Res. Inst., New Delhi, 1953-54:89.
- Anonymous, 1955. Rep. Div. Mycol. Pl. Path., Sci. Rep. Agric. Res. Inst., New Delhi, 1954-44:89.
- Anonymous, 1956. Rep. Div. Mycol. Pl. Path., Sci. Rep. Agric. Res. Inst., New Delhi, 1955-56:88.
- Anonymous, 1957. Rep. Div. Mycol. Pl. Path., Sci. Rep. Agric. Res. Inst. New Delhi, 1956-57:88.
- Anonymous, 1958. Rep. Div. Mycol. Sci. Rep. Agric. Res. Inst. New Delhi. 1957-58:72.
- Anonymous, 1959. Rep. Div. Mycol. Pl. Path., Sci. Rep. Agric. Inst., New Delhi, 1958-59:133.
- Anonymous, 1960. Rep. Div. Mycol. Pl. Path., Sci. Rep. Agric. Res. Inst., New Delhi, 1959-60:93.
- ATHEYA, S.C., 1974. Progress of Work Done on Barley Plant Pathology During 1973-74. Sixth All India Barley Research Worker's Workshop, Solan (HP).
- ATHEYA, S.C., 1974b. Resistance of Barley Varieties to Stripe Disease in U.P. Indian J. Mycol. & Pl. Path 4: 83.
- ATHEYA, S.C., 1974c. Barley Varietal Resistance to Covered Smut (*Ustilage hordei*) in Uttar Pradesh. Indian J. Mycol. & Pl. Path. 4:82.
- ATHEYA, S.C., 1980. Fungi Associated with Barley Seed. Ph.D. Thesis, Chandra Shekhar Azad Uni. of Agri. & Tech., Kanpur.
- ATHEYA, S.C. and SINGH, D.V., 1971. Discussion of Results of Disease and Covered Smut. Fourth All India Barley Research Worker's Workshop, Hissar (Haryana).
- ATHEYA, S.C. and SINGH, D.V., 1972. Investigation on Barley Diseases, Yellow Rust, Powdery Mildew and Virus Disease at Kanpur. Fifth All India Barley Research Worker's Workshop, Jaipur (Rajasthan).
- ATHEYA, S.C. and SAKSENA, H.K., 1974. Resistance of Indigenous and Exotic Barley Varieties to Races of Black Rust. Indian J. Mycol. & Pl. Path. 4:97-98.
- ATHEYA, S.C. and SAKSENA, H.K., 1976. Resistance of Indigenous and Exotic Barley Varieties to Indian Races of Yellow Rust. Indian J. Mycol. Pl. Path. 6:111.

- ATHEYA, S.C., GOYAL, R.D. and LAKHI, Ram. 1979. Resistance of Barley Varieties to Stripe Disease in Uttar Pradesh. First National Symposium held at Karnal, 61 pp.
- DALELA, C.G. and MATHUR, B.N., 1972. Investigations of Barley Diseases in Rajasthan. Fifth All India Barley Research Worker's Workshop, Jaipur (Rajasthan).
- DHANRAJ, K.S., 1968. Investigations on Barley Mosaic in India I.A.R.I., Ph.D. Thesis, New Delhi.
- DHANRAJ, K.S., 1971. New Leaf Spot Disease of Barley Caused by Alternaria alternata f. hordei. All India Barley Research Worker's Workshop, I.A.R.I. New Delhi.
- GREWAL, J.S. and DHARAMVIR., 1964. Efficacy of Different Fungicides VIII. Field Trials for the Control of Barley Smut (Ustilago hordei). Indian Phytopath-17:162-164.
- GULATI, S.C., 1966. Discussion on the Need of Establishing a Collection of Breeding Stock for Distribution to Barley Breeders. All India Wheat Research Worker's Conference. Jaipur.
- GUPTA, R.B.L., 1979. Evaluation of Barley Varieties Against Covered Smut (Ustilago hordei) in Rajasthan. Indian J. Mycol. & Pl. Path. 9:91.
- HANDA, D.K. and MATHUR, B.N., 1979. Studies on Control of Molya Disease of Barley by Chemical and Cultural Method. First National Symposium on barley, Karnal.
- JOSHI, L.M. 1971. Downy Mildew of Barley. All India Barley Research Worker's Workshop held at I.A.R.I., New Delhi.
- JOSHI, L.M., PRASADA, R. and GOEL, L.B. 1965. Studies on Puccinia hordei, Physiologic Specialization Screening of Varieties. Indian Phytopath. 18:267.
- KHANNA, A.N., SINGH, D.V., and KHANNA, B.M. 1968. Resistance of Indigenous and Exotic Barley Varieties to Indian Races of Yellow Rust (Puccinia striiformis West.) Indian J. Microbiol. 8:267-270.
- KHANNA, A.N., SINGH, D.V. and VERMA, P.C. 1969. Resistance of Indigenous and Exotic Barley Varieties to Races of Black Rust. Indian J. Mycol. 8:259-260.
- LELE, V.C., SINGH, B. and MISRA, D.P. 1965. Studies in Rusts of Wheat and Barley During 1962-63. All India Wheat Research Worker's Seminar I.A.R.I., New Delhi.
- MATHUR, R.S., MATHUR, S.C., SAKSENA, K.N. and MATHUR, S.C. 1960. Resistance of Barley Varieties Against Loose Smut (Ustilago nuda Jens. Rotr.) Ustilago hordei Pers. Kellerm & Single in Uttar Pradesh. Curr. Sci., 29:280-281.

- MATHUR, R.S., SWARUP, J. and VERMA, S.C. 1964. Barley Varietal Resistance to Loose Smut, Covered Smut in Uttar Pradesh. Labdev. J. Sci. Tech., 2:209.
- MATHUR, R.S., TRIPATHI, R.C. and AHMAD, Z.A. 1969. Comparison Organo Mercurial Seed Dressing Fungicides Against Covered Smut of Barley. Labdev. J. Sci. & Tech., 7:338-339.
- MATHUR, B.N. 1971. Sources of Resistance of Molya Disease of Barley. All India Barley Research Worker's, I.A.R.I., New Delhi.
- MEHTA, P.R. 1951. The Effectiveness of Agrosan GN and Ceresan for the Covered Smut of Barley. Agric. Husb. 2:3-7.
- MEHTA, P.R., SINGH, B. and MATHUR, S.C. 1953. Varietal Reaction to Barley Stripe. Sci. & Cult. 19:152.
- MEHTA, P.R., SINGH, B., MATHUR, S.C. and SINGH, S.B. 1953. Varietal Reaction of Covered Smut of Barley. Sci. & Cult. 19:262-263.
- MISRA, A.P. and PRAKASH, G. 1972. Studies on a New Leaf Spot Caused by Helminthosporium catenarium. Indian J. Mycol. & Pl. Path., 2: 147-151.
- MISRA, R.P. and RATH, G.C. 1975. Sclerotium Root Rot of Barley. Sci. & Cult. 41:286-287.
- NAGAICH, B.B. and VASHISTH, K. 1963. Barley Yellow Dwarf - a New Viral Disease of India. Indian Phytopath. 16:318-319.
- NENE, Y.L. 1964. Flexibility Desirable in Fungicide Recommendations for Externally Seed-borne Cereal Smut Disease Control. Pl. Dis. Repr. 48:120-121.
- PRAKASH, O.M. and MISRA, A.P. 1976. Barley Varieties as a Source of Resistance to Net Blotch. Indian J. Mycol. & Pl. Path., 1:109-110.
- PILLAI, P.K. and SURYANARAYAN, D. 1979. Stripe Disease of Barley in India. First National Symposium on Barley, Karnal, pp 61.
- PRASADA, R. 1965. An Appraisal of Disease Situation in Wheat and Barley During 1964-65. Fourth All India Wheat Research Worker's Seminar, Ludhiana.
- PRASADA, R. 1968. A Report on the Survey of Rusts, Alternaria Leaf Blight, Smuts and Bunts. Fourth All India Wheat Worker's conference, Jaipur.

- PRASADA, R., LELE, V.C., JOSHI, L.M., MISRA, D.P., PAYAK, M.M., SINGH, S.D., GEEL, L.B., KRISHANA, G. and SHARMA, S.K. 1966. Occurrence of Physiologic Races of Wheat and Barley Rusts in India During 1957-1962. *Indian Phytopath.* 19:45-58.
- PRASADA, Y. & SINGH, D.R. 1972. Root Rot and Seedling Blight of Barley. *Indian J. Farm. Sci.* 1:115.
- SINGH, D.V. 1968. Sources of Resistance Against Certain Barley Diseases. First All India Barley Research Workers' Workshop. Pantnagar (UP).
- SINGH, M.L. 1972. Virus Diseases of Barley in India. All India Barley Worker's Workshop. Jaipur.
- SINGH, D.V. and R.L. KATIYAR. 1970. Varietal Resistance of Barley to Powdery Mildew. *Sci. & Cult.* 36:226-227.
- SINGH, D.V. and ATHEYA, S.C. 1970. Resistance of Barley Varieties to Stripe Disease in Uttar Pradesh. *Indian J. Microbiol.* 10:87-88.
- SINHA, V.C., AHMAD, S.T. and GOEL, L.B. 1969. Sources of Resistance in Exotic Barley Varieties Against Races 24, 57 and G of *Puccinia striiformis*. Second All India Barley Worker's Workshop, New Delhi.
- SRIVASTAVA, J.N. 1969. Occurrence of Physiological Races of Covered Smut (*Ustilago hordei*) of barley in Bihar. Second All India Barley Research Worker's Workshop, I.A.R.I., New Delhi.
- SWAMINATHAN, M.S., JOSHI, L.M., RAO, M.V. and DAKSHNAMURTI. 1968. The Rust Disease of Wheat. *Bull., I.C.A.R.*, New Delhi.
- TANDON, I.N., SINGH, P.P., and PRASAD, S.N. 1966. Varietal Reaction to Loose Smut in Barley. *Sci. & Cult.*, 34:303-306.
- VASUDEVA, R.S., PRASADA, R., LELE, V.C. and PAL, B.P. 1962. *Res. Ser. Indian Council Agri. Res.* 32:72.
- VERMA, P.C. 1977. Studies on the Pathology and Physiology of *Helminthosporium* sp Causing Net Blotch of Barley. Ph.D. Thesis, Kanpur Univ., Kanpur.
- YADAVA, H.R., MATHUR, R.S., and TANDON, I.N. 1969. Results of Recent Resistance Tests of Wheat and Barley Loose Smut in Uttar Pradesh. *Labdev J. Sci. & Tech.*, 7B:237-238.

Table 1. Sources of Resistance to Various Diseases.

Disease	Sources of Resistance
Yellow Rust	B-50-1, B-50-3, B-70, B-75, EB 158, EB 198, EB 438, EB 1470, EB 410 and EB 1556.
Black Rust	EB 85, EB 767, EB 772, EB 1172, EB 2535, EB 2371, EB 2829, EB 5193, EC 1069, EC 10620, EC 10622, K 82, Mexican 6, Mexican 22, and Sel 15-96/1
Loose Smut	Fairly tolerant (1-5%) C 44, C 59, CN 292, Cn 294, Black barley and NP 13
Covered Smut	Moderately resistant (below 2%) Bajpur local, C 50, C 84, CN 292, K 12, K 18, K 19, K 24, and K 70.
Stripe Disease	BHS 4, EB 438, EB 873, EB 928, EB 4003, EB 4032, BHL 1, K 12, K 24, K 125, K 572/11 (Vijaya), KN 30, KN 73, and Sel 64/2-
Net Blotch	Ahor 2376/76, Almaya black, BHD 12, BHD 22, BHD 23, BHD 24, BHS 2, BHS 6, BHS 11, BJ 29, BR (12) (5), BPL 12, BR 22, BR 27, BR 30, BR 31, BR 58-126, C 12, C 84, C-138-2, CN 292, CN 294, EB-9, EB 27, (hooded), EB 56, EB 102, EB 149, EB 178, EB 180, EB 181, EB 182, EB 184, EB 188, EB 189, EB 191, EB 192, EB 197, EB 198, EB 199, EB 204, IB 1, IB 19, K 12, K 24, K 78, K 99, K 127, K 131, K 139, K 140, K 142, K 143, K 144, K 148, K 4407, K 24427, K 4437, K 4455, K 4717, K 4727, K 4816, K 4826, K 4836, K 4847, K 310-2, KN 20, KN 30, NP 109, Sval of Mari, Sel 64/24, and Zepher.
Powdery Mildew	EB 438, EB 675, EB 873, EB 858, EB 928, and KN 87
Molya Disease	AQ 25, Research, AQ 853, AQ 1127, BL 8, C 50, CI 18334, CI 3902, Campana, Cape barley, Glacier, Excelsior, Fayette, Frontier, Gabron, Hanchen, BHL 52, Kron, K 572/10, Leon, Manchauria, Marcaine, Morocco, Peatland, PI 253826, RD-386, RD-387, RD-392 and Statfrontrollens.

THE MOROCCAN BARLEY IMPROVEMENT PROGRAM
AND DISEASE PROBLEMS

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Fall and winter-sown spring barley (about 2 million ha) occupies about one-third of the annually cultivated area in Morocco. At present only six-rowed landraces are grown by farmers with the exception of limited contract growing of two-rowed barley for malting purposes. Experiment station test results show that the best two-rowed types have consistently yielded more than the best six-rowed types. Several excellent two-rowed barleys and at least two good six-rowed varieties have yet to be multiplied. Less than one percent of the seed requirements are produced each year. One introduction (Arig 8) has been tested over 16 years without being multiplied.

The main goal of the Moroccan barley breeding program is to create an array of genotypes adapted to diverse environmental conditions. For low rainfall areas, short-season genotypes are being selected at Tessaout near Marrakech. Late maturing and short-statured types adapted to high rainfall and irrigated areas are selected at Merchouch. Cold tolerant spring barleys adapted to mountain areas and off-season increases and generation advances will hopefully begin this year at Annoceur in the Middle Atlas mountains, east of Fez.

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Two-rowed barley in present yield trials are mostly the result of work done by Tegye and Kuc; less progress has been made with six-rowed types but work was done by Caddel, who screened the World Barley Collection. After the departure of the above researchers in the mid-70's, contacts were established with CIMMYT and ICARDA. Presently over one thousand F₂ populations supplied by these two organizations are in the field. Also direct contacts are maintained with European programs for two-rowed barleys and USA west coast programs for six-rowed types which demonstrate promise. Over 350 entries are in preliminary yield trials at Tessaout and Merchouch, but the severe drought in 1980-81 and lack of irrigation have given the Merchouch operation a severe setback.

Powdery mildew, leaf rust and net blotch are the predominate diseases; however, barley stripe and BYDV can occasionally become epidemic. Good levels of resistance to net blotch are present in current breeding lines. Powdery mildew resistance is rather poor in six-rowed types but very good in two-rowed types coming from Europe. The Pa₃, Pa₇ and Pa₉ genes for leaf rust resistance as well as several genes for mildew resistance are being backcrossed into high yielding lines. Yellow (stripe) rust occurs mainly on introductions and black (stem) rust is found very late in the growing season usually in mountain areas where planting is very late. Losses due to root rots and Pseudomonas sp remain unquantified. Scald occurs only occasionally. Shortages of trained manpower and equipment have led to program discontinuities and a slow rate of progress in barley improvement.

Net blotch

Net blotch of barley caused by *Pyrenophora teres* Drechs. frequently has been reported as one of the major diseases of Moroccan barley landraces (Boulif 1975; Boumer 1976). Field surveys (Table 1) made in 1975 and 1976 showed that on the basis of prevalence and severity *P. teres* may be considered as one of the more important pathogens affecting barley in the country (Boulif 1975).

Yield losses

Caddel (1976) used fungicidal sprays to control net blotch and demonstrated yield losses of 26% on the cultivar Rabat 071 (CI 4979) and of 51% on Monte Cristo (CI 1017). Using the varieties Rabat 071 and Arig 8 (905), Ndiaye (1978) evaluated the combined influence of net blotch and powdery mildew using two chemical treatments (Table 2). The results suggest that yield losses are caused by relatively low severities of powdery mildew and net blotch. Yield losses of 15% on Arig 8 and 21% on 071 were due largely to powdery mildew and net blotch, respectively. Table 3 presents more recent data collected by Burleigh (pers. communication 1981) and supports the results of Caddel that losses due to net blotch are important.

Resistance to net blotch

From 2,608 USDA World Barley Collection samples, eighty barley lines were found to be resistant to net blotch and relatively free of other diseases (Caddel and Wilcoxson 1975). Taking all but one of these lines, Bjarko (1979) found only three lines resistant to 9 out of 9 virulence groups and only 6

others resistant to 8 out of 9 virulence groups composed of isolates from the Middle East and Montana.

Powdery mildew

Powdery mildew caused by *Erysiphe graminis* occurs every year throughout the barley growing areas in Morocco. Field trials conducted in the Meknes region in 1976 on two cultivars demonstrated significant yield losses (Table 4) from powdery mildew. The cultivar Rabat 071 had losses greater than 30% while Arig 8 had less than 10% loss when yields from the best fungicide treatment were compared with those of the untreated controls.

Sources of resistance to powdery mildew in Morocco

During the 1972-73 growing season, Caddel evaluated a total of 10,420 barley entries from the USDA Small Grains Collection for their reaction to powdery mildew in Morocco. Some 3,141 entries were resistant and 2426 were found moderately resistant but only 109 were relatively adapted and did not lodge (Caddel et al. 1975).

Moreover, among the resistance genes that were tested by Caddel, the genes Ml-na, Ml-p and Ml-y appeared to be the most important genes for powdery mildew resistance in Morocco, while the genes Ml-a, Ml-a?, Ml-a³, Ml-at, Ml-at?, Jml^asn, Ml-g?, Z, Ml-h and Ml-n were found ineffective in obtaining high levels of resistance. Table 6 presents a comparison of powdery mildew scores recorded by Caddel (1976) at Meknes with those taken this year at Rabat (Burleigh 1981). The genes Mlna, Mly and perhaps Mln, Ml-mw, and Jlmnn appear useful.

Barley stripe

Barley stripe caused by *Pyrenophora graminea* (synonym = *Helminthosporium gramineum* Rab. ex Schl. 1957) is a destructive disease of barley, occurring throughout the barley growing regions of the world (Abu Mohammed and Mohmood 1973; Ech-Chabi, M'Hammed 1977; Nielsson 1975; Teviendale and Hall 1976). In Morocco, a preliminary survey during the growing season of 1975 showed that 5% of the inspected fields contained 0.5-20% stripe-infected plants (Boulif, 1975). In 1977, Rolli et al. (1977) inspected 177 commercial fields around the country, and found stripe infection to vary from a minimum of 0.4 to a maximum of 26%. Averages of stripe infection rates observed within different regions in Morocco are shown in the Table 8.

Yield losses from barley stripe

Preliminary field studies involving fungicidal treatments of seed of twelve barley varieties showed that yield losses from natural infection may be as high as 55% in susceptible lines (Table 9). The loss was mainly due to a significant reduction in fertile tillers per unit area.

Varietal resistance control

Even though barley stripe can be controlled satisfactorily by use of fungicides, it is obvious that control by means of varietal resistance is more desirable and convenient for farmers because it eliminates hazard from the use of chemicals, as well as the extra costs generated by the fungicidal treatments. Furthermore, varietal resistance is the only practical means of control in developing countries,

because fungicides are not always available for farmers, and when they are, a certain level of education is necessary for the efficient use of these products.

In 1977 a preliminary evaluation of stripe reaction in 34 barley varieties (Table 10) was carried out in Morocco (Rolli et al. 1977) using the inoculation method developed by Nielsson (1975). Barley seeds (200 of each variety) were incubated between two actively growing cultures of *P. graminea*, at 3-5°C for 14 days. After this period, the seed with its growing point barely emerging was planted in four meter-rows in the field. Two fungus isolates were used in this experiment. Selections made from crosses using Esperance as one parent have a high level of resistance to infection. Metz and Scharen (1979) also reported that a high level of resistance was transferred from Betzes to backcross derived progeny and that this resistance was relatively good against three isolates, one of which was Moroccan.

Generally varieties and lines that appeared heavily infected from natural inoculum in breeders plots (Atlas 68, Atlas 46, CI 9806, CI 14100, CI 14300) showed high infection rates from artificial inoculation of the seed. On the other hand some varieties that usually show only limited stripe infection in the field did exhibit fairly high infection rates from seed inoculation. e.g. Arig 8, Orge IV, Kozan, Kristina, CI 8422. Because perpetuation of barley stripe in the field occurs through floral infection, the question is raised whether the mere incubation and planting of naturally infected seed is maybe sufficient for evaluating resistance to stripe in barley

varieties.

Seed borne fungi

Table 11 presents the results of a survey of seed borne fungi found on 38 samples collected from Moroccan farmers in 1974.

In this same study, the maximum percentage of heads destroyed by *H. gramineum* was 26% with an average field showing a 1% loss. This disease plus the two smuts were estimated to cause average losses of 2.6% in the six sample regions (Table 12).

Barley yellow dwarf virus

For several years wheat, barley and oats have been observed in Morocco to show symptoms of barley yellow dwarf virus. Last year the disease incidence was estimated at 75% in the breadwheat variety Nasma 149 and 90% in the durum wheat variety Kyperounda in the Tessaout area. In barley nurseries, numerous lines coming from California having the Yd₂ gene provide good resistance. Resistance to BYDV has not yet been effectively incorporated into promising two rowed barleys.

Research done last year (El Yamani 1980) suggested that the aphid species, *Rungia maidis*, is a vector of BYDV. Strains of the virus present in Morocco include the PAV, RPV (*R. padi* specific, and the RMV (*R. maidis* specific strain with PAV the non specific strain being most abundant. BYDV seems widespread in Morocco.

References

- ABU MOHAMMED and MAHMOOD. 1973. Resistance to Helminthosporium Stripe in Barley Cultivars in India. Plant Dis. Repr. 57:495-499.
- BJARKO, M.E. 1979. Sources of and Genetic Action of Resistance in Barley in Different Virulence Types of Pyrenophora teres, the Causal Organism of Net Blotch; M.S. Thesis, Montana State University. 89 pp.
- BOULIF, M. 1975. Contribution a l'etude des Helminthosporioses de l'orge au Maroc, Memoire de 3eme Cycle Presente a l'Institut Agronomique et Veterinaire Hassan II. 54 pp.
- BOUMER, Ahmed. 1976. Tentatives d'evaluation de Pertes de Rendement Causees Par Les Principales Maladies Cryptogamiques de la Culture d'orge Dans la Region de Meknes. Memoire de fin d'etudes Presente a l'Ecole Nationale d'Agriculture de Meknes. 39 pp.
- BURLEIGH, J. 1981. Personal communications.
- CADDEL, J.L. 1976. Sources of Resistance to Powdery Mildew of Barley in Morocco. Plant Dis. Repr. 60:65-68.
- CADDEL, J.L., THOMPSON, A. and R.D. WILCOXSON. 1975. Quelques Aspects de l'amelioration de l'orge au Maroc. Hommes, Terre et Eaux. Volume 4:77-81.
- CADDEL, J.L. and R.D. WILCOXSON. 1975. Sources of Resistance to Net Blotch of Barley in Morocco. Plant Dis. Repr. 59:491-494.
- ECH - CHABI, M'hammed. 1977. La Maladie Striee de l'orge (H. gramineum Rab.): Influence Sur les Rendements. Memoire de Fin d'etudes Presente a l'Ecole Nationale d'Agriculture de Meknes. 37 pp.
- EL YAMANI, H. 1980. Identification Du Virus de la Jaunisse Nanisante de l'orge (VJNO) au Maroc. Memoire de 3eme cycle. Rabat. 84 pp.
- METZ S.G. and SCHAREN., A.L. 1979. Potential for the Development of Pyrenophora graminea on Barley in a Semi-Arid Environment. Plant Dis. Repr 63:671-674.
- NIELSSON, Bengt. 1975. Resistance to Stripe (H. gramineum) in Barley. International Symposium. Barley Genetics III:470-475.

- NDIAGY CHEIKH IBRAHIM. 1978. Essai de Lutte Contre les Deux Principales Maladies Foliaires de l'orge Dans la Region de Meknes: l'oidium. (E. graminis) et la Maladie de la Tache Brune (H. teres). Memoire de Fin d'etudes Presente a l'Ecole Nationale d'Agriculture de Meknes. 38 pp.
- ROLLI, K., LYAMANI, A. and MOUJANE, L. 1977. Maladies de l'orge Transmises Par Les Semences. Bulletin de la Protection Des Cereales. Bulletin de la Protection Des Plantes No. 2:3-10.
- TEVIODALE, B.L. and HALL, D.H. 1976. Factors Affecting Inoculum Development and Seed Transmission of H. gramineum. Phytopathology 66:295-301.

Table 1. Percentages of Fields Showing Slight (a), Moderate (b), or Severe (c) Attack by Various Foliar Diseases During Two Field Surveys in 1975^d and 1976^e.

Pathogen	a		b		c	
	1975	1976	1975	1976	1975	1976
<i>E. graminis</i>	20.8	14	20	31	20	24
<i>P. teres</i>	14	41	28	11	7	4
<i>R. secalis</i>	25	11	12	0	9	2
<i>H. sativum</i>	18	--	8	--	--	--
<i>Puccinia</i> spp ¹	0	0	0	1	0	0

1 Leaf (brown) rust was not severe in this survey but is one of the four most important diseases along with barley stripe. Leaf rust is especially severe in the Khemis Zemara area.

a Isolated spots in the field

b Foliar necrosis and chlorosis 5%

c Foliar necrosis and chlorosis 5%

d 66 barley fields inspected during the second week of April 1975

e 71 barley fields inspected during the first and second week of April 1976.

Table 2. Yields of Varieties Rabat 071 and Arig 8 (905) under Varying Levels of Net Blotch and Powdery Mildew Infections During the 1978 Growing Season in Meknes, Morocco.

Treatment	Average Net Blotch Score (a)	Average Powdery Mildew Score(b)	Yield Quintal/ha
Cultivar 071			
Untreated check	4.97	5.02	20.1
Methylthiophanat + maneb	3.38	3.33	29.1
Tridemorph	5.88	2.16	30.0
Cultivar 905			
Untreated check	3.59	3.64	43.5
Methylthiophanat + maneb	1.87	2.68	51.0
Tridemorph	3.67	1.57	55.0

- (a) Average of two observations taken at early heading (April 20) and 14 days later. Each observation involved disease readings on 40 plants selected on the 10 central rows within each plot. Disease ratings were made on a 0-9 scale.
- (b) Average of 5 observations taken every two weeks starting at the tillering stage, until 10 days after heading.
- (c) Whole plots harvested (16 m² each)

Table 3. Relationship Between Yield Loss and Net Blotch Severity on Several Barley Lines at Various Locations During a Two Year Study.

Year	Location	Variety	% <i>P. teres</i> at Soft Dough	% Yield Loss
1978-79	Tadla	013	56	7.7
	Douyet	013	83	11.0
	J'maa Shaim	43/75	73	26.0
1979-80	Sidi Kacem	Arig 8	8.3	19.6
		Br. Maroc	83.8	24.0
	Dcuyet	Arig 8	1	0
		Br. Maroc	5.7	0
	Tessaout	Agrig 8	12.2	14.8
		Br. Maroc	4.5	14.9

These data suggest that the old land race 013 might have greater tolerance than 43/75 under severe disease conditions. While 013, 43/75 and Brasserie Maroc appeared to be equally susceptible, Arig 8 which has some resistance, was disproportionately affected by the pathogen.

Table 4. Yield of Cultivars Rabat 071 and Arig 8 Under Varying Levels of Powdery Mildew Infection in Meknes, 1976.

	Cv. Rabat 071		Cv. Arig 8	
	Average P.M. Score (a)	Yield (b) (qx/ha)	Average P.M. Score (a)	Yield (b) (qx/ha)
Tridemorph	2.19	41.4*	1.63	42.5*
Methylthiophanat + maneb	3.24	39.1*	2.43	42.6*
Benomyl mancozeb	3.97	34.9	3.07	42.1
Untreated check	4.52	30.5	3.50	39.3

* Yields significantly superior (5% level) to those of untreated checks.

(a) Average powdery mildew score equals average of five observations taken every two weeks from late tillering, up to 10 days after heading.

(b) Yields based on harvest of whole plots (16 m²).

Data in Table 5 show that powdery mildew significantly reduced the number of fertile tillers per plant on both cultivars Rabat 071 and Arig 8. The kernel weight of Rabat 071 was significantly reduced by powdery mildew, while that of Arig 8 was not affected.

Table 5. Effect of Powdery Mildew on Yield Components of Cultivars Rabat 071 and Arig 8.

Yield Components	Untreated check		Tridemorph		Methylthiophanat	
	Rabat 071	Arig 8	Rabat 071	Arig 8	Rabat 071	Arig 8
Fertile tillers/plant (a)	1.2	1.6	1.9*	1.9*	1.9*	1.9*
Kernels/spike (a)	42.8	33.1	45.3	36.3	42.5	36.5
Kernel weight (mg)	50.1	50.0	52.4*	49.5	51.3*	50.0

(a) Each figure is the average of 120 observations.

Table 6. Comparison of Powdery Mildew Scores on USDA Elite Powdery Mildew Lines in Two Locations in 1974 and 1981.

Entry	Cultivar	Genes	Meknes (1974)	Rabat (1981)
CI 1017	Monte Cristo	Mla + Mlm	0	0
1016	Kwan	Mlk	2	2
928	Gold foil	Mlg	0	3
906	Hanna	Mlh	3	3
13130	<u>H. spontaneum</u> <u>nigrum</u>	Mla ⁶ + Mlm	0	3
6305	Psaknon	Mlp	1	2
6168	Long Glume	Ml-a?	1	0
4974	--	Ml-a?, Ml-at	3	3
3933	Vagabond	Ml-a?	1	2
3401	Multan	Mla	0	0-1
2483	Modia	Mlat	3	3
2444	Nigrate	Mlp + Mly	1	0
1179	Algerian	Mla _{a1} + Mlat	3	3
11555	--	Jmlsn	1	1
11549	Nigrinudum	Jmlnn	0	1
11546	Russian 81	Jmlr 81	1	1
7672	--	Ml-a?	0	0
7619	--	Ml-a?	1	2
7555	Engledow India	Mlna	0	0
6306	Ricardo	Ml-a ³	2	3
8503	--	Mla?	0	0
3400	Mianwali	Ml-mW	1	0
11567	Mulyan	Mu	1	0
13132	Gatersleben Mut 501	Ml-a ⁶	1	3

Table 7 demonstrates the difficulty which CIMMYT has in trying to breed barley for Morocco. In the 7th IBON, sixty percent of the lines observed for one disease in one location were more severely attacked than Arig 8, the control.

Table 7. Frequency Distribution in Percentage of Barley Entries Scored for Severity of Powdery Mildew in International Nurseries Grown at Buich, Rabat, Morocco.

International Nurseries	Year	0	Tr	1	2	3	4	5	6	7	8	9	Total Entries
5th IBON	1978-79	0	1	1	16	7	22	14	13	13	7	5	276
6th FON		15	6	16	17	14	13	7	4	5	1	1	369
7th IBON	1979080	--	--	--	--	12	6	11	11	20	19	21	269
9th FON		--	--	--	--	29	19	14	18	14	5	1	141
Two row checks (Orge IV and Orge I)													
Six row check (Arig 8)													

In 1979-80, scores lower than three were not given because of lower leaf senescence. Orge I and IV are highly resistant to mildew; Arig 8 is moderately susceptible.

Table 8. Prevalence of Barley Stripe Caused by *P. graminea* in Morocco.

Region	Average Infection Rate Observed (% Diseased Plants) (a)
Rabat - Casablanca	0.4
El Jadida - Essaouira	0.5
Marrakech - Settat	1.0
Beni Mellal	0.5
Fes	1.2
Oujda	2.0

(a) For each field, average infection rate was evaluated on the basis of counts made on 4-10 replications of 1 m² each.

Table 9. Effect of Two Seed Treatments on Stripe Infection in 12 Barley Varieties and Yield Increases Resulting from these Treatments.

Variety	Treatment Untreated check		Treatment with Panactine U. (b)		Treatment with Granopera (c)	
	% Stripe	Yield(a) (qx/ha)	% Stripe	%Yield Increase Over Check	% Stripe	%Yield Increase Over Check
1 Minnesota 23	0	23.9	0	-	0	-
2 Kozan	0	19.8	0	-	0	-
3 MFC 251	0	21.8	0	-	0	-
4 CI. 8422	0	20.6	0	-	0	-
5 Gem	1.2	26.2	0.7	1.9	0	8
6 Arig 8	1.2	25.5	0	2.7	0	10.1
7 Galt	9.0	22.6	0.9	11.06	1.4	12.4
8 Rabat 071	9.3	24.8	0	1.6	0	0.4
9 Hiproly	2.2	11.5	1.8	23.4	1.0	2.7
10 CI 9806	44	12.8	2.7	53.9	1.7	49.2
11 CI 14030	47	12.6	2.0	51.5	1.6	55.5
12 CI 14100	49	14.2	2.7	45	0.9	46

(a) Yields were measured on 2 x 3m plots (4 replications).

(b) Panactine Universal (=Fenfuran 7.5 + Guazatine 30% + Imazalil 1.5%) a fungicide obtained from Kenogard, Sweden.

(c) Organomercurial included for comparison.

Table 10. Percentage of Stripe-Infected Plants Resulting from Artificial Inoculation Using the Nielsson Method.

Variety	I _M	Fungus Isolate I ₃₉	Check (a)
Stanka X Esperance	0	0	0
CI 9737	0	0	0
CI 9359	0	0	0
Proctor X Esperance	2	2	0
Esperance	1	5	0
Kozan	0	7	0
Minerva X Esperance	3	5.5	0
Minnesota 23	4.5	7	0
Multan	2.5	9	0.5
Stanka X Esperance	5	7.5	0
Trophy	1	12	0
M. 22	1	12.5	0
CI 10779	7	12.5	1.5
MFC 251	12.55	9	1.5
Flynn 37	18.5	8.5	1.5
Blanco-Mariout	21.5	18	1
Kristina	14	32	1
Agri 8	19	33.5	1
CI 8422	19	39.40	0
Arivat	22	39.5	1
Orge IV	26.5	49	0.5
Hiproly	26	46	9.5
CPI 7737	17.5	65.5	1
Rabat 071	31.5	34	20.5
Galt	41	45	10
Gem	25	79.5	6.5
Merzaga 077	45.5	79.5	6
CI 14030	80.5	54	28
Atlas 68	72	64.5	26.5
CI 11008	65	66.5	38
CI 11008	57.5	67	48
CI 9806	74	79.5	49.5
CI 14100	62.5	77.5	43
Cebadalupe	80	81.5	24.5

(a) Infection resulting from natural seed borne inoculum. The seed was not disinfected before incubation.

Table 11. Fungi Species, Percentage of Infected Seed, and Average Percent of Infected Barley Seeds in 38 Samples from Moroccan Farmers.

Fungi	% Infected Seed Samples	Average Infected Seeds
<i>Cephalosporium</i> sp.	63	5.7
<i>Helminthosporium gramineum</i>	47	4.2
<i>Helminthosporium sativum</i>	34	0.7
<i>Helminthosporium teres</i>	21	5.5
<i>Fusarium avenaceum</i>	13	9
<i>Fusarium culmorum</i>	10	4.2
<i>Fusarium dimerum</i>	8	1.7
<i>Fusarium equiseti</i>	34	2.2
<i>Fusarium gramineareum</i>	8	2
<i>Fusarium moniliforme</i>	47	1.8
<i>Fusarium oxysporum</i>	8	1.7
<i>Fusarium semitectum</i>	13	1.6

Table 12. Observations of Smut on Barley in Five Regions of Morocco, 1975-76.

Disease	% infected fields	Max.	smutted ears	
			Min.	Ave.
Covered smut	78	10.7	0.7	1.2
Loose smut	57	5.6	0.1	0.5

BARLEY DISEASES IN SPAIN

J. Hernando Velasco*

The national barley hectarage is 3,518,000 hectares with an average yield of 2.29 mT/ha and a total production of 8,100,000 mT. Since 1968, the area dedicated to barley has just doubled whereas the total production has multiplied 2.5 times. Spain has 20 million hectares of areable land of which 40% is cultivated with winter cereals (wheat, barley, oats and rye). The area under barley cultivation represents 55% of the cereal land.

Of the barleys grown, 50% is winter barley, exclusively 6-rowed types, and the other 50% is spring barley, exclusively 2-rowed types. In both cases the yields are similar despite the fact that there are better spring varieties than winter ones.

Most of our barley is cultivated under dry land conditions without irrigation, and with a rainfall ranking from 400-600 mm per year. The main barley areas are Duero Valley (30% of the national hectarage, Ebro Valley (20% of the national hectarage) and Central Region (25% of the national hectarage).

The problems encountered in Spain are related to the following matters:

1. We have a good collection of Spanish land populations which has been assembled and evaluated properly. Such a collection, with approximately 2,000 entries, is very well adapted to our local conditions with good resistance to diseases (except powdery mildew), frost tolerance and drought tolerance. On the

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other hand it has disadvantages such as weak straw, shattering and lodging.

2. The main winter varieties under cultivation are local ones Albacete, Almunia, Berta (235%) and Hatif de Grignon (50%). These are Spanish varieties which were improved a long time ago, except Hatif de Grignon, which is French in origin. Nowadays, some Western European varieties are starting to be introduced, such as Ager, Astrix, Monlon, Precoce le Peuple, Robut, Sanja, Hop and Alpha (25%).
3. The spring varieties under cultivation, apart from 10% of land varieties, are of European origin and include Wisa, Beka, Logra, Lud, Pallas, Union, Trait d'Union, Karina, Hassan, Rika and more recently Koru. These spring types are used either for brewing or for feeding purposes, whereas the winter types are used only for feed.
4. Nothing has been done in breeding for quality. A project is being conducted to raise the lysine content and lower the fibre content (hull-less grain) using donor varieties from CIMMYT, and Hiproly, Riso 1508 and Nopal for lysine content.
5. The barley diseases recorded are powdery mildew (Erysiphe graminis)/ BYDV; scald (Rhynchosporium secalis); and Helminthosporium stripe (H. gramineum). Incidentally, but without economic importance, we can find spot blotch (H. sativum) and brown rust (Puccinia hordei). Of these, only powdery mildew, BYDV and Helminthosporium stripe are important, especially the first one. According to data from 1978 to 1980, the national incidence of powdery mildew was around 80% of the total barley area. To some extent it is controlled with

applications of Bayleton, although the cost of treatment is rather high (near 400 kilos of grain with two applications) and not too effective. In the agricultural year 1979-80, BYDV affected nearly 40% of the sown barley. Mild weather early in spring increased the population of aphids, mainly Sitobion avenae and Rhopalosiphum padi.

There are no accurate figures on the importance of Helminthosporium stripe, but we know it is important because the farmers tend to resow their seed without chemical treatment. As the price of selected seed is reduced (actually it is double the official price of barley grain), much more will be used by the barley growers and so this disease will become less and less important. Our varieties are highly susceptible, especially Berta.

Spot blotch was first reported in 1973 in breeding material. It was mainly observed in winter barley and we can expect it will come up with increasing seed rates, short stems, monoculture and with the introduction of new varieties. In our trials and nurseries, the following spot blotch scorings were obtained:

<u>Trial</u>	<u>Year</u>	<u>% Susceptible lines</u>
6th IBON	1978-79	5
Advanced lines	1978-79	20
7th IBON	1979-80	2
Advanced lines	1979-80	15

The scoring used was a scale ranking from 0 (soil level) to 9 (top of plant) with the value 5 for the mid point. Black-

points symptoms have never been recorded and nothing has been recorded above the mid-point value. In the present situation it is concluded that yield losses cannot be expected due to the fact that the green parts which are very active during grain filling are clean (flag leaf, peduncle, awns and spike).

Scald is not an important disease. It has been increasing since 1979.

Powdery mildew is the most damaging disease at present. From 1978 to 1980, more than 70% of our advanced breeding lines scored more than 5. Good sources for mildew resistance are the Western European varieties, especially Hop and Astrix. This disease has built up since the amount of nitrogen fertilizer started to increase. CIMMYT material is highly susceptible when sown in winter. We have seven advanced breeding lines ready for registration all high yielding and with lodging resistance but with high mildew scoring (all of them above 5). It is intended to start working on variety mixtures by bringing together 4 or 5 varieties differing from each other in mildew reaction but with similar maturity time, heading date and height. Problems to be taken into account are competition effects and selection pressure, which can shift the initial composition of the mixture.

Leaf rust is not a problem any longer because there are good sources for resistance in the local populations.

During the agricultural year 1978-79, there was an outbreak of cereal cyst nematode (Heterodera avenae) in nearly 30% of the cereal area of Andalusia and nearly 20% of the cereal area of the Central Region. It was because of abnormal

temperatures in autumn. Resistance is controlled by a dominant gene A, and Sarbarlis and Tintern are good donors for resistance. However, it has been decided not to start a backcross program. Instead several crop management rules will be used to control it. Among them are burning straw, crop rotation, using weed-killers, pulling up weeds by ploughing, extra nitrogen fertilization, etc.

The breeding objectives in the barley improvement project are:

1. Increase yield of the local varieties, especially in winter types, in order to reduce the land under cultivation but at the same time to maintain the total production. At present there is self-sufficiency in barley. However, 30% of the barley is located in durum wheat areas because of the Government price policy. The cultivation of durum wheat has started to be stimulated and therefore a shortage in land available for barley can be expected. Lodging resistance should be introduced. Good sources for both yield and lodging are in the Western European varieties mentioned above.
2. Introduce resistance to powdery mildew and BYDV. Some crosses between Spanish winter barleys and USDA barleys exhibit a reasonable level of resistance. Other sources which have proved highly successful are the F₂ Spring X Winter from CIMMYT.
3. Get barley adapted to the environmental conditions in Spain, with a high lysine content and naked grain. This can be used to substitute maize in feeding pigs and poultry. Every year, Spain imports 4.5 million metric tons of maize.

4. Develop good spring barley types suitable for cultivation under both irrigated and rain fed areas. These types should be of short growing period, stiff-strawed and disease resistant. CIMMYT material would be useful, provided that a cooperative network of field trials can be organized.

BARLEY DISEASES IN TUNISIA AND SOURCES OF RESISTANCE

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Introduction

Barley is the second most important cereal crop in Tunisia. About 55,000 tons were consumed in 1978 as human food and four times as much as animal feed. During the 1979-1980 season, barley has been grown over 360,000 ha producing 220,000 cereal tons. This represents 30% of the area planted to cereals and 22% of the total production. The dominant barley varieties are Martin and Ceres, the former being much more extended in the Central part of the country.

Barley production at present is limited by the agricultural practices, climatic conditions, disease and the low yield potential of local cultivars.

With the assistance from ICARDA, the main objective of the Tunisian Barley Program is to breed varieties that have a high and stable yield, disease resistance and drought tolerance. In the Program, efforts have been made to identify lines with different sources of resistance.

Material and Methods.

A wide disease survey covering many barley fields in different agro-climatic conditions in the northern and the

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central areas of Tunisia, was commenced 2 years ago. Disease identifications were made from common symptoms and/or by microscopic examination (Boewe 1960; Dickson 1956).

The different lines coming from ICARDA, CIMMYT and FAO Barley Programs were screened under conditions of natural infection by the different diseases prevailing at Beja, Mateur, Kef and Fahs, during the cycle 1978-1979 and 1979-1980.

Scoring for rusts, and other foliar diseases was done according to Loegering, and 0-9 scale, respectively.

Results

The resistant and moderately resistant lines tested during the last 2 years to different diseases are shown in Tables 1-7.

Barley Diseases in Tunisia

The major and the minor diseases and their importance in the different barley areas in Tunisia are briefly described below:

Powdery Mildew (*Erysiphe graminis*)

It occurs on barley, wheat and other grasses in the North and Center of Tunisia. Although some of the barley varieties are tolerant, many of the introduced lines are more susceptible to powdery mildew than local varieties, to the extent that the severity of symptoms on some of the introductions masks other foliage diseases.

The attack usually starts in early March and becomes serious during April infecting all aerial portions of the plant. Certain lines react to *E. graminis* by exhibiting black

spots of different sizes similar to symptoms of spot blotch, thereby creating a difficulty during notation time to distinguish between the two diseases.

Net Blotch (*Helminthosporium teres*)

This disease exists in all barley fields and is one of the main barley diseases. It also attacks wild barley.

Symptoms appear early in March and can be critical at the end of the month and the beginning of April. Blotches are longer in the cool regions (12^o-15^oC) and cover all the leaf area. In Central Tunisia where the spring temperature is higher than 20^oC, the blotches are frequently associated with leaf edges.

Barley Stripe (*Pyrenophora graminea*)

It is a great problem in the North and the Center because of the utilization of uncertified seeds. In late February, it causes seedling blight and later, the leaves and tillers of infected plants die gradually.

This year in the Kairouan region, about 15% of Martin variety plants were completely killed at the boot stage. All plants of some of the introduced lines died at Beja experimental station. Apam-Gva = CMB 72-1-6Y-B-OY.

Spot Blotch (*H. sativum*)

It is a disease of little importance and is not widespread. It only starts in the late stages of plant development. Symptoms appear mostly on the upper leaves which are already infected by other more frequent diseases. This pathogen can infect the lower parts of the plant causing foot

and root rot.

Scald (*Rhynchosporium secalis*)

The disease is frequent in the North and the intermediate zone on the local varieties. Its severity varies from year to year. It is unusual for it to appear in Central Tunisia.

Symptoms start as early as those of net blotch in early March. During the 1979-80 and 1980-81 cycles, many lines in the International Nurseries were highly susceptible at Beja, Mateur and Kef. Scald exists also on wild barley.

Loose and Covered Smuts (*Ustilago nuda*; *U. hordei* respectively)

Loose smut is very common in most barley fields from the North to the South, whereas the covered smut occurs only in the Center and the South, especially on Martin and other local varieties. In the Kairouan region for instance, 20% of the heads of Martin were infected by covered smut during the 1979-80 cycle.

Leaf Rust (*Puccinia hordei*)

This disease is important in the North and less frequent in the Center. It normally starts in April when the temperature exceeds 20°C. It becomes epidemic if it rains during late March- early April. In the 1979-80 cycle, a few lines of the introduced material showed some resistance under Beja conditions.

Stripe Rust (*P. striiformis*)

It was noticed during April 1980 in the cool regions. At

Mateur, some lines were completely wiped out, ie. R. T. Ramages (11-13, 7AP and AP Bulk-9). It was also seen in the Beja and Kef regions.

Foot and Root Rots (*H. sativum*; *Fusarium* spp)

This complex of pathogens occurs mainly in the Center. The dominant pathogens in this complex are *H. sativum* and *Fusarium* spp. Plants at different stages are exposed to infection, causing damage to seedlings and tillers. The infected plants lodge and dry at the boot or heading stage.

Bacterial Stripe (*Xanthomonas translucens*)

It is a minor disease, mainly in the northern Tunisia. It has been observed mostly on some lines of the International Nurseries.

Barley Yellow Dwarf Virus

It exists in the different experimental stations as well as in the commercial fields. This disease attacks oats, barley and wheat. It was epidemic on these three crops in the 1978-1979 cycle.

The severity ranges from a slight effect to stunting, depending on the time of infection.

Discussion

In Tunisia, there is a wide range of barley diseases which present a potential threat to yield in a given year. Although some diseases commonly occur in Central and Northern Tunisia, others are specific to one region. Leaf stripe and net blotch are still the most important diseases in both regions (Saari

and Prescott 1977).

Many of the introduced lines are resistant or moderately resistant to one or more of the diseases. Some of them are resistant to 5 diseases (Table 1).

The agro-climatic conditions of the barley region are variable and affect the prevalence of pathogens. As a result, different varieties may be needed for the southern, central and northern areas.

References

- BOEWE, G.H. 1960. Diseases of Wheat, Oats, Barley and Rye, Illinois Natural History Survey, Circular 48, 157 pp.
- DICKSON, J.G. 1956. Diseases of Field Crops, McGraw-Hill Book Company Inc., New York, 517 pp.
- SAARI, E.E. and PRESCOTT, J.M. 1977. Barley Diseases and their Surveillance in the Region. Pages 320-330 in Fourth Regional Winter Cereal Workshop-Barley, Vol. II, Amman-Jordan, April 24-28, 1977.

Table 1. Barley Lines With Resistance or Moderate Resistance to Leaf Rust, Stripe Rust, Powdery Mildew, Net Blotch and Scald at Beja and Mateur, 1979-1980.

Manuet	IL-OAP
Tunis - XV 2240	
Vanguard	
Legia	
Alger/Union 385-2-2	
II 258/L 2179-74	
9120/CI 13280 (5 Cr 276/92)	
Promesa/Arivat	CMB 72 A-94L-2L-4AP
Aurore/Esperance	LB-2L-9L
Bante 025	
M 65. 127/M 66. 91. 1//Hja	
Koher	
Roho	
Api/CM67//Asse	CMB 74 A-964-3S-OAP
WI 2291	
AS/Tra/Cer//Toll/4/Avt/Ki// BZ/3/VT/5/Pro	CV-2780-1R-5R-1M
Arimar/2763-6L-OSK	
Impala/Magnif 102	

Table 2. Barley Lines With Resistance or Moderate Resistance to Leaf Rust, Stripe Rust, Powdery Mildew and Scald at Beja, 1979-1980.

Aurore/Esperance	LB 21-1L
Api-CM67 x B1	CMB 75-88-4Y-1M-1B-2Y-OP

Table 3. Barley Lines With Resistance or Moderate Resistance to Powdery Mildew, Net Blotch and Scald at Beja, 1980.

ER-Apam	
CM 67-Sv Mari	CMB72-140-8Y-1B-3Y-1B-0Y
WI 2198	
Coho-Zephyr	Kronstad 72-73-39-1B-1Y-1B-1Y-0B
Nordgrol-Kristina, Ca 12551	
SV 66 344-Iris Ca 12551	
110 12.2-Impala x Birence	CMB74A-1697-B-2B-2Y-0B
Api-CM67 x Nackta	CMB75-415-12Y-2B-1Y-1B-2Y-0B
Api-CM67 x Nackta	" " " " " "-3Y-0B
CM67-U. Sask-1800xPro- CM67/RM1508	CMB75-527-6Y-1B-1Y-1B-1Y-0B
RM 1508 x Api - CM67	CMB 75-613-41Y-1B-1Y-1B-1Y-0B
Arivat x Local D8	
Setzes	

Table 4. Barley Lines With Resistance or Moderate Resistance to Leaf Rust and Powdery Mildew at Beja, 1979-1980.

FL 80-1	
CLF 525	
Mazurka	
Asse - Nackta	6399/3002-1B-1Y-1B-0Y
Asse	
Lechtaler	
Api-CM67 x Mzq	CMB73A-367-500B-500Y-0B
Klapes 11 Ach 989/Bine	Oregon S.F.220-3S-1S-0S

Table 5. Barley Lines With Resistance or Moderate Resistance to Net Blotch and Scald at Beja, 1979-1980.

Arivat	
Manker	
Conquest	
Clipper	
Bamba x Jo-Galt/Api-CM67 x 110 12.2	CMB 74A-1597-E-4B-1Y-1B-1Y-0B

Table 6. Barley Lines With Resistance or Moderate Resistance to Powdery Mildew and Scald at Beja, 1979-1980.

Bco.Mr-Godiva	
Minn 126-CM67	
Emir	
HP 119/7	
Aramir	
Sualof Rupal	
CLF 796	
Celaya-WI 2269	CMB 74A-44-4B-1Y-1B-1Y-1B-0Y

Table 7. Barley Lines With Resistance or Moderate Resistance to Powdery Mildew and Net Blotch at Beja, 1979-1980.

Bonus	
Zephyr	
Hja C 4215	
Carben CI 14007	
CB 1227 CI 14010	
CI 13540	
Alger - Ceres	362-1-1-OAP
EH 8B/FY EL-GC	
Sultan x Cr 115 - Por	CMB 79-297-3y-1B-1Y-0B
A 16-Sv Mona	CMB 73A-249-4S-5S-0S
Celaya - CI 3909.2	CMB 73A-790-11B-1Y-3B-500Y-0B
CI 8887 - CI 5761	SEA-13-285-6S-0S

SUMMARY OF BARLEY DISEASES AND IMPLICATIONS**E.L. Sharp***

During the last three days, we have talked about many different things pertaining to disease resistance, and it would be presumptuous of me to think that I could accurately summarize all the various aspects that have been discussed. I will, therefore, deal only with some of the highlights.

Our idea in having this workshop was to get people together who have certain goals in common, who are interested in improving barley, and who have the latest information on controlling barley diseases and their implications.

Prevalence of Diseases

The ranking of disease importance on a long term basis in each region is quite well established for specific diseases. However from time to time, local outbreaks occur and often a person tends to focus on them instead of pursuing the long term approaches to disease problems.

During the workshop, questions arose several times on which diseases should be emphasized, and should certain people or certain locations take the responsibility for specific diseases. I think that these are good points, and ones that need to be further considered because naturally, there is no one place nor accumulation of people in one area who can devote a lot of time to all the major diseases of barley.

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Disease Losses

We need more information and concrete evidence on just how much loss is being caused by specific diseases. There have been good surveys on the smuts where there is generally a direct relationship on a one-to-one basis.

With a number of other diseases, the time that they take to develop is very important. We also have situations, for example, where a plant may be heavily diseased with rust that may appear fairly early; but if the crop is tolerant to this disease, it still may not cause much loss. We need definite evidence on just how much loss this disease is really causing. We should know the qualifying factors on when does it need to start, and to what extent must it develop in order to attain more reliable disease-loss data.

We should be concerned with the other factors that are affecting yield components and should be able to separate the ones caused by diseases from those factors that limit yield components.

Major Genes and Minor Genes

We have had quite a discussion on major and minor genes. I think that in some cases we are talking about the same thing. If one believes that the major genes alone will also do the job, by all means use them.

Yesterday, Dr. Schaller advised that the Yd_2 gene, for example, can vary from a high resistance to almost complete susceptibility depending on what other genes are in the host background. We must always consider these background genes whether we call them residue genes, partial resistance genes,

minor genes or some other name. I think that they may be expressed in different ways and in some cases, there is not any hypersensitivity.

There are the so-called slow rusters, and slow mildewers which have a normal-size pustule but do not develop to the same amount on plants as susceptible check; the severity is low and yield losses are relatively small. At the same time, we have evidence that we can put genes together from varieties that normally appear susceptible and obtain resistance from them.

Plant Protection

So far in this workshop, resistance is the one type of disease control that has been particularly emphasized. I think we need to look at control of barley diseases from the standpoint of plant protection.

Plant protection involves the whole gamut of control measures. Disease resistance is but one measure and, although it is one of the major control measures, others of importance are chemical treatments and crop rotations; sometimes a combination of these other control measures are most effective.

New Diseases

We have heard about Molya disease in India which is apparently caused by a combination of nematodes and bacteria. An interesting case of Alternaria alternata f. hordei has also been reported from India.

Root Rots

This group of diseases has not received the emphasis which

it deserves. Dr. Mathre attributes this partly to their not being readily seen as with rust and mildews which exhibit abundant top symptoms. It is difficult to work with root rot diseases. There are a number of factors which cause symptoms in plants that could be caused by root rots or by non-parasitic causes such as frosts.

However, there appear to be some methods that can be used for working with root rot. One of the main and easiest ones is to select for high yield which automatically results in obtaining some resistance. Somebody has pointed out that if you take hold of a plant and it pulls out of the soil easily, it is quick evidence that there is a root rot organism present. Every two years, it is necessary to rotate to a different crop to obtain some idea of the severity of root rot.

Disease Surveillance

Surveillance trap nurseries which have been conducted by CIMMYT for a number of years have been very good. Dr. Prescott from CIMMYT has told us about improved data collection, computer programming and the analysis of these data. This will be very useful for people working on disease resistance.

Atmospheric data for disease prediction is being collected by about 20 satellites which are circling the globe; some are gathering information on an hourly basis, others collect data at different time periods, and some are recording only maximum and minimum temperatures.

Studies of the data collected together with our studies of some of the diseases will enable the forecast of an epidemic to be made with a higher probability.

Inoculum has been mentioned frequently in the workshop. A lot more information should be gathered on inoculum potentials. We could easily hold a two- or three-day conference on the subject of inoculum.

THE MONTANA-USAID PROGRAM FOR THE DEVELOPMENT
OF BROAD-BASED RESISTANCE IN BARLEY

H. E. Bockelman, E. L. Sharp, and R. F. Eslick*

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

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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 populations, thus preventing such multiple mutations from becoming widespread (Parlevliet and Zadoks 1977). There is, also, evidence that multi-genic resistance may have 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 this resistance.

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 (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. hull-less, 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 (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 "multiline", 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 has 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 (RSP-5 Rrs). 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 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 populations were each started individually to keep selection pressures and population sizes 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.

References

- BOCKELMAN, H. E., ESLICK, R. F., and SHARP, E. L. 1980. Registration of Barley Composite Cross XXXVI. *Crop Sci.* 20:675-676.
- NELSON, R. R., MACKENZIE, D. R., and SCHEIFELE, G. L. 1970. Interaction of Genes For Pathogenicity and Virulence in Trichometasphaeria turcica With Different Numbers of Genes For Vertical Resistance in *Zea mays*. *Phytopathology*, 60:1250-1254.
- PARLEVLIET, J. E. and ZADOKS, J. C. 1977. The Integrated Concept of Disease Resistance: a New View Including Horizontal and Vertical Resistance in Plants. *Euphytica* 26:5-21.

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

Herta	Union
Ingrid	Vireo
Bruens Wisa	Summit
Zephyr	Maris Mink
Early Betzes	Hull-less Compana
Dekap	Cumhuriyet 50
Hector	Two-row, hull-less Glacier
Waxy Compana	Compana msg 10

Table 2. Agronomic Varieties in the 6-row populations.

Gem	Steptoe
Unitan	Hull-less Vantage
Arimont	Hull-less Glacier
Waxy Titan	Minn. 21
Nordic	Athenais
Atlas 68	Atsel
Beecher	CM 67
Galt	Manchuria (2330) msg 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.XXVI)	(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 <u>Xanthomonas</u>)
RSP-5 Rps	(6-row <u>Pseudomonas</u>)
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 RrsMinor	(2-row scald, minor genes)
RSP-4 Rpt Minor	(2-row net blotch, minor genes)

**THE ICARDA BARLEY PROGRAM AND EFFORTS IN
BREEDING FOR DISEASE RESISTANCE**

M. S. Mekni and A. H. Kamel*

The improvement of small grain cereals is one of the major responsibilities of ICARDA with a primary responsibility for the production and improvement of barley germplasm. ICARDA's barley program is in its fourth year. It is large, expanding and contains a diversified collection of nurseries, yield trials and segregating populations. The major thrusts can be grouped in the following five fundamental research objectives:

1. Development of two and six-row barley genotypes with greater yield potential, yield stability, disease resistance, adapted to short, medium and long maturity duration environments.
2. Development of drought tolerant genotypes adapted to low rainfall areas.
3. Development of dual-purpose barley types for grazing and grain production under the various farming systems of the ICARDA region.
4. Development of hull-less barleys with improved nutritive value, acceptable grain appearance and processing qualities for use as human food and livestock feed.
5. Development of winter habit barley germplasm for high altitude, cold and winter growing areas.

ICARDA's program efforts to improve the disease resistance

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of the barley germplasm is a major component of the breeding strategy, and since the workshop's focal point is on barley diseases and associated breeding methodologies, only this part of the program activities will be discussed in this paper.

Disease resistance is considered throughout all the stages of line development. Moreover, it is the main criterion on the basis of which the line is discarded from the disease nursery or promoted to observation and yield testing nurseries. All barley germplasm, whether generated at ICARDA or introduced from cooperating programs and institutions enters disease nurseries as the first stage of the line testing (Table 1). Promising lines are promoted for observation and yield testing and into a Key Locations Disease Nursery (KLDN).

The objectives and methodology of the disease resistance work can be grouped as follows:

1. Identification of Sources of Genes Governing Resistance to Priority Barley Diseases

During each crop season, the resistance to diseases of all barley germplasm is evaluated. The material is screened under plastic house conditions as adults, to the three rusts and powdery mildew. Screening is also done under field conditions at Tel Hadya and Lattakia, Syria and at Terbol, Lebanon for leaf rust, powdery mildew, scald and covered smut and in the region for prevalent diseases. The lines identified as showing a good level of resistance are further used afterwards in the breeding program.

Tables 2 & 7 show the lines identified for resistance to the main barley diseases during 1978-79 and 1979-80.

2. Identification of Types of Resistance to Each of the priority Diseases

Each year disease data are carefully analyzed. They are gathered mainly from the regional nurseries grown under a wide range of environments. The lines are grouped according to the similarity in reaction to each disease at the various locations where certain diseases are usually severe. Then the most frequently selected entireties from these groups on the basis of performance in the region are intercrossed in an aim to pyramid the genes for resistance to each disease.

Tables 8-18 show examples of these groupings for the main barley diseases in the ICARDA region.

3. Utilization of Genes Governing Resistance to Build Germplasm with Multiple Disease Resistance

In its breeding program ICARDA uses material containing multiple disease resistance genes and also those which are resistant to a particular disease.

The emphasis is given to develop stocks with different sources of resistance genes and to develop lines with multiple disease resistance which greatly depends upon the importance of the disease in the region, the number of genetic backgrounds and their agronomic types. The F_1 lines obtained by combining disease resistance are later used in top or double crosses with other barley lines or F_1 's having good yield and wide adaptation (Table 19).

Analysis of disease data from the ICARDA region in 1979-80 has indicated that three lines combined resistance to five of the following diseases: the three rusts, scald, net blotch,

and powdery mildew, and that 31 combined resistance to four of the above mentioned diseases (Table 20).

Similarly analysis of 1980-81 data showed that the variety Asse has a good level of resistance to six diseases, Alouette has resistance to five diseases, four varieties have resistance to four diseases, nine varieties are resistant to three diseases and Martin barley variety has a good level of disease resistance to leaf rust and the cyst nematode (Table 21). These varieties are extensively used in the breeding program to upgrade the level of resistance.

4. Use of the Male Sterile Facilitated Recurrent Selection Populations (MSFRSP) to Develop Germplasm with Multiple Genes for Resistance

The objective here is to develop resistance in diverse, yet desirable, genetic backgrounds to the local (Syrian) populations of scald, net blotch, and powdery mildew.

ICARDA has the following recurrent selection populations (RSP):

(1) RSP-5 Rrs: developed at Montana State University for R. secalis (scald). It has resistance to North American isolates of scald.

(2) RSP-5 Rpt: developed at Montana State University for resistance to H. teres (net blotch).

(3) & (4):

CCXXXIIIA)

CCXXXIIIB)

Both were developed for tolerance to Barley Yellow Dwarf Virus (BYDV). The first population has also short, stiff strawed types not present in the second.

(5) RSP-5 Reg (rs pt): made up of 50% of RSP-5 Rrs and 50% RSP-5Rpt; it is being developed for resistance to powdery mildew.

5. Key Location Disease Nursery (KLDN)

During the crop season 1979-80, a key location disease nursery was established to put a high selection pressure on diseases at key locations in the region where natural attacks are severe for the major barley diseases and virulences. A set of 1200 entries representing the most advanced barley lines in addition to sources of resistance to different diseases are planted during the current season at "hot spot" locations. These locations and the diseases they cover are presented in Table 22.

Table 1. Composition of Disease Screening Nurseries.

Nursery	No. of Sites	Germplasm Material Included
Regional Disease and Insect Screening Nursery (RDISN)	40 - 60	Lines and cultivars coming from national and international programmes. Sources of resistance to different diseases.
Initial Disease Nursery (IDN)	4	ICARDA's early and later generation bulks. Material in initial yield trials. Promising nursery material from the previous season.
Key Location Disease Nursery (KLDN)	10 - 13	Material in preliminary and advance yield trials. Sources of resistance to different diseases.

Table 2. Lines Resistant to Scald (*Rhynchosporium secalis*) Identified in the Region During 1978-79 Season.

Line and pedigree	Location and Disease Score*			
	Ethiopia Holetta	Finland Hankkiiia	Cyprus Nicosia	Portugal Elvas
Herawi	5	1	2	1
Chile Comun / An 57 CMB 73A-8-3011-OAP	3	0	0	3
Chile Comun / An 57 CMB 73A-8-3012-OAP	4	1	1	5
Centinela	3	1	5	1
6 - 73	3	1	0	4
Abyssinian 33	5	1	0	1
Godiva	5	1	1	4
Average infection of all entries of this nursery	8	2	3	7

* (0-9) Scale for appraising foliar diseases.

Table 3. Lines Resistant to Scald (*Rhynchosporium secalis*) Identified in the Region During 1979-80 Season.

Line and pedigree	Location and Disease Score*			
	Syria Lattakia	Syria Tel Hadia	Tunisia Le Kef	Turkey Izmir
Beecher	4	0	1	2
Lignee 686 (Montpellier)	-	3	0	1
Tanekase 2/Baitori//Aths	2	1	1	0
As 46/pro//Baladi 16/Api	0	0	1	0
As//DWG 1Ms00dM59.24 //2*Api	0	1	1	0
CI 7117-9/Deir Alla 106	1	0	2	0
CM 67/Apm//Gva	0	T	1	0
Cevada = (CI 455)	1	0	1	0
FB - 489-6-3 x -2	0	0	2	0
B 225 / Research	0	0	-	0.5
Calhoun 3	1	0	1	0
CI 2543	2	1	1	0
Gold Foil	0	1	1	0
Alger / Ceres,362-1-1-OAP	2	0	-	0
Overall average infection for all entries in this nursery	3.3	5.1	6.5	3.7

*(0-9) scale for appraising foliar diseases.

Table 4. Lines Resistant to Powdery Mildew (*Erysiphe graminis hordei*) Identified in the Region During 1978-79 Season.

Line and Pedigree	Location and Disease Reaction*						
	Egypt Giza	Greece Thessal- aloniki	Spain Barc- elona	England Camb- ridge	Leb- anon Terbol	Fin- land Hank kiia	Yemen Taiz
Minn126/CM67	0-1	2	-	5	-	1	-
Kokubi 1 Cup54	-	3	2	5	0	2	0
CI887/CI5761 SEA 13-285-OS	0-1	3	3	3	0	5	0
Chevron CIIIII/Coho SEA G-43S-5S-OSS	3	3	-	4	0	4	0
CI8887/CI5761 SEA 13-20S-1S-OS	3	2	1	3	0	2	0
CI8887/CI5761 SEA 13-24S-3S-OS	3	5	1	2	0	1	0
CI8887/CI5761 SEA 13-24S-1S-OS	2	2	1	4	4	3	0
CI8887/CI5761 SEA 13-24S-3S-OS	1	3	1	3	0	4	0
Menuet	3	3	1	4	1	1	0
Carina	2	2	1	4	0	1	0
Overall average of all entries in the nursery.	6.8	7.4	4.9	5.4	2.2	4.3	7.8

* (0-9) scale for appraising foliar diseases.

Table 5. Lines Resistant to Powdery Mildew (*Erysiphe graminis, hordei*) Identified in the Region During 1979-80 Season.

Line and Pedigree	Location and Disease Reaction*					
	Cyprus Athal- lassa	France Mont- pellier	Jordan Deir Alla	Turkey Izmir	U.S.A. Beltsville	Syria Tel- Hadia
Athos	1	2	0	1	1	1
Lignee 640 (Montpellier)	1	2	1	3	-	1
Lignee 1479 (Montpellier)	1	0	0	3	1	0
MV - 46	1	3	0	3	1	1
Gula Abed	0	2	0	1	1	1
Kite	0	0	0	2	1	1
Keg	0	0	0	2	1	1
Claret	0	0	0	2	1	2
Dram	-	0	0	0	1	1
Minn 126/ CM 67	1	0	1	2	1	1
Arivat / 2763-7L	1	0	-	2	1	1
Al6-B	1	0	-	2	1	2
Nordgrol/ Kristina	1	0	-	3	1	1
Sv 66344/Inis	1	0	-	2	1	1
Cr 451-4	1	0	0	4	1	0
Overall average for for all entries in this nursery.	4.3	7.5	1.4	4.5	4.5	5.9

*(0 - 9) Scale for appraising foliar diseases.

Table 6. Lines Resistant to Leaf Rust (*Puccinia hordei*) Identified in the Region During 1978-79 Season.

	Greece Thessaloniki	Pakistan Islam- abad	Pakistan Faisal- abad	Cyprus Nicosia	Yemen Taiz	Ethiopia Eoletta	Egypt Sakha	Spain Barce- lona	Kenya Njoro	Afghan- istan Kabul	England Cambridge
Cr270-2-3	5MR	0	0	5R	0	20MS	10MS	T	0	0	0
Cr366-73-2	5MR	0	0	5MR	0	TMS	5S	5MR	0	0	MR
Dabaku D837	5MR	TMP	0	R	0	-	30MS	-	TMS	0	R
Cr366-16-2	5MR	0	0	10MR	5S	TMS	20MS	TR	0	0	R
Harbin/Avt// Attiki Cyb 19- 1A-OA-OA	10MR	5MR	0	10MR	20MS	10MS	5MS	5MS	TMS	0	R
Vanguard/Julia// Zephyr Kronsted72- 73-89-1B-1Y-1B- 1Y-OB	10MR	20MR-MS	5R	3R	20MS	TMR	5MS	T	TMS	0	MR
Average coefficient of infection of all entries in this nursery (ACI)	6.3	6.7	15.0	11.4	42.5	15.10	14.1	41.0	26.9	4.8	19.7

Table 7. Lines Resistant to Yellow Rust (*Puccinia striiformis*) Identified in the Region During 1978-79 Season.

Line and Pedigree	Location and Disease Reaction				
	Afghanistan	England	Kenya	Pakistan	Pakistan
	Kabul	Cambridge	Njoro	Faisalabad	Islamabad
Er/Apm.	0	R-MR	TMS	0	TMR
W.W.Tether	0	R-MR	0	0	5MR
S 72159	9	M	TMS	0	TMR
Belfort Barley	0	R-MR	0	1.5MR	10MR/MS
Purdue 5623A-1315P	0	M	TMS	0	TMR
Pro/Kristina CMB73-18-1Y-3B-1Y-OB	5MS	R-MR	TMS	0	50MR/MS
CI8887/CI5761 SEA13-28S-OS	5MR	M	TS	0	15MR/MS
Chevron CIIIII/ Coho SEA/G-43S-5S-OS	TR	R-MR	TMS	0	0
CI8887/CI5761 SEA13-10S-4S-OS	0	R-MR	0	10MR	TMR
Minuet	TR	R-MR	0	0	TMR
Average Coefficient of infection for all entries in the nursery (ACI).	21.3	9.5	4.7	13.4	6.1

Table 8. Barley Lines and Cultivars Grouped According to Similarity in Reaction to Scald at Different Locations During 1978/79.

Varietal group	Location and Disease Reaction			
	Ethiopia	Finland	Cyprus	Portugal
	Holetta	Hankkiia	Nicosia	Elvas
A	R	R	R	R
B	R	R	R	S
C	S	R	R	R

Table 9. Barley Cultivars Grouped According to Similarity in Reaction to Scald (*Rhynchosporium secalis*) in 1978-79 in Different Locations.

Varietal Group	Line or Pedigree	Frequency ¹
A	Centinela	12*
	Chile Comun/An57 CMB 73A-8-3011-OAP	5
B	Cr366-16-2	7*
	Chile Comun/An57 CMB 73A-8-3010-OAP	5
C	Manchuria	10*
	CI8887/CI5761 SEA 13-28S-OS	9*
	CI8887/CI5761 SEA 13-23S-3S-OS	9

¹- Frequency-Number of locations at which the line was selected as adapted and good yielder.

* Selected for intercrossing to pyramid the genes.

Table 10. Barley Lines and Cultivars Grouped According to Similarity in Reaction to Powdery Mildew (*Erysiphe graminis hordei*) at Different Locations.

Varietal Group	Location and Disease Reaction							
	Egypt Sakha	Egypt Giza	Greece Thessal- oniki	Spain Barce- lona	Lebanon Terbol	England Cambridge	Finland Hankkiia	Yemen Taiz
	R	R	R	R	R	R	R	R
	S	R	R	R	R	S	R	R
I	S	R	S	R	R	S	R	R
II	S	R	S	S	R	S	R	R
	S	S	R	R	R	S	R	R
	S	R	S	S	R	R	R	S

Table 11. Barley Cultivars Grouped According to Similarity in Reaction to Powdery Mildew (*Erysiphe graminis hordei*) During 1978-1968.

Varietal Group	Line and Pedigree	Frequency
A	Minn 126 / CM 67	9*
	CI8887 / CI5761 SEA 13-28S-OS	9*
	CI8887/CI5761 SEA 13-24S-OS	9
BI	CI8887/CI5761 SEA 13-16S-6S-OS	8*
II	Purdue 5623A=1315P	8*
III	2762/Beecher-6L	8*
C	Vanguard/Julia//Zephyr K.72-73=89=1B-1Y-1B-1Y-OB	9*
	Esp. /1808-2L	6
D	6-73	5*

* Selected for intercrossing to pyramid the genes for resistance.

Table 12. Barley Cultivars with Good Resistance to Net Blotch (Helminthosporium teres) in the Region.

Line and Pedigree

Mari / Coho

CN42/CI7772//Fun/Fun/3/Tch/4/Fun/Ki
DII-11694-2R-Bulk-7N-4N

Cr 355-8 (Giza 120x N.S.43)

Centinela

Purdue 5623A-1315 P

CI8887/CI5761

SEA 13-28S-OS

Table 13. Groups of Barley Lines Characterized by Similar Reaction to Leaf Rust in Different Locations.

Varietal Group	Location and Disease Reaction							
	Greece Thessa- loniki	Pakistan Islama- bad	Pakistan Faisala- bad	Yemen Taiz	Egypt Sakha	Spain Barcelona	Afghanistan Kabul	England Cambridge
A	R	R	R	R	R	R	R	R
B	R	R	R	R	R	R	R	S
C	R	R	R	R	R	R	S	R
D	R	R	R	R	R	S	R	R
E	R	R	R	R	S	R	R	R
F	R	R	R	S	R	R	R	R

Table 14. Barley Cultivars Grouped According to Similarity in Reaction to Leaf Rust (*Puccinia hordei*) in Different Hot Spot Locations During 1978-79.

Varietal Group	Line and Pedigree	Frequency
A	Cr270-2-3	6
	Cr366-16-2	7
II	Vanguard/Julia//Zephyr K.72-73-89-1B-1Y-1B-1Y-OB	9*
III	H 272 500Y-500B-500Y-OB	10*
BI	Mari/CM67//Pro CMB 72A-211-C-1B-2Y-1B-1Y-OB	7-
	WI 213// 2	8
II	CN 42/CI 7772//Fun/Fun/2/Tch/4/Fun/Ki II-11694-2B-Bulk-7N-4N	9*
CI	Gizeh 68/7028-L26-5L	9*
II	CI8887/5761 SEA 13-28S-OS	9*
D	CI8887/5761 SEA 13-23S-3S-OS	9
	Cr 355-8	9
	Jordan/Avt-OSK	8
EI	Mari/Coho	10*
	CM 57/Sv.Mari CM 72-14D-8Y-1B-3Y-1B-OY	11*
	Centinella	12*
F	Minn 126/CM 67	9
	ER/Apm	10*
	Manchuria	11*

* Selected for intercrossing to pyramid the genes.

Table 15. Barley Lines and Cultivars Grouped According to Similarity in Reaction to Yellow Rust at Different Locations During 1978-1979.

Varietal Group	Location and Disease Reaction					
	Morocco	Pakistan	Pakistan	Kenya	England	Afghanistan
	Merchouch	Islamabad	Faisalabad	Njoro	Cambridge	Kabul
A	R	R	R	R	R	R
BI	R	R	S	R	R	R
II	R	R	S	R	R	S
III	R	S	S	R	R	R
IV	R	R	S	S	R	S
CI	R	S	R	R	R	R
II	R	S	R	R	R	S
III	R	S	R	S	R	S
D	R	R	R	S	R	S
E	R	R	R	R	S	S
F	R	R	R	R	R	S

Table 16. Barley Cultivars Grouped According to Similarity in Reaction to Yellow Rust (*Puccinia striiformis*) in Hot Spot Locations During 1978-79.

Varietal Group	Line and Pedigree	Frequency
A	ER / Apm	10*
	CI8887/CI5761 SEA 13-28S-OS	9
	Purdue 5623A-1315 P	8
BI	Centinela	12*
	Mich63-201.44/Shabet K.72-73-40 2B-1Y-1B-OB	10
CII	Jordan/Avt-OSK	8
III	Minn 126/CM 67	9*
DI	Mari/CM67//Pro CMB 72A-211-C-1B-2Y-1B-1Y-OB	7*
II	H 272 300M-5018-OY-OSK	6
EII	Ahor 880-6	8*
	Cr 372-4-2	6
F	Cr 355-8	9*
	2762/Beecher- 6L	8*
	Harbin/Avt//Attiki CMB 19-1A-OA-OA	7

* Selected for intercrossing to pyramid the genes for resistance.

Table 17. Barley Lines and Cultivars Grouped According to Similarity in Reaction to Stem Rust at Different Locations in 1978-79.

Varietal Group	Location and Disease Reaction			
	Yemen	Afghanistan	Pakistan	Cyprus
	Taiz	Kabul	Faisalabad	
A	R	R	R	R
B	R	S	R	R
C	S	R	R	R

Table 18. Barley Cultivars Grouped According to Similarity in Reaction to Stem Rust (*Puccinia graminis hordei*) in Different Hot Spot Locations in 1978-79.

Varietal Group	Line and Pedigree	Frequency
A	Cr 270-2-3	6*
	Mari/CM67//Pro CMB 72A-21-C-1B-2Y-1B-1Y-OB	7*
	Chile Comun/An 57 CMB 73A-8-3011-OAP	5
	Ahor 874-59	5
B	Harbing/Avt3//Aths CYB 6A-OA-OA	6*
	WI 2231 b	5
	WI 2198	5*
	Line 251-11-2	5
C	CN 42/CI 7772//Fun/Fun/3/Tch/4/Fun/Ki II-11694-2B-Bulk-7N-4N	9*
	M69.69/Apm-RL	8
	Manchuria	10*
	Centinela	12*
	CI8887/CI5761 SEA 13-24S-1S-OS	9*
	CI8887/5761 SEA 13-24S-1S-OS	8
	CI8887/5761 SEA 13-24S-3S-OS	9

* Selected for intercrossing to pyramid the genes for resistance

Table 19. Simple, Top and Double Crosses Made for Disease Resistance in Different Years.

Disease*	Type of Cross and Year					Total
	Simple Crosses			Top & Double Crosses		
	1977	1978	1979	1979	1980	
PM	--	83	53	102	63	301
SC	45	59	48	78	198	428
NB	--	21	56	64	311	452
3 Rusts	10	15	102	--	--	127
LR, SR	3	-	--	--	--	3
LR, YHR	14	26	--	--	--	40
YR	26	11	--	30	46	113
LR	13	3	--	55	61	132
SR	18	23	--	68	114	223
BB	--	--	--	2	6	8
SD	--	--	--	--	4	4
CN	--	--	--	--	1	1
Total	129	241	259	399	804	1832

* PM = Powdery mildew, SC = scald, NB = Net blotch,
 YR = Yellow rust, LR = Leaf rust, SR = Stem rust,
 BB = Bacterial blight, SD = stripe disease,
 CN = Cyst nematode

Table 20. Lines with Multiple Disease Resistance Identified in the Regional Nurseries, and Used in the Crossing Programme 1979-80.

Designation	Disease					
	YR	LR	SR	PM	SC	NB
Esp./Sv.Mari	*	*	*	*		*
Cholo	*	*		*	*	*
CI8887/CI 5761	*	*	*	*		*
SEA 13-16S-5S-OS						
CI03548		*		*	*	*
Gebloux 458		*		*	*	*
08387		*		*	*	*
08393		*		*	*	*
W.W.Tether	*	*		*		*
Hewari	*	*			*	*
Cr 254-22	*	*	*			*
Abiyu	*	*			*	*
Hankar 00912	*	*			*	*
Chile Commun/An 57	*	*	*		*	
CMB 73A-8-3010-OAP						
Belfort Barley	*	*		*		*
Tunis	*	*	*			*
Api/CM 67, CMB 72-60-	*	*		*		*
500Y-504B-501Y-500B-OY						
0 8738 D	*	*	*		*	
Purdue 5623A 1315P	*	*		*		*
CI8887/CI5761 (10	*	*		*		*
sister lines)						
Chevron CI1111/Coho	*	*		*		*
SEA-G-43S-5S-OS						
CI8886/CI8014 (2	*	*		*		*
sister lines)						
Menuet	*	*		*		*
6-73	*	*			*	*
CI3909-2-502-500B-500Y-OB	*	*			*	*

Table 21. Germplasm With Multiple Disease Resistance Used in the Barley Crossing Programme, 1980-81.

Line or pedigree	Diseases*							
	YR	LR	SR	PM	SC	NB	BB	BYDV
Asse	*	*	*	*	*	*		
Alouette	*	*	*	*		*		
CI8887/CI7561 SEA 13-23S-3S-OS	*			*	*	*		
Menuet	*	*		*				*
Line 10805	*	*	*			*		
5 Cr 276-92				*	*		*	
Roho		*	*	*				
Belfort Barley	*		*	*				
Mazurka	*			*	*			
Cq/Comun// Apam/12410		*					*	*
Minn. 480/Gva CMB 74-736-2Y- 2B-2Y-1B-1Y-OB		*	*		*			
Emir	*	*		*				
Aramir		*	*	*				
H 2210	*	*	*					
Harrison CI 10667	*			*	*			
Martin -2				*				

* Asterisks indicate resistance to this disease in the region.

BB = Bacterial Blight

1. Resistant to stripe disease as well.

2. Resistant to cyst nematode as well.

Table 22. Key Locations in the ICARDA Region Where High Natural Disease Pressures are Prevalent.

Location	Disease					
	Scald mildew	Powdery mildew	Helmin- thospor- ium spp.	Leaf rust	Yellow rust	Stem Cover- rust smut erial blight
Morocco (Rabat)	*	*	*	*	*	
Tunisia (Mateur)	*	*	*	**	**	
Egypt (Sakha)		**	*	**		*
Turkey (Izmir)	**	*	*	**	*	*
Kenya (Njoro)	**		*	*	**	**
Pakistan (Islamabad)	*	*	*	*	*	*
Ethiopia (Holetta)	**		**			
(Debre Zeit)	**	*	*	**	**	
Yemen Arab Rep. (Taiz)	*	*	*	**		**
Syria (Tel Hadia)	*	**		*		* *
(Lattakia)	**	**		**		
Lebanon (Terbol)	*	**		**		

* Severe

** Very severe

THE CIMMYT BARLEY PROGRAM AND EFFORTS TO
BREED FOR DISEASE RESISTANCE

Enrique Rodríguez*

The Barley Breeding Program at CIMMYT has been operating for almost eight years to breed superior genotypes that can be used for human food.

In its initial stages the program was largely involved in trying to develop genotypes with wider adaptation, higher yield potential, stiff straw, high nutritional quality, hull-less grain and earliness.

During the last two years, the emphasis had been placed on incorporating resistance to the major diseases in these genotypes. These diseases are:

1. Scald (Rhynchosporium secalis)
2. Leaf rust (Puccinia hordei)
3. Barley yellow dwarf virus (BYDV)
4. Spot Blotch (Helminthosporium sativum)
5. Stripe rust (Puccinia striiformis)
6. Powdery mildew (Erysiphe graminis var hordei)
7. Loose smut (Ustilago nuda)
8. Aluminum toxicity (non-parasitic)

In Mexico, we can observe all the diseases, however, the environmental conditions are such, that one year we might have the predominance of one of them while the next year there might not be any signs of it.

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Leaf Rust and Scald

To overcome these irregularities and to facilitate the selection, we have been trying for the last two cycles to induce artificial epidemics for at least two of these diseases, namely leaf rust and scald.

The conditions of the Yaqui Valley in the northwest part of Mexico permit the selection of good agronomic types. With the exception of leaf rust and sporadic spots of barley yellow dwarf virus, the presence of some other diseases is almost nil. Under these conditions, we have to rely almost exclusively on artificial epidemics to test our materials.

During the summer cycle when the material is grown in the central part of Mexico, the weather conditions are very suitable for the development of diseases. Nevertheless, we want to make sure the material is subjected to a severe disease pressure.

Natural epidemics of powdery mildew and R. secalis occur more or less regularly depending upon the weather conditions. With respect to R. secalis, isolates of the fungus collected in the barley growing areas of Mexico have been cultured in the laboratory, and barley varieties have been inoculated using an ultra low volume type of sprayer. A total of six distinct isolates have been isolated. Such isolates were collected in the high plateau of Mexico where barley is an important summer crop.

The inoculations were made early in the evening, and the first symptoms appeared 5 days later. A fully developed epidemic took place about three weeks later. It was observed

that the best time for making the inoculation was when the plants were at the boot stage. Because of the differences in maturity of the lines, several inoculations have to be made in order to assure a more uniform epidemic.

It appears that in general the CIMMYT materials are lacking resistance to the isolates of *R. secalis* that were used. Nevertheless several lines and varieties, both early generation and advanced lines, were selected as being resistant. These lines were assembled in a special crossing block designed as the crossing block for resistance.

With respect to leaf rust, artificial inoculations of spores were also made using isolates of the common races found in the barley growing areas of Mexico. The inoculations were made in a similar manner as in the case of *R. secalis*. Susceptible border rows were interplanted within the breeding material. Selected materials were incorporated into the crossing block for resistance in its correspondent section. This crossing block is being heavily used in crosses.

Barley Yellow Dwarf Virus

As is well known, this disease is becoming more and more important in many areas of the world, or perhaps the problem is being recognized more readily by barley workers. In the past, the disease was probably being mixed up with certain types of nutrient deficiencies, stresses or abnormalities of the crop.

In Mexico, in spite of the fact that the aphid vector population is very high at both stations where the CIMMYT barley materials are grown, the percentage of aphids carrying

the virus is very low. Therefore, the infection is very erratic and appears in isolated spots in the field. The screening of materials under these conditions becomes very difficult, if not impossible.

To try to overcome this, we have been heavily crossing materials reported resistant by breeders working in BYDV hot disease spots. Material provided by Dr. C. Schaller and the Montana Group have been crossed extensively. In addition to this, advanced materials from the program have been tested at both Davis, California and Montana locations. The segregating F_2 crosses are being selected in situ in problem areas in Ecuador and Chile, where CIMMYT has established regional programs.

Stripe Rust

This disease is receiving special attention, specially for high altitude areas in South America and very specifically in the Andean Zone where the appearance of a new virulent biotype has devastated the barley crop in Colombia, Ecuador, Peru and more recently in Bolivia. In 1976, several materials from the World Collection were screened in Colombia and Ecuador and more than 200 entries were shown to be resistant. These lines were incorporated into the CIMMYT crossing material and several thousand crosses have been made.

It is interesting to note that, in our summer plots in Mexico, the conditions for the development of the disease are perfect, nevertheless, seldom if ever, do we see an epidemic of stripe rust high enough to make a good screening. Under these conditions, the crosses made using resistant parent materials

also have to be screened in situ. Whenever a cross is made using resistant materials, the F_1 plants are harvested and the F_2 seed is sent in bulk to the areas where the disease is a problem. Since these crosses are mainly designed to incorporate resistance to this particular race in the Andean zone, we have designated these, as F_2 "Zona Andina" (Andean zone F_2 's); these materials have also been sent to requesting cooperators.

In addition to the materials selected from the world collection, we have also been using resistant local cultivars and improved lines from different national programs from the area. These materials have been obtained either through personal contacts with the people involved in the national breeding programs or through regional nurseries such as the VEOLA (Latin American Observation and Disease Nursery) which includes entries submitted by the national programs of the areas.

Powdery Mildew

This disease appears endemically in Mexico during the summer. In some years it has been very severe and we have had a chance to select resistant materials. It appears, however, that the races present in Mexico are rather weak as is indicated by the fact that most European varieties regardless of how many resistant genes they carry, show a high degree of resistance. On the other hand, the materials which are showing some resistance in Mexico are generally susceptible to the races present in Europe. Therefore, we have been trying to use

the European varieties as well as the lines and varieties reported in the ICARDA nurseries as being resistant in crosses with CIMMYT materials.

Loose Smut

The work on loose smut, although limited, has received some attention. Artificial inoculations have been made in the parental material using the vacuum method of inoculation, with isolates present in Mexico. Some crosses have been made using resistant progenitors, however, few attempts have been made to do a thorough screening in segregating populations. The work has been reduced to discarding advanced lines and segregating populations which show a high per cent of infection.

Aluminum Toxicity

For areas with low pH soils where aluminum gets tied up and causes toxicity, materials have been screened to search for types that can withstand this problem. So far, the levels of tolerance found, have been very low. There are, however, some differences in reaction and, at the present time, several lines showing certain tolerance have been selected and they are currently being used in crosses.

With respect to other diseases, some future plans are being made to incorporate resistance. This coming summer, with the help of the CIMMYT pathology section, we are planning to start working with H. teres and H. gramineum. The first steps have already been taken by making collections of these two organisms in the field. Even though the two diseases appear sporadically, and never constitute a threat to the commercial

fields in Mexico, isolates of these two organisms will be cultured and later inoculations in the field will be made at least to a limited scale with certain materials.

We are constantly basing our crosses on results obtained from different international and regional nurseries, and we will continue to do so. We want to thank the cooperators from the different national and international programs for the time and efforts they devote to sending us their information. We hope this cooperation will continue in the future.

BREEDING FOR DISEASE RESISTANCE AT THE
UNIVERSITY OF CALIFORNIA, DAVIS

C. W. Schaller*

Four diseases have received the major attention in our barley breeding program at Davis, California, viz. barley scald, *R. secalis*, net blotch, *H. teres*, powdery mildew, *E. graminis hordei* and barley yellow dwarf (BYD). Of these, BYD is the most serious, with annual losses approaching 15 percent. In any given year, scald and net blotch will cause greater losses, but their occurrence is less frequent. Powdery mildew can be particularly severe on late planted barley, resulting in yield reductions of 15-20 percent. In addition to the four diseases, agronomic characteristics receiving attention include straw quality, shatter resistance, maturity differences and more recently, salt tolerance.

Our breeding activities have utilized modified backcross system, combined with pedigree selection. Selection follows each backcross, and, at the same time, backcrossing is continued. The number of backcrosses is not predetermined nor is the main objective to duplicate the recurrent parent, but the combined backcross-selection procedure is continued until the desired combination of characteristics has been obtained, while retaining as many of the favorable attributes of the recurrent parent as possible. Cultivars have been released with only one backcross; whereas seven backcrosses were necessary to break the unfavorable linkage between straw

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strength and resistance to BYD. Unlike the classical backcross method, our modified procedure requires yield testing, as with other breeding methods.

Our program is designed not only to transfer a specific character to an adapted cultivar, but also as a mechanism for improving the recurrent cultivar in a stepwise and predictable manner. These improvements consist of both disease resistance and desirable agronomic characteristics, and, in general, their individual effects have been found to be additive. The improved cultivars become the recurrent parents in subsequent programs. For the most part, each character is transferred separately during the early backcrosses and combined during latter stages, thus permitting each program to be handled individually, avoiding delays necessitated by a complicated testing program.

Complimentary studies on the genetics of disease resistance have been an integral part of our program, including the continuing search for new sources of resistance. Major portions of the USDA barley collection have been screened for scald, net blotch and BYDV. Information on the genetics of resistance for a given disease, including the identification of specific genes, is essential for a successful program, regardless of the breeding methods used. Unfortunately, this phase of disease investigations has not kept pace with breeding activities per se and, is often referred to as "gene chasing" and not considered as a productive endeavour by many individuals or administrators. Of equal importance is the continued surveillance of the pathogenic races or strains of

the causal organism. In a recent survey in California, races of *R. secalis* were found which were capable of attacking all known genes conferring resistance to barley scald. Although this information necessitated modifying our breeding program, with greater emphasis being placed on nonspecific or field resistance, it provided the basic information on which to build a long range program to cope with the present and potential variability of the pathogen. Certain combinations of genes appear capable of providing the coverage required.

In general, our breeding activities have emphasized the so-called "vertical", "race-specific" (or whatever) type of resistance. It is believed that much of the criticism against race-specific resistance is not justified. However, "non-specific" (horizontal; field) resistance can play an important role in reducing disease losses and should be considered in all breeding programs. It is not a case of either/or, but more likely, a combination of both will be necessary to produce the desired result. The ML-o gene for resistance to powdery mildew and the Yd₂ gene for tolerance to BYDV have provided long-term protection in California, whereas we have found it necessary to rely on non-specific resistance to provide a measure of protection against barley scald.

The non-random chromosomal distribution of identified genes for disease resistance, which appears to be prevalent in barley, poses additional problems in obtaining the desired combination of genes. For example, five of the eight genes conferring resistance to powdery mildew, which have been identified in our studies, are located on chromosome V, three

probably being allelic. Seven of the 12 genes conferring resistance to barley scald are on chromosome III, three probably allelic. In addition, the only major gene conferring tolerance to BYDV (Yd_2) is also on chromosome III, together with genes conditioning straw strength. In our program, it required seven backcrosses, coupled with extremely large populations to obtain the desired combination of stiff straw and barley yellow dwarf resistance. As yet, we have not been able to combine the desired level of scald resistance with these two characteristics.

The non-random distribution of genes conferring resistance to a specific disease, together with the fact that barley is a diploid species with only seven chromosome pairs, is a definite restricting factor when attempting to pyramid genes for resistance, either by conventional breeding methods or relying on natural selection, even though male sterility is used to facilitate outcrossing. Success of such attempts will eventually require the use of specific races of the pathogen to identify and follow specific genes in the population.

A brief recapitulation of our breeding program is presented graphically in Figs. 1 and 2, which illustrates the cumulative and additive effect of combining disease resistance and desirable agronomic characteristics, as well as their subsequent acceptance by the growers.

Prior to 1969, California Mariout was grown on 50 percent of the California barley hectarage, Arivat 20 per cent, with a combined total of approximately 715,000 hectares. Although both were well adapted, Cal. Mariout had extremely weak straw,

was susceptible to scald, BYDV and powdery mildew, but possessed a satisfactory level of tolerance to net blotch. Arivat had good straw quality, moderate tolerance to scald, but was susceptible to BYDV, net blotch and powdery mildew.

Numar is essentially a stiff-strawed version of Cal. Mariout, CM 67 a yellow dwarf tolerant version of Cal. Mariout, each showing a yield superiority over the recurrent parent. UC 566 consolidated the individual gains of the two previous releases in approximately an additive manner, 25 percent vs 12 and 14 percent for Numar and CM 67, respectively.

CM 72 is a mildew resistant version of CM 67, combining resistance to mildew and BYDV, with a yield superiority of 5 percent, attributable to mildew resistance.

Briggs, which represents a higher yielding version of Arivat (almost identical phenotypically), obtained its acceptable tolerance to net blotch from Cal. Mariout, plus additional favourable genes which apparently contributes to its higher yield.

The cultivar, Prato, released in 1979, consolidates previous gains into a single variety, with a yield superiority of 25 per cent over previous releases and, approximately 50 percent over the original cultivars, California Mariout and Arivat. Much of its yield superiority can be attributed to the additive effect of individual character additions. Prato combines the scald tolerance and straw quality from Briggs with the net blotch tolerance and the more positive resistance to BYDV and mildew from CM 72.

Numar and Briggs essentially replaced Arivat and

California Mariout within four years after their release, and, in turn were replaced by subsequent releases (Fig. 2). It is anticipated that Prato will essentially replace all previous releases and could occupy 70-80 percent of the California barley hectarage, at least that portion planted to cultivars released by public agencies.

Table 1. Comparative Response of Two Barley Cultivars to Different Levels of Net Blotch Infection (*Pyrenophora teres*)

Cultivar	Net blotch	Scald	Yield		Test Weight
	(0-10)*	(0-10)*	kg/ha	% Kombar	(lb)
Disease-free Nurseries (4 locations)					
Prato	<1.0	<1.0	7623	104	51.5
Kombar	<1.0	<1.0	7343	100	50.3
Severe Net blotch Infection (7 locations)					
Prato	2.4	1.5	5055	143	50.4
Kombar	8.5	1.2	3536	100	46.0

*0 = No infection; 10 = Severe infection.

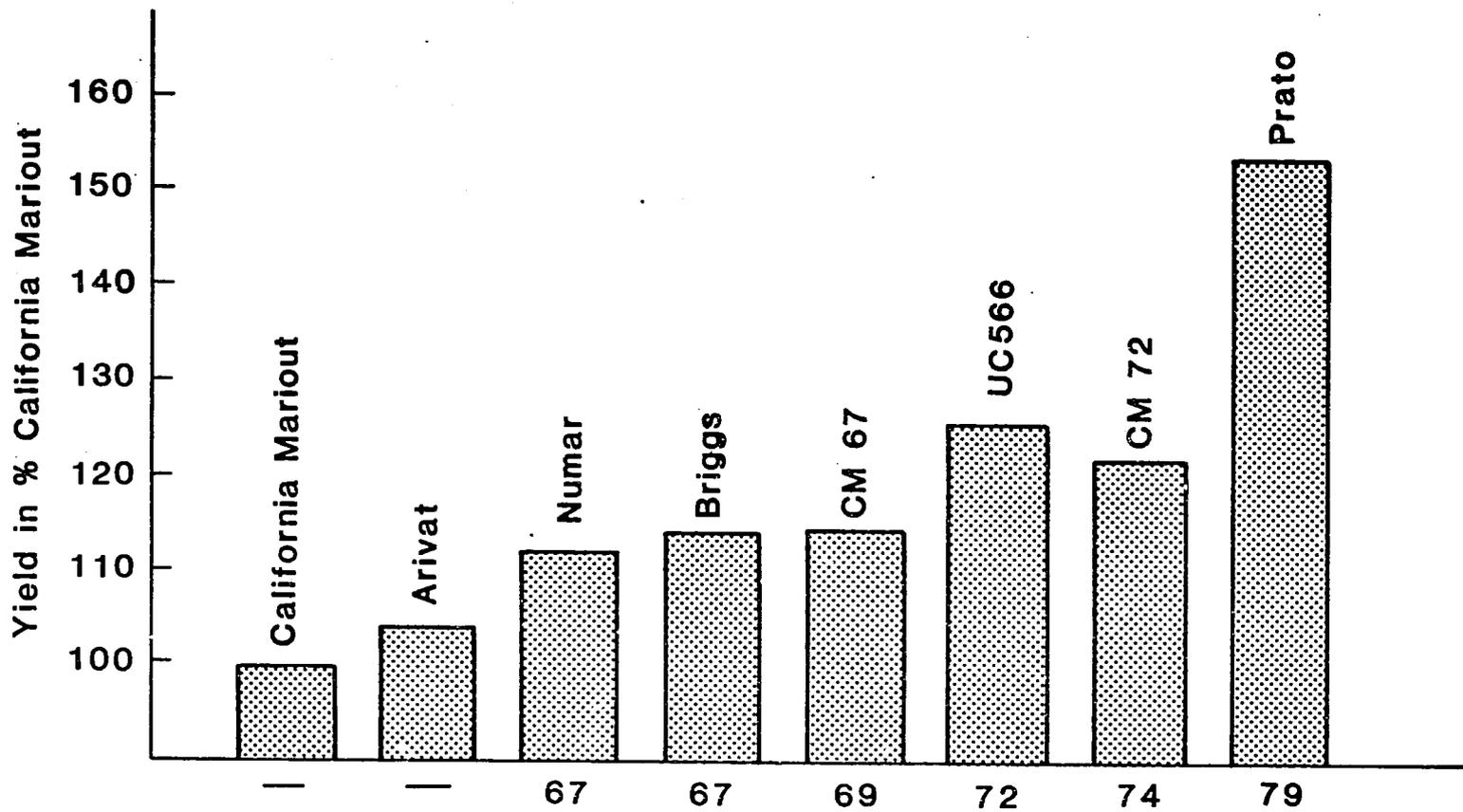


Figure 1. Year Released
Yield increase over California Mariout

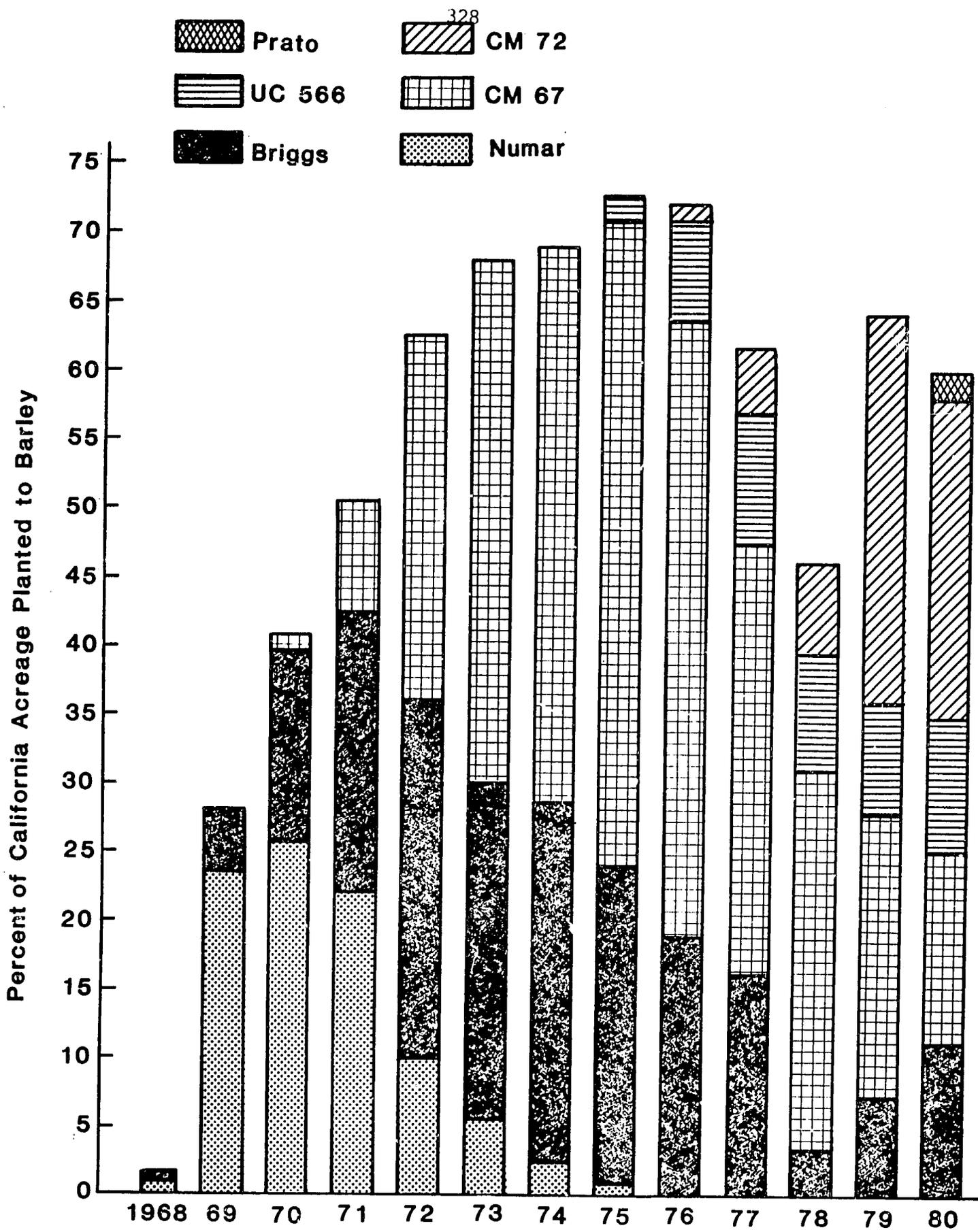


Figure 2. Yearly Changes in Percent of California Acreage Grown to Indicated Varieties

RECURRENT SELECTION FOR RESISTANCE TO SCALD

M. M. Harrabi, E. L. Sharp and H. E. Bockelman*

Scald of barley caused by *Rhynchosporium secalis*, can seriously limit yield in many humid and sub-humid growing areas. Control of this disease has been achieved mainly by genetic resistance.

Nine major genes for resistance have so far been reported in the literature (Jackson et al. 1977; Shipton et al. 1974; Dyck and Schaller, 1961; Wells and Skoropad, 1963). Habgood and Hayes (1970) found 11 genes for resistance, four of which are recessive (rh_5 , rh_6 , rh_8 and rh_{11}). They further reported 5 alleles at the Rh locus; two dominant, two incompletely dominant and one recessive. These 5 alleles were found on chromosome III.

The inheritance of scald resistance has been reviewed elsewhere (Habgood and Hayes 1970; Dyck and Schaller 1961).

The pathogen is highly variable. Seventy-five races have been found in California (Jackson et al. 1977). Several isolates collected from the Mediterranean area prove the variability of the fungus in the region based on their reactions on 45 barley cultivars with known major genes for resistance (Bockelman, personal communication). Most varieties developed with scald resistance contain one major gene for resistance. Due to the highly variable nature of the pathogen this has resulted in a frequent loss of resistance (Houston and

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Ashworth, 1957). However, the use of single major genes for resistance remains an attractive method for plant breeders because of ease of handling. The use of multigenic resistance to increase the stability of resistance has been infrequently used because of its difficulty in handling.

Recurrent selection procedures are an effective means of accumulating genes and developing multigenic resistance. It has been used extensively in cross-pollinated crops such as maize. By the use of genetic male sterility to facilitate recombination, recurrent selection procedures can be adapted to barley, a self-pollinated crop. Male sterile facilitated recurrent selection population (MSFRSP) has also been utilized in sorghum.

In 1975 a MSFRSP, designated C.C.XXXVI was established to "pyramid" genes for scald resistance. A detailed description of the population has been described elsewhere (Bockelman et al. 1980). The purpose of this work was to measure changes in terms of resistance and associated yield and yield components, over four cycles of recurrent selection.

Materials and Methods

Five cycles of composite cross 36 were used in this study. These were designated cycle 0, cycle 1, cycle 2, cycle 3 and cycle 4. The five cycles were planted in a disease nursery in Bozeman, Montana in 1980, in a randomized complete block design with 4 replications. Planting rates were similar to commercial. Inoculation with a Montana isolate (Lewis B77) was done 35 days after planting. A spore suspension was applied using a mist blower back pack sprayer in the evening. The

plots were covered with sheets of plastic over night. Four weeks after inoculation, plants were classified for scald reaction using a 0, 1, 2, 3 scale. (0 = no visible lesions, 1 = marginal lesions only, 2 = restricted scald lesion and 3 = typical scald lesion). Ratings of 0, 1 and 2 were grouped as resistant and rating 3 as susceptible. Each plant was identified so that measurements of yield and yield components could be made at harvest time. The frequencies of resistant plants in each cycle were calculated along with the correlation matrices and multiple regressions.

Results and Discussions

Analysis of variance for reaction type, yield and yield components revealed significant differences between the five cycles (Table 1). When percent (%) resistance was regressed on the five cycles, a rapid response to selection was observed (Fig. 1). The frequency of resistant to susceptible plants was calculated in each cycle (Table 2). The percentage of plants showing some degree of resistance has increased dramatically in the first three cycles reaching a maximum of 90.58% resistant plants to 9.43% susceptible. A slight decrease was observed in the fourth and fifth cycle. This may possibly be attributed to difficulty in selecting resistant plants in some nurseries due to insufficient or absence of natural infection.

In some cases selection in these areas was based on agronomic traits rather than disease reaction as no disease had occurred. An example would be Tunisia in 1978. The decrease in resistance does not appear to be significant but the

probabilities of selecting resistant plants in these populations appear to be adequate. It could be inferred that genes controlling resistance to scald may be linked to other genes that confer a selective advantage to individual plants in the population such as heading date. Significant negative correlation was observed between disease reaction, and yield and kernels per spike, but accounted for an insignificant amount of the variations in yield or kernels per spike (Table 3). No association existed between reaction type and kernel weight or tiller number. The correlation matrix indicated no correlated responses between disease reaction and yield components. From a breeding point of view, selection for resistance and high yield could be done simultaneously.

When yield components were regressed on cycles in the absence of selection for yield or yield components, there was no significant change in tiller number and an increase in kernel number per spike and decrease in seed weight. The frequency of plants with high kernel weight has decreased significantly probably due to component compensation. The overall yield has increased slightly ($b = 1.55$). It is obvious that natural selection favors plants that produce a large amount of seed. To maintain a good kernel weight, a breeder should sieve out smaller kernels and keep selecting for good agronomic traits important in his region such as plant height, maturity date, etc. (Table 4).

Smail (1980) using isogenic lines differing in increments of heading date and grown in 15 dryland environments has found that kernels per spike is the component controlling the

response in tillering, kernel development and yield. Kernels per spike thus appears to be the most heritable and stable component to select for in populations with varying yield components. Thus in the Recurrent Selection Populations (RSP), it may be that natural selection is favoring plants with a high number of kernels per spike especially under stress conditions.

References

- BOCKELMAN, H.E., ESLICK, R.F. and SHARP, E.L. 1980. Registration of Barley Composite Cross XXXVI. *Crop Sci.* 20:675-676.
- DYCK, P.L. and SCHALLER, C.W. 1961. Inheritance of Resistance in Barley to Several Physiological Races of the Scald Fungus. *Can. J. Genet. Cytol.* 3:153-164.
- HABGOOD, R.M. and HAYES, J.D. 1970. The Inheritance of Resistance to *Rhynchosporium secalis* in Barley. Welsh Plant Breeding Station. Aberystwyth, Wales.
- HOUSTON, B.R. and ASHWORTH, L.J., Jr. 1957. Newly Determined Races of the Scald Fungus in California. *Phytopathology* 47:525 (Abstr.)
- JACKSON, L.F., KAHLER, A.L., WEBSTER, R.K., and ALLARD, R.W. 1978. Conservation of Scald Resistance in Barley Composite Cross Populations. *Phytopathology* 68:645-650.
- SHIPTON, W.A., BOYD, W.J.R., and ALI, S.M. 1974. Scald of Barley. *Ann. Rev. Plant Pathol.* 53:839-861.
- SMAIL, V. 1980. The Pleiotropic Effect of Maturity and Row Type Isogenic Lines on the Yield Stability and Development of Barley (*H. vulgare* L). *Amer. Soc. of Agron. Abst.* p.70.
- WELLS, S.A. and SKOROPAD, W.P. 1963. Inheritance of Reaction to *Rhynchosporium secalis* in Barley. *Can. J. Pl. Sci.* 43:184-187.

Table 1. Analysis of Variance for Reaction Type, Yield and Yield Components.

Source of Variation	df	Mean Squares				
		Reaction	Plant Yield	Kernel Weight	Kernels/Spike	Tillers/Plant
Rep	3	12.4**	544.75**	2.12**	788.15**	148.46**
Cycle	4	6.99**	1113.53**	19.82**	1858.98**	136.48**
Error	12	.84	90.36	.712	174.76	24.56

Table 2. Frequencies of Resistant and Susceptible Plants in Five Cycles of Recurrent Selection.

	Cycle 0	Cycle 1	Cycle 2	Cycle 3	Cycle 4
% Resistant	76	86.13	90.58	89.27	86
% Susceptible	24	13.87	9.42	10.73	14

Table 3. Correlation Matrix Between Five Measured Traits in RSP.

	Plant Yield	Kernel Weight	Kernels/Spike	Tillers/Plant
Reaction	-.0995**	-.0145	-.059*	-.0447
Plant Yield		-.0213	.5002**	.6546**
Kernel weight			-.4398**	-.0155
Kernels/spike				-.0155

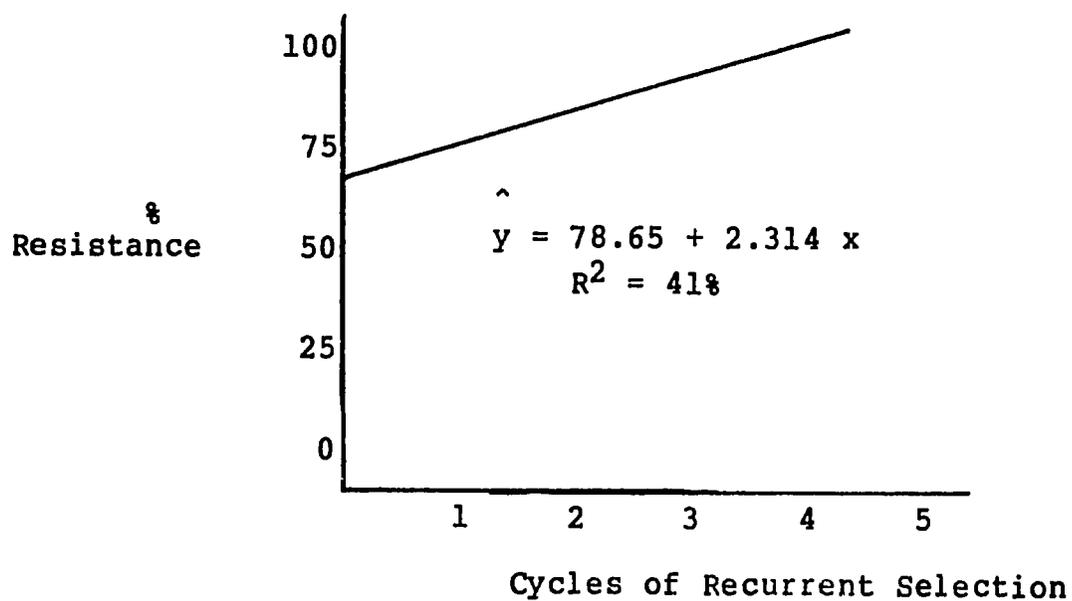
Table 2. Disease Reactions of 17 Selected Lines, 1980.

Group	No. of Line	<u>Helminthosporium</u> <u>teres</u>	<u>Erysiphe</u> <u>graminis</u>	<u>Rhynchosporium</u> <u>secalis</u>
I	1	110/MR	0/Trace	20/MR
	2	5/MR	2/20	10/MS
	3	110/MS	2/Trace	10/MS
	4	Trace	3/10	Trace
	5	5/R	2/10	10/MR
	6	X	Trace	10/MS
	7	50/MS	6/40	20/S
II	1	110/MR	8/30	10/R
	2	5/R	0/Trace	5/MR
	3	10/MS	6/40	20/MR
III	1	10/MR	0/Trace	Trace
	2	5/MR	2/10	10/R
	3	10/MR	8/30	10/MS
	4	10/MS	0/Trace	10/MR
	5	10/R	6/40	10/R
	6	20/S	8/30	20/MS
	7	10/MS	0/Trace	20/MS
Martin		10/MR	2/10	10/MS
Ceres		20/MR	TRACE	10/R

Table 4. Regression Coefficients of Four Measured Traits on Five Cycles of RSP.

	Plant Yield	Kernels/Spike	Kernel Weight	Tillers/Plant
b	1.55	6.09*	-8.94	-7.0 ^{ns}
R ²	5.32%	72.63%	77.98%	.02%

Figure 1. Response to Five Cycles of Recurrent Selection for Resistance to Scald.



BREEDING BARLEY FOR NORTH WEST AND CENTRAL TUNISIA

A. Daaloul and M. Harrabi*

Barley has been gaining importance as an alternative crop to wheat in the high plateau of North West Tunisia and the marginal areas of Central Tunisia. The breeding of high yielding varieties adapted to those areas has become a priority aim. According to the Rapport d'Activite de la Division Technique De L'office des Cereals 1974, a new breeding program was commenced in 1973. The objectives are earliness, high yielding ability and disease resistance.

Several varieties were introduced and in 1973 and 1974 many crosses were made and following modified pedigree selection, several promising lines became available for yield testing.

Materials and Methods

Since 1976 at the El Kef experimental site about 115 selected or introduced new lines were tested. Five yield trials each containing 23 lines and 2 check varieties were planted. The checks were Martin and Ceres. A standardized randomized block design with four replications was used. The plots contained 6 rows each 5 meters long with 0.25 meter spacing. The main diseases observed were Helminthosporium sp Rhynchosporium sp and Erysiphe graminis. Other observations were made on heading date, plant height and grain yield.

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Results and Discussion

Of the 115 lines tested initially, only 17 remained in the harvest of July 1980 (Rapports d'Activite de Recherche De L'Ecole Superieure des Grandes Cultures du Kef 1977, 1978, 1979, 1980).

A summary of their pedigrees and yield is given in Table 1 which also compares the selected lines with the check varieties for yield increases. The increases ranged from 17-84% in the first group, 2-34% in the second group, and from 14-334% in the third group.

Table 2 shows a summary of the disease notes for Helminthosporium teres, Erysiphe graminis and Rhynchosporium secalis, in 1980. These infections occurred naturally i.e. without inoculation. The conditions did not favor the development of Helminthosporium and Rhynchosporium.

In the 1980-81 cropping season, these 17 lines will be tested in three different locations. The most promising ones will be multiplied, if their performance is good, and demonstrations of the promising ones will be conducted over a wide range.

References

Rapport d'Activite de la Division Technique De L'office des Cereals. 1974.

Rapports d'Activite de Recherche De L'Ecole Superieure des Grandes Cultures du Kef. 1977, 1978, 1979, 1980.

Table 1. Pedigrees and Yields of 17 Selected Lines from Trials I, II and III.

No.	Pedigree	Yield (q/ha)	% of Martin	% of Ceres
GROUP I				
1.	WI 2198	61.00	140	184
2.	Esperance x Two rows L 24 21 - 82	51.20	118	155
3.	WI 2291	53.70	123	162
4.	Line 251/14	50.80	117	154
5.	WI 2197	59.65	137	180
6.	Aurore x Esperance 2321-IL	51.83	119	157
7.	Pro - 11012-2	51.98	119	157
	Martin	43.55	100	--
	Ceres	33.08	--	100
GROUP II				
1.	Atlas x Kindred	56.11	112	134
2.	Emir	51.25	102	123
3.	Minn 23- WI 2197- TC 74- 25 I-Bj-Obj	51.24	102	123
	Martin	50.00	100	--
	Ceres	41.75	-	100
GROUP III				
1.	(Avt-Ki (Avt/Toll-BZxVI) Iris) CMB 73A- 153-7bj-Obj	50.20	125	116
2.	H. Engeles III/pro-Tol Cer 2- Tol CMB 73A-862-6Bj-Obj	50.60	126	117
3.	Apam IB65xFAO/22425 CMB 74A-930-2Bj-Obj	53.80	134	124
4.	Chipper-Minn 907 CMB73A-581-6Bj-Obj	52.20	130	121
5.	Apam IB65x FAO/22425 CMB74A-930-14BJ-Obj	48.70	124	115
6.	Trail-1038xCM67 CMB74A-430-5Bj-Obj	49.45	123	114
7.	BKF x Magnelone 1604-Iris TC73-18-6Bj-Obj	52.60	131	122
	Martin	40.20	100	--
	Ceres	43.30	--	100

USDA BARLEY GERMPLASM COLLECTION AND
SOURCES OF DISEASE RESISTANCE

J. G. Moseman and D. H. Smith*

There are about as many barley germplasm collections as there are individuals involved in the development of improved barley. Most plant breeders including those attending this workshop maintain a collection of barley germplasm as part of their research program. Some collect more germplasm than required for their immediate needs to preserve the genetic diversity of the species. In general the intended use of the germplasm and the availability of funds determine the type and number of accessions and the general operation of any given germplasm collection.

There are two broad types of germplasm collections, the base and the working. The primary purpose of a base collection is to collect, describe and maintain indefinitely the maximum amount of genetically diverse germplasm possible to be used to overcome some factor, usually a disease or insect pest, which may in the future threaten the production of a crop. The primary purpose of a working collection is to collect, maintain, evaluate and distribute that germplasm which can be used by an individual or by groups of individuals in their research.

USDA Barley Germplasm Collection

The USDA barley germplasm collection was started about

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1915 by H. V. Harlan and was continued by G. A. Wiebe and J. G. Moseman who were the leaders of the USDA Barley Investigations at Beltsville. There are about 23,000 accessions in the collection including more than 2,000 Hordeum spontaneum and other Hordeum species. Information is available on most of the accessions with respect to species, origin, growth habit and row number. Most of the accessions in the collection were obtained from the programs of the scientists in the Cereal Crops Research Branch at Beltsville who conducted research on the improvement of barley production in the United States. Some of the characteristics possessed by older accessions are no longer being studied or needed for barley improvement. There are many early generation selections from crosses from individual research programs, and stocks with unusual morphologic and other characteristics in the collection.

The senior author has assisted for the last 25 years in the development and management of the USDA barley germplasm collection at Beltsville and has used the collection in his research to identify and develop improved barley germplasm with resistance to plant pathogens and other stresses. He now finds it difficult to evaluate the accessions in the collection for modern needs and to identify the germplasm with specific characteristics required to develop productive, stable, pest resistant, high quality cultivars. The older accessions have been grown and evaluated by plant breeders and other scientists involved in research on barley improvement in many countries. They have identified and used those accessions needed in their research. Those accessions have been evaluated for their

reactions to one or more strains of pathogens and insects which cause the following diseases: powdery mildew, leaf rust, scald, net blotch, nuda loose smut, barley yellow dwarf virus, barley stripe mosaic virus, cereal leaf beetle, green bug and Hessian fly. They have been evaluated for reactions to stresses such as acid soils or aluminum toxicity, winter hardiness and lodging. Plant breeders have also selected those accessions with desirable agronomic characteristics such as tillering capacity, time of ripening, protein content and other morphologic characteristics. Unfortunately the data from those evaluations have not been compiled nor summarized. Nevertheless, information regarding those accessions outstanding for specific useful traits has been distributed through workshops, newsletters, other publications and through many personal contacts, and those accessions have been used as parents in cultivars developed and are now grown in many countries. The curator of the collection is being requested to add large groups of accessions into the collection. The reasons for incorporating those accessions in not always clearly defined.

Supplemental Working Collection of Barley Germplasm

A supplemental working collection of barley germplasm is being developed to identify germplasm which can be used to develop productive, less vulnerable, and genetically diverse barley cultivars. The supplemental collection consists of the following 5 groups of accessions: (1) cultivars grown in North America: (2) cultivars grown in other countries; (3) land

racess from other countries; (4) barley collected in Ethiopia; (5) Hordeum spontaneum collected in Israel.

Cultivars Grown in North America

The barley cultivars grown commercially in North America should be collected, classified, evaluated and maintained. The barley cultivars grown commercially in North America were last classified in 1958 by G. A. Wiebe and D. A. Reid in USDA Technical Bulletin No. 1224 (Wiebe and Reid 1961). Those cultivars which have been developed since 1958 in North America have been assembled. Seed of these cultivars are being increased in Arizona and Idaho. They will be described, evaluated for specific characteristics and the information published. The cultivars, which are not in the USDA Barley Germplasm collection, will be added to that collection.

Cultivars Grown in Other Countries

Modern barley cultivars have been developed by breeders and other scientists in many other countries. These cultivars are adapted for maximum production under the different environmental conditions in those countries and are used for many purposes. Germplasm used to develop these modern cultivars is diverse. Breeders and other scientists have been contacted in most of the barley producing countries as part of the cooperative Israel-United States Binational Science Project No. 1841. They have been requested to furnish seed of about 5 cultivars which have made the greatest impact on barley production in their country during the last 5-10 years. Seed of 150 cultivars received from 19 individuals in 17 countries

is being increased in Idaho.

Land Races from Other Countries

Varieties of many crops which were grown prior to the recent development of improved modern cultivars, are rapidly disappearing (Harlan 1975). Some of those varieties have been grown by farmers in isolated areas for many years. We refer to those varieties as land races. Those land races must have been relatively productive and stable to have survived and to have been grown for many years. Plant breeders and other scientists in many countries have likewise been requested to furnish seed of up to 20-30 land races which were grown in their country prior to the development of modern cultivars. They have been requested to obtain the land races from as many areas with different environments and growing conditions as possible in their country. Seed of 450 land races from 20 individuals in 15 countries is being increased in Idaho.

Barley Collected in Ethiopia

Ethiopia has been recognized for many years as the center of the greatest genetic diversity of barley germplasm (Harlan 1975; Vavilov 1951). Collections of barley have been made in Ethiopia in recent years by scientists in many countries (Fischbeck et al. 1976; Porter 1980). There are over 2,000 accessions collected in Ethiopia in the USDA barley germplasm collection at Beltsville. Sources of resistance to each of 7 diseases of barley were identified among the 654 accessions in the collection, which were introduced from Ethiopia prior to 1954 (Qualset 1975). The source of resistance in some

cultivars recently developed and released in North America originated from these accessions introduced from Ethiopia.

In 1970, G. A. Weibe collected seed from spikes of over 1,000 plants at about 150 locations in Ethiopia. Sets of seed from 244 of those spikes including one spike collected from each location have been assembled. The sets are being distributed to individuals who will evaluate the accessions for various characteristics. Arrangements have been made to have these data computerized so that it can be summarized and distributed.

H. spontaneum Collected in Israel

H. spontaneum, a progenitor of barley, has existed in Israel and the fertile crescent region for over 5,000 years (Harlan 1979). Nevo et al. (1979) by studying proteins detected by gel electrophoresis, have shown that the H. spontaneum accessions collected in Israel are genetically more diverse than are the plants in composite cross population XI. Studies of H. spontaneum accessions collected in Israel have shown that they are not only highly genetically diverse with respect to reactions to the powdery mildew and leaf rust pathogens but that many of them are highly resistant to those pathogens (Anikster et al. 1976; Fischbeck et al. 1976; Moseman and Craddock 1976). H. spontaneum accessions also have been used by plant breeders as sources of resistance to pathogens in cultivated varieties (Fischbeck et al. 1976; Hayter 1980; Porter 1980).

We have assembled a set of 258 H. spontaneum accessions collected in Israel which we found resistant to the powdery

mildew and leaf rust pathogens. This set of accessions is being evaluated by pathologists for their reactions to other pathogens. Arrangements have been made to have these data computerized so that it can be summarized and distributed.

Conclusions

We hope that the supplemental working collection of barley germplasm will contribute to the improved productivity and decreased vulnerability of barley production in many countries. Most of the accessions in the collection will be incorporated into the present USDA barley germplasm collection and will be available to scientists interested in barley improvement.

The accessions in the supplemental working collection should be very useful in developing productive, stable and genetically diverse barley cultivars. The cultivars and land races should contribute to the maintaining and improving of the productivity of new barley cultivars. The land races, barley from Ethiopia and *H. spontaneum* from Israel should contribute to the stability because of their tolerance to many diseases and other stresses. The cultivars and land races from other countries, barley from Ethiopia and *H. spontaneum* from Israel should contribute new sources of genetic diverse germplasm.

Only a limited amount of information is available on the accessions in the supplemental barley germplasm collection at the present time. Seed of the accessions is being increased. The accessions are being evaluated for reactions to pathogens and insects and other stresses, quality and other characteristics. As those evaluations are completed the data

will be computerized, summarized and analyzed and published. Sufficient information should be available by May 1982 to begin furnishing seed of accessions with specific characteristics from this collection. Many scientists interested in developing productive, pest resistant, stable, high quality, and genetically diverse cultivars are involved in this program. We thank those who are participating and welcome those who would like to participate in evaluating accessions in the collection.

References

- AHOKAS, H. 1980. Cytoplasmic Male Sterility in Barley. Part 7: Nuclear Genes for Restoration. *Theor. Appl. Genet.* 59:193-202.
- ANIKSTER, Y., MOSEMAN, J.G., and WAHL, I. 1976. Parasite Specialization of *Puccinia hordei* Otth and Sources of Resistance in *Hordeum spontaneum* C. Koch. Pages 468-469 In *Barley Genetics III, Proc. Third Int. Barley Genet. Symp.*, Garching, 1975.
- FISCHBECK, G., SCHWARZBACK, E., SOBEL, Z., and WAHL, I., 1976. Types of Protection Against Barley Powdery Mildew in Germany and Israel Selected for *Hordeum spontaneum*. Pages 412-417 In *Barley Genetics III, Proc. Third Int. Barley Genet. Symp.* Garching, 1975.
- HARLAN, J.R. 1969. Ethiopia: A Center of Diversity. *Econ. Bot.*, 23:309-14.
- HARLAN, J.R. 1975. Our Vanishing Genetic Resources. *Science* 188:618-621.
- HARLAN, J.R. 1979. On the Origin of Barley. Pages 10-36 In *Barley: Origin, Botany, Culture, Winterhardiness, Genetics, Utilization, pests.* In U.S. Dept. of Agric. Handb. No. 338.
- HAYTER, A.M. 1980. Pages 61-66 in *Scottish Plant Breeding Station Report April 1979 to March 1980.*
- MOSEMAN, J.G., and CRADDOCK, J.C. 1975. Genetic Basis for Collecting, Evaluating and Maintaining Barley Germplasm. Pages 51-57 In *Barley Genetics III, Proc., Third Int. Barley Genet. Symp.*, Garching, 1975.
- NEVO, E., BROWN, A.H.D., and ZOHARY, D. 1979. Genetic Diversity in the Wild Progenitor of Barley in Israel. *Experientia* 35:1027-1029.
- PORTER, G.E. 1980. Page 33 In *Annual Report 1979, Plant Breeding Institute, Cambridge, England.*
- QUALSET, C.O. 1975. Sampling Germplasm in a Center of Diversity: An Example of Disease Resistance in Ethiopian Barley. Pages 81-96 In *Crop Genetic Resources for Today and Tomorrow*, 492. Cambridge Univ. Press, London, England.
- VAVILOV, N.I. 1951. The Origin, Variation, Immunity and Breeding of Cultivated Plants. *Chron. Bot.* 13(1/6). 364 pp.

WIEBE, G.A., and REID, D.A. 1961. Classification of Barley Varieties Grown in the United States and Canada in 1958. U.S. Dept. Ag. Tech. Bull. No. 1224. 234 pp.

SUMMARY OF BREEDING TECHNIQUES

D. C. Rasmusson*

This paper presents ideas that have occurred to me during the workshop. It seems that it is useful, from time to time, to reinforce some of the ideas and the philosophy that dictate how we approach our research even though they may be familiar. If some of the ideas appear to be yours, do not be surprised since items included here are those that have been mentioned to me during the course of the conference.

Disease breeding programs frequently fail to achieve their goal. If you have done very much disease breeding, you almost certainly have had programs which did not go according to plan. Sometimes we fail to appreciate just how difficult it is to get from the starting point to the end point in a disease breeding program. As a barley breeder, you can make a new set of crosses each year and show and talk about your disease breeding effort, and yet not get the job done. Getting the job done means a new variety that is being used and that affords protection to the disease in question.

Breeding Format or Strategy

It seems that it helps if we have a format or a strategy that we follow with various steps clearly defined. It also might serve to make us a little more accountable in terms of whether or not progress is being made. Let me outline steps in a disease breeding format or strategy which are:

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Step 1. Make a decision about breeding for the disease in question

This is a topic that has been discussed at some length at this workshop. The point has been made that we need information on yield losses before deciding to breed to control a disease. We can do carefully designed experiments utilizing common approaches such as measuring losses due to disease, using chemicals to provide control plots, and comparing resistant and susceptible cultivars or isogenics. But these experiments will not provide the whole answer. We need to know about losses that occur in farmers' fields. The best solution, is to know the crop and the disease. You can be sure that if leaves are destroyed by the disease by heading time, yield losses are going to be substantial. If there are only a few lesions, or if the crop is nearly mature before the infection becomes severe, losses will likely be small. If you know the crop and watch it throughout the season in the whole of the growing area, you can get a good reading on whether you ought to breed for disease resistance. Special studies may help, but working closely with the crop is the best solution.

Step 2. Obtain information about the disease and how to screen for resistance

If you are going to do disease breeding, you ought to do it in cooperation with others. Cooperators may have information on the nature of the disease and its pathogenicity as well as on screening procedures. Hopefully, screening for disease reaction can be done in the field. You might be concerned with which of several locations to use and what

planting date is most conducive to high levels of infection. If you do not have good screening techniques, you are not likely to be effective.

Step 3. Obtain resistant genes or sources of resistance

You can screen collections for resistant sources or you can obtain them from cooperators. The quality of these stocks deserves a lot of attention, not only from the standpoint of the disease resistance they possess, but also from the standpoint of their agronomic merit. In most cases you should make crosses only after you have evaluated the resistant sources under your conditions.

Step 4. Transfer of resistance to a suitable genetic background

If the stocks possessing resistance are unimproved poor types that lodge or do not yield you ought to prepare yourself for a long breeding program that may entail transferring the genes for resistance into an improved genetic background before you can expect to obtain a new variety. Once this transfer is accomplished, the chances of obtaining a new variety are much improved. Often too much time and resources are wasted with poor parental material.

Step 5. Make the new variety cross and do selection and evaluation

This is where most of the breeding effort is concentrated. This is appropriate so long as the other steps are not neglected.

Step 6. Seed distribution

Plant breeders are really not effective until the varieties are in the growers' hands. Getting seed to growers

may be a difficult task, but it is one that must be done and one that we as breeders should concern ourselves with on a continuing basis.

Suggestions When Doing Disease Breeding

Success in disease breeding means making correct decisions and following them through. Some suggestions for conducting disease breeding are:

1. Start with the best possible germplasm: This job takes time and it may require a couple of years to identify the best sources of resistance. Consider the best sources from the standpoint of disease reaction and agronomic performance. The overall genetic merit of the stock makes a difference since it may determine whether or not your program is successful. When someone says this stock provides a good source of resistance, ask in what sense is it good. A good source is one that will lead to a new variety in a short period of time so the program can serve the farmer. We ought not to be thinking only about the disease reaction. If your sources of resistance are poor agronomically speaking, you do not have good "sources of resistance". You have good germplasm only if you can expect to get a new variety to the farmer in a reasonably short time.
2. When resistant sources are introduced, handle the breeding so as to preserve "local germplasm": Most often local varieties or germplasm have something that will benefit the progeny or is required in the progeny. You may want to make an F_1 and then backcross to the local variety. If you introduce germplasm into your program make sure that you test derived lines

rigorously since introduced germplasm may be extremely susceptible.

3. Keep programs simple: Breeding programs like those of CIMMYT and ICARDA are not good models for most of us. They are working for many countries with an extremely wide range of growing conditions. Most of us should identify one disease or two and concentrate on it.

4. Be durable in pursuing disease breeding objectives: It is of the utmost importance in doing disease breeding to follow through. In most cases, it is good to continue to work with the "resistant genes" in which you have an investment, rather than to start with new stocks every year or so. Keep in mind that it may take 10, 15 or 20 years to complete a disease breeding program.

5. Use resistant sources that give good protection in your country: Unfortunately new varieties do not come from discussions about horizontal versus vertical resistances, major versus minor genes, or durable versus non-durable resistance.

You should evaluate various resistant stocks in different sites in your target area or country. Take the time to find out about the protection they provide. Let us not confuse the issue by preoccupation with major genes vs. minor genes, or horizontal vs. vertical resistances. As plant breeders, it is enough that we use stocks that give consistent reactions in our target areas. You might decide to use stocks that give a high level of resistance or stocks that give partial resistance.

6. Secret to success in disease breeding: You can read the literature, you can come to a workshop, you can have an

elaborate plan, but all these are not enough. If you want to be a successful disease breeder or pathologist, what you need to do is work. Do any of you know successful breeders or pathologists who do not get out in the field and work with the disease and the crop? There is a lot of value in basic research but those of us who are charged with disease breeding, i.e., developing varieties, should concentrate on the breeding job. If we spread ourselves thin we are not likely to make progress.

There is one basic area where we ought to cooperate, and that is on research on durable resistance. This is an important problem for all disease workers. A couple of possibilities that involve cooperation that were discussed earlier, are impressive. One of them has to do with horizontal resistance and the work being done by the scientists from the Netherlands with funding from FAO. The other possibility is the research being done by the Montana group in developing barley gene pools having many genes for resistance. It seems to me that these programs deserve our support and cooperation.

Cooperation in Disease Breeding

In disease breeding, cooperation is very essential. We need to cooperate for many reasons - most of which have become apparent during the course of this conference. There are some situations where cooperation is desirable, if not essential:

A major component of disease breeding is finding resistance. When we search for and find resistance to a disease, we ought to make our findings available to colleagues. We should report on them in newsletters and bring the

information to workshops like this one. Similarly if we have information about virulence of pathogens, new races etc., we ought to share it. We should also work towards "planned allocation" of resistance sources so that the chances of holding a disease in check are enhanced.

To improve our disease breeding efforts we ought to utilize and contribute to international nurseries. We should all do our best to cooperate with the international barley centers, namely ICARDA and CIMMYT. How many of us have taken the time to consider how important these centers are to our barley work. It seems that relatively few of us support these programs as vigorously as we should. Also we should support and utilize the international barley disease program that is being led by Montana. All of us benefit from this kind of effort and it will only be successful if we support and utilize it.

We ought not pass up the opportunity to encourage individuals or teams to accept responsibility for researching in depth a given disease of barley. There is merit in picking a given disease and working on both basic and applied aspects of the disease over a long period of time. With a long-term commitment you are much more likely to make an important contribution. This is not always possible for a researcher in a developing country, however, there are a number of people here from the centers and the developed countries who could accept responsibility for a concerted effort on a given disease.

In such programs, researchers could be involved in

developing screening procedures, accumulating sources of resistance, determining genetic relatedness of resistant stocks, transferring resistance to a good genetic background, maintaining stocks, and monitoring the protection they provide, as well as pursuing various types of basic research. It seems that we could benefit a great deal if the international centers and a number of researchers in the developing countries would say, "This is my disease; I will concentrate on it."

PROGRAM

BARLEY DISEASES AND ASSOCIATED
BREEDING METHODOLOGY WORKSHOP

Rabat, Morocco 19-23 April 1981

<u>Sunday, 19 April</u>	Registration - Hotel Tour Hassan	Rabat, Morocco
	All day	
<u>Monday, 20 April</u>	Opening Session - Institut Agronomique et Veterinaire	
0830-1030	Welcome	H. Faraj
	Vote of Thanks	R.J. Jackson
	Opening Remarks	M.A. Nour
	Current Status & Constraints to Barley Production	J.P. Srivastava
1030-1100	Coffee	
1100-1130	Barley Diseases in the Higher Rainfall and Irrigated Areas	E.P. Saari
1130-1200	Barley diseases in the dry areas	A.H. Kamel
1200-1400	Lunch	
1400-1500	Net blotch of barley (<u>Helminthosporium teres</u>)	
	Discussion leader	E.L. Sharp
	Net Blotch Situation	
	- Egypt	T.M. Abdel Hak
	- Tunisia	A. Daaloul M. Harrabi
	- Morocco	M. Boulif, et al.

- 1500-1600 Spot Blotch of Barley (H. sativum)
 Discussion leader A.L.Scharen
 Spot Blotch
 - North Africa A.El-Ahmed
 - Algeria B.Nabil
 I.Mohand
 - Tunisia A.Ghodbane
 - India S.C.Atheya
 et al.
 - Spain J.F.Velasco
- 1600-1630 Coffee
- 1630-1730 Helminthosporium Stripe of Barley
 (H. gramineum)
 Discussion leader M.Boulif
 Helmithosporium stripe
 - Tunisia A.El Ahmed
 et al.
 - Morocco J.R.Burleigh
 - South Korea E.S.Lee
- 2000 Workshop banquet - Hassan II
- Tuesday, 21 April
- 0900-1000 Scald of barley (Rhynchosporium secalis)
 Discussion leader O.Mamluk
 Scald
 - Portugal M.Barradas
 - USA M.Harrabi
 et al.
 - USA H.Bockelman
 - Ethiopia A.H.Gebre
 - ICARDA E.M.El-Ahmed
- 1000-1030 Coffee

- 1030-1130 Powdery mildew of barley
(Erysiphis graminis hordei)
- Discussion leader J.Moseman
- Powdery Mildew
- Spain J.H.Velasco
 - Greece E.Skorda
 - Tunisia A.Ghodbane
et al.
- 1130-1230 Leaf rust of barley
- Discussion leader E.J.Parlevliet
- Leaf Rust
- Algeria B.Nabil
I.Mohand
 - Egypt E.Ghobrial
 - USA & Mediteranean
area E.Sharp
- 1230-1430 Lunch
- 1430-1530 Yellow (stripe) and black (stem)
rusts of barley
- Discussion leader R.W.Stubbs
- Review of yellow & black rusts in
- Pakistan F.Ali
 - India S.C.Atheya
et al.
- 1530-1600 Coffee
- 1600-1700 Barley yellow dwarf virus & aphids
- Discussion leader T.Carroll
- Review of BYDV & aphids in
- India S.C.Atheya
et al.
 - USA C.W.Schaller

1700-1800 Bacterial diseases of barley
 Discussion leader D.Sands

Wednesday, 22 April

0800-1300 Field trip - Visit barley nurseries at Rabat and Merchouch and farmer fields enroute.

Thursday, 23 April

0900-0930 Smut Diseases of Barley
 Discussion leader M.Besri
 Review of smut diseases in

- Jordan A.M.Tell
M.Al-Zughbi
O.Mamluk
- India S.C.Atheya
et al.
- Tunisia A.El Ahmed
et al.

1000-1030 Coffee

1030-1130 Review of root rots of barley
 D.E.Mathre

1130-1200 Status of barley diseases surveillance
 J.M.Prescott

1200-1230 Summary of barley diseases
 and implications
 E.L.Sharp

1230-1400 Lunch

1400-1430 Breeding techniques for disease resistance
 Discussion leader D.Rasmusson

The Montana State University/
 USAID programme for development
 of broad based resistance to
 barley diseases
 H.Bockelman
 et al.

1430-1500	Use of male steriles & recurrent selection for disease resistance	R.F.Eslick
1500-1530	Breeding for disease resistance at the University of California	C.W.Schaller
1530-1600	Coffee	
1600-1630	The ICARDA barley programme & efforts in breeding for disease resistance	M.Mekni A.Kamel
1630-1700	The CIMMYT barley programme & efforts in breeding for disease resistance	E.Rodriguez
1700-1730	USDA-Germplasm collection & sources of disease resistance	J.Moseman D.H.Smith
1730-1800	Summary of breeding techniques for disease resistance	D.Rasmusson
1800	Concluding remarks	
	Appreciations	J.Prescott, J.Srivastava, E.Sharp

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