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Progress in Breeding Fusarium Head Blight Resistant Barley

By **John V. Wiersma, Research Agronomist**

As busy as you are, you probably spend some time in April each year thinking about past springs and the coming year. In recent years your thinking may have gone something like this:

- April, 1992 - Are we ever going to return to a 'normal' weather pattern? This drought is devastating.
- April, 1993 - Yes, last year was a good year for small grains, but this year should be even better.
- April, 1994 - And what are vomitoxin and Fusarium head blight (FHB) anyway? Thankfully, these epidemics never happen two years in a row.
- April, 1995 - What do you mean, there aren't any resistant varieties?
- April, 1996 - So...when will they release a new barley variety that is resistant to FHB, that always has less than 1 ppm vomitoxin, high yield, excellent malting quality, early maturity and good lodging resistance?
- April, 1997

We are making progress; however... breeding for resistance to FHB in barley, as well as wheat, is complex. For example, with wheat we're fairly certain that several species of fungi, and numerous isolates of each species, can cause FHB. There are probably four or five types of resistance that plants use to combat these fungi, each type having several components and each component being controlled by one or more genes. We are not certain, however, that these generalizations apply to barley as well as wheat. There is no standardized, reliable method for evaluating resistance and, as yet, no highly resistant sources have been identified. Also, our ability to differentiate between susceptible and resistant genetic materials depends not only on genetic resources, but also upon the level of disease established and the characters studied. Additional barriers to rapid advancement in barley include malting quality requirements and stringent limitations on toxin concentrations in the grain.

Despite these and other challenges, we are making progress. One of several trials conducted at the NWES during 1996 (in collaboration with the UM Barley Breeding and Genetics Project, Don Rasmusson) is briefly described in this article and some of the results are presented to document our progress.

Six cultivars/lines of barley were evaluated at each of six levels of FHB, which were established using different methods of disease inoculation. Methods of inoculation included a noninoculated control, a treatment designed to reduce FHB (Folicur/Benlate applications), and treatments designed to enhance FHB (infected wheat seed, wheat straw, corn seed and corn residue). These methods resulted in six levels of FHB, or six levels of disease pressure, and are referred to as 'envi

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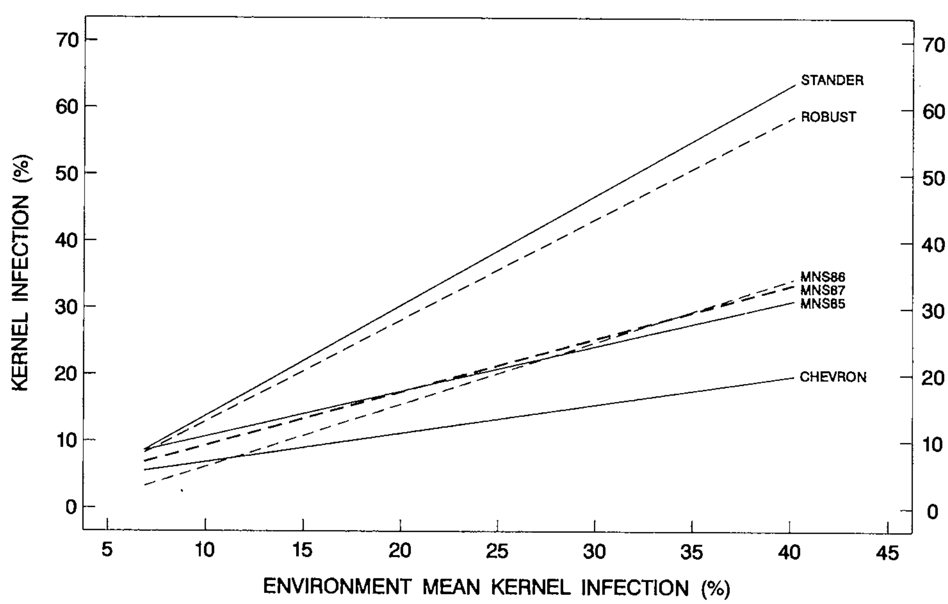

FIG. 1 BARLEY CULTIVAR RESPONSES TO INCREASING FHB DISEASE PRESSURE MEASURED AS KERNEL INFECTION, CROOKSTON, 1996.

Smith's Comments

There is still a six-foot snowdrift in a farmstead adjacent to the Station and we are spraying weeds in our sugarbeets for the first time. The goofy weather patterns we have experienced for the past seven months continue. It makes one wonder what will happen next; a July frost, an August blizzard, a summer drought or record rainfall.

The crop scientists at the Station have finally finished planting the research plots both on and off the Station. It was a trying spring for all involved, but the dedication and commitment of the staff was again demonstrated. At times this spring, Dale Kopecky, farm foreman of the Station, and his staff probably wanted to send me on a very extended vacation. I changed the Station's cropping plan at least three times and was working on the fourth when they barricaded by office, cut the telephone line, took away my pickup and disappeared every time they saw me coming. As usual, they knew what needed to be done, how and when to do it and did not need my constant harassment. I heard the statement "chill out" more than once.

Subject to final negotiations and approval, an entomologist will be joining the Station's research staff in August. We look forward to his arrival which will further the University of Minnesota's commitment to better serve the needs of this region. Thanks to all who supported and worked to make this needed position happen.

Two summer crops tours are now scheduled. The **Weed Control Tour** will be on **Tuesday, July 15** and the **Small Grain Tour** on **Tuesday, July 22.** Further information relative to times and topics will follow.

Have a good summer!

Jacobson Receives Award

Marlyn C. Jacobson, assistant scientist at the Northwest Experiment Station received the Outstanding Alumni Award for 1996 at the annual meeting of the Delta Theta Sigma (DTS) Agricultural University of Minnesota fraternity at a banquet held in St. Paul.

Marlyn was awarded this high honor for his continued dedication and service to the fraternity and his personal accomplishments since he was an active member 30 years ago.

Jacobson was recognized for his exceptional service to international agriculture, first with his service to the University of Damascus in Syria in 1983 through United States Agency for International Development and then at Krasnador, Russia, at the Privolonge Farm in 1994 and again to Kuban Gosagru University in Russia in 1996.

Marlyn is a 31-year employee of the University of Minnesota, NWES Dairy Department.

Congratulations, Marlyn, on receiving this distinguished award.

Cameron Named Employee of the Year

James Cameron, Sr. Research Plot Technician, was the recipient of the **11th Annual Employee of The Year Award.**

Jim began working at the Station in 1975 in the agronomy department. He was transferred to the pesticide/water quality department in 1988 where he is responsible for seedbed preparation, planting, spraying, harvesting and data collection in the chemical resistance and weed control varietal trials for Dr. Bev Durgan, St. Paul and Dr. Bobby Holder, NWES.

Jim does miscellaneous plot work with soil fertilizer trials for Dr. Albert Sims, NWES. He is also official "weatherman" for the Station.

Jim was nominated for this award by his co-workers because of his knowledge of his job, his willingness to help other employees and his friendliness toward his co-workers.

The **Employee of the Year Award** was designed to promote and recognize excellence in job performance among Civil Service and Bargaining Unit personnel. Funds for this special award come from a President's Club donation designated especially for this purpose.

Spring Soil Compaction

by Albert Sims, Soil Scientist

After experiencing one of the worst winters in recent history, many of us are now thinking spring tillage and planting operations. The massive amounts of water moving across fields indicate that fields are very wet. As the normal planting date rapidly approaches, yet winter still persists, there may be a tendency to start field operations sooner than we should. Though I am relatively new to the Red River Valley and northwest Minnesota, I know this has been the situation for the last couple of springs. If field operations start before the soil is dry enough, there is a danger of detrimental soil compaction and yield reduction. I am sure that all of us have seen stunted, light green to yellow plants in somewhat regular patterns across the field. Presumably, much of this is caused by soil compaction, primarily in the wheel tracts.

Soil compaction problems have been apparent since the beginning of cultivated agriculture. More recently the vigil over soil compaction has been associated with the tremendous increase in tractor and machinery size as well as greater yield expectations. In the 1940's, a large tractor might have weighed 3 tons, but today a large tractor might weigh 20 tons. At the same time, tire technology and widths, or the distribution of the weight on the soil surface, has also increased so that the increase in pressure at the soil-tire interface (contact pressure) has not increased proportionately. Nevertheless, total axle weight has been shown to influence soil compaction. Research conducted at Lamberton and Waseca, MN indicates that contact pressure influences soil compaction within the plow layer while total axle weight influences soil compaction below the plow layer. Applying these forces to the soil when it is too wet can have serious consequences for the production potential of the compacted zone.

What is Soil Compaction?

Soil compaction occurs when soil volume is compressed and the porosity, or non-solid phase of the soil, is reduced. The pore space is where water infiltrates and drains through the soil profile, air is exchanged between the soil system and atmosphere, and roots grow and access stored water and nutrients. Increases in soil compaction can be measured through increases in soil bulk density (weight per unit volume of soil) or the force required to penetrate the soil layer. When soil compaction reduces pore space to such an extent that water and gas movement and exchange are reduced, or plants cannot provide the energy necessary for root penetration to acquire water and nutrients, the results are unhealthy plants and reduced yields.

What Causes Soil Compaction?

Basically soil compaction is caused by any downward or outward force that can move the soil solids into the pore space. Water tends to lubricate the soil solids such that they will move easier compared to drier soil conditions. The contact point at the tire-soil interface is generally where most of the force is applied. As the pressure or force at this contact point is increased, wet soil solids are more apt to be moved. The pressure levels applied are not great enough to actually compress the solids themselves, but they are great enough to move the solids into the air and water filled pore space. The tillage implement can also cause soil compaction as the soil is sheared, pressed, lifted, and pushed out of the way of the mechanical shovel. Nevertheless, the regular patterns of stunted plants in many fields suggest that tire tracks are of greatest concern in most situations. In addition, the force required to pull the implement through the field is exerted at the tire-soil contact point. The mechanism by which a tractor can propel itself, such as slippage, creates shear stresses on the soil causing compaction. As the force required to pull an implement through the field increases, shear stress and the downward compression at the tire-soil interface also in crease.

Does Soil Compaction Cause Yield Reductions?

To put it simply, if the soil compaction is great enough, yields will be reduced. Whether the compaction generally experienced in valley and surrounding soils is great enough to cause yield reductions will depend on the soil, degree of compaction, type of crop grown, and weather conditions after the compaction event. It is important to note that some compaction is desirable to maintain optimum yield potential. The use of press wheels on planting implements is a good example. Press wheels compact the soil over the seed bed to provide better seed-soil contact and conserve soil moisture for seed germination. Some compaction also forces the plant root system to branch and explore more of the lateral soil volume to acquire water and nutrients. However, too much soil compaction reduces the soil pore space to such a degree that plant roots must physically move the soil solids to grow. When the energy required to do this exceeds the

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energy available, in addition to lack of newly acquired water and nutrients, plant health begins to deteriorate.

Research at Morris and Lamberton, MN on wheat and soybean, respectively, indicate that during drier years, yields were actually greater in compacted soil than less compacted, or uncompacted soil. This is an indication of the water conservation effects of compaction where soil pores are not continuous to the soil surface allowing water evaporation. However, during wetter years, yields in compacted soil were reduced compared to less compacted or uncompacted soil. In two studies conducted near Grand Forks, ND by soil scientists at North Dakota State University, spring soil compaction reduced wheat yields, up to 11 bushels per acre, compared to fall soil compaction or uncompacted soil during a wetter year. In one of these studies, no yield reductions occurred the following year, but grain protein was reduced with spring soil compaction. In all other years of the studies there were no differences in yields or protein content among spring, fall, no soil compaction treatments. These results emphasize the importance of climatic factors in determining the effects of soil compaction. They also suggest that the degree of soil compaction may vary depending on the soil conditions at the time the compaction treatments were imposed. Nevertheless, visual observations of patterned stunted, unhealthy plants in many fields the last couple of years leads one to believe that yields are reduced in these plants.

What can be done about Soil Compaction?

The reality is that some soil compaction is unavoidable. However, growers will want to reduce the detrimental soil compaction as much as possible. As the optimum planting date approaches, each grower must assess their own situation and develop a balance between potential yield loss due to soil compaction and the potential yield loss due to late planting. Once soil compaction has occurred, there is little that can be done during the growing season. Four approaches to soil compaction can be considered.

1. **Avoidance** - This is the most desirable, but sometimes not feasible, approach. Simply put, "Don't work the soil until it is fit to work." The exact optimum water content to work the soil is difficult to ascertain. If the soil is moist, but crumbly when worked by hand it can probably be worked without serious compaction consequences.

2. **Acceptance** - In this case the grower has decided that other factors play a bigger role in their management decisions than soil compaction. Thus they have decided that they can live with the soil compaction consequences. This often happens as the optimum planting date is passed or if a lot of acres need to be covered.

3. **Controlled Traffic** - Maintaining wheel tracks in the same general area in each pass across the field will reduce the amount of land area that is compacted. In row crop situations this is probably easier than in small grain crops. Nevertheless, reducing the number of passes across the field and maintaining the wheel tracks in the same general area should help the overall field conditions. It may, however, further exaggerate the patterned appearance of the field.

4. **Alleviation** - Actual alleviation of soil compaction is difficult to do once the crop has been planted. If, however, the grower can ascertain the cause of plant health problems, some measures may be taken to improve plant health without actually alleviating the soil compaction. For instance, if nitrogen is detected as the problem, additional nitrogen fertilizer may improve plant productivity in compacted soils. It should be noted that this type of correction can bevery difficult to do as symptoms of several different problems can be similar in appearance and can be highly interactive.

As the snow melts, flood waters subside, and spring finally arrives we can only hope for a good growing season. Last spring was also late, but for the most part crops produced in excess of expectations. Perhaps it will happen again. The only advice I can give growers is to be patient and assess the pros and cons of working fields too early. Each grower must evaluate the situation themselves and use the management strategy that best fits their situation. Good luck and may the bins be over flowing this fall.

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In Memory

Cheryl Engelkes, former graduate student and Northwest Experiment Station employee, died September 28, 1996 in Minneapolis.

Juel K. Torvi died September 30, 1996 in St. Paul. Juel was farm foreman at the Northwest School of Agriculture and Experiment Station from 1923 to 1971.

Olaf C. Soine died October 11, 1996 in Arden Hills, Minnesota. Olaf was an instructor, soil scientist and agronomist at the Northwest School of Agriculture and Experiment Station from 1945 to 1974.

Marge Johnson, staff secretary at the Northwest Experiment Station from 1966 to 1972, died January 26, 1997 in Albuquerque, New Mexico.

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ronments' in describing the results. Barley cultivars/lines included a resistant entry (Chevron), two susceptible entries (Robust and Stander) and three advanced breeding lines (MNS85, MNS86, MNS87). These lines have Chevron in their pedigree, are thought to be moderately resistant to FHB, and are considered to be potential variety releases. Several agronomic and disease-related characters were measured including, grain yield, test weight, kernel plumpness, visual FHB, kernel infection by *F. graminearum*, and vomitoxin concentration.

Cultivar responses to increasing levels of FHB, measured as kernel infection and vomitoxin concentration, are given in Figures 1 and 2. As the level of FHB increases (or as the environment mean increases) going from left to right in Fig. 1, we would expect the more resistant lines to show less increase in kernel infection than the more susceptible lines. Similarly, going from left to right in Fig. 2, we would expect the more resistant lines to show less increase in vomitoxin concentration than the more susceptible lines. Indeed, in both cases Chevron (more resistant) responds less to higher disease than do Robust and Stander (more susceptible). The responses of the three MNS lines are intermediate and represent substantial improvements compared to Robust and Stander for both kernel infection and vomitoxin concentration. As the environment gets better and better for disease, kernel infection and vomitoxin in the MNS lines increase at about one-half the rate of Stander and Robust. These improvements come at little cost to grain yield, test weight, or kernel plumpness, as shown in Table 1. Although encouraging, please remember that these results are from one trial and one year. Additional research is necessary to verify these results and to test other advanced breeding lines.

Although FHB is a nasty problem that is likely to be around for some time, we are making progress. Barley line MNS85 was increased in Arizona last winter and will undergo extensive testing this summer for FHB resistance, malting quality, and agronomic performance. It could be released in 1998. Also, barley lines from China and progeny from crosses involving Chinese lines are being evaluated cooperatively with scientists at NDSU. Some of these lines appear promising. Ultimately, continued, cooperative testing will result in varieties that are significantly more resistant to FHB with superior agronomic performance.

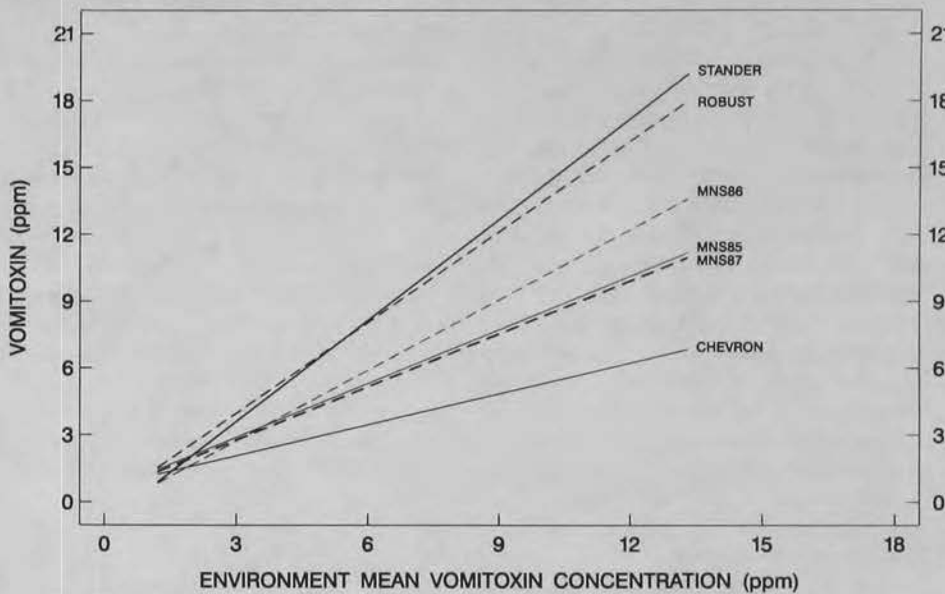


FIG. 2 BARLEY CULTIVAR RESPONSES TO INCREASING FHB DISEASE PRESSURE MEASURED AS VOMITOXIN CONCENTRATION, CROOKSTON, 1996.

Table 1. Grain yield, test weight, and kernel plumpness of cultivars and advanced lines of barley grown in a Fusarium head blight nursery, Crookston, 1996.

Cultivar	Grain yield bu/acre	Test weight lbs/bu	Kernel plumpness %
Robust	108	42.9	76
Stander	107	44.0	84
MNS85	121	44.5	77
MNS86	113	43.5	78
MNS87	118	44.3	77
LSD (P=0.05)	7.2	0.8	3

NWES Faculty Member Elected to National Office

Dr. Carol E. Windels, Associate Professor at the University of Minnesota's Northwest Experiment Station, Crookston and the Department of Plant Pathology, St. Paul, recently was elected President of the American Phytopathological Society (APS), a national organization of over 5,000 plant pathologists.

Since 1984, she has done research on control of seedling and root rot diseases of sugarbeet. She has a BA in biology from St. Cloud State College and master and doctorate degrees in plant pathology from the University of Minnesota.

She will serve as vice president of APS in 1997, president elect in 1998, and president in 1999.

NWES Gets Tangled in the Web

by Jochum Wiersma, Small Grains Specialist

The Northwest Experiment Station is slated to take over the Agri-Industries Telecommunications Project of the Red River Trade Corridor. Amongst others, the project hosted the Minnesota Association of Wheat Growers and the Sugarbeet Research and Education Board's Websites. Funded by a USDA grant, the Agri-Industries Telecommunications Project received a lot of visibility and very positive reviews. As the grant runs out, the NWES is stepping in to ensure the future of this important work. The project will continue as the Red River Ag Communications Project. Watch for us on the Internet later this summer.

Small Grains Website

The Minnesota Association of Wheat Growers' website has grown steadily and undergone a major facelift. The usage of the site has been monitored closely in the past few months and it surprised even me. The website averages 75 users a day. Roughly 63% of the users originate in the U.S. Sixteen percent of the users are from abroad. The most active foreign countries are Canada, Australia, United Kingdom and France.

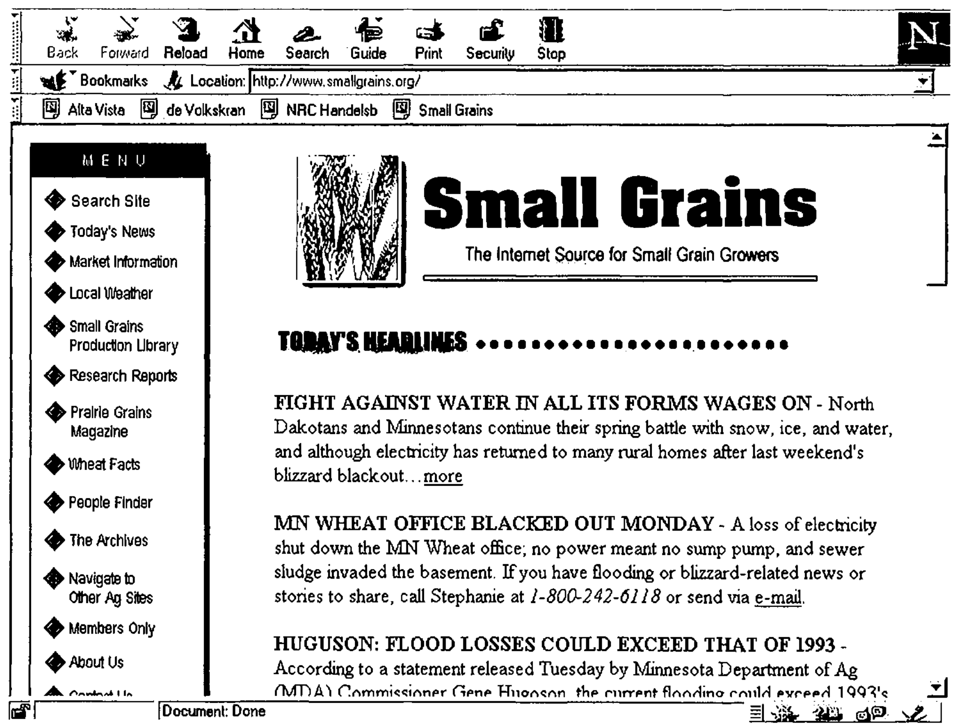
Red River On-Farm Yield Trials

During the 1996 season, the NWES initiated a number of off-station yield trials for wheat and barley across northwest Minnesota. These off-station trials are part of a concerted effort to expand and improve the variety descriptions and recommendations for wheat and barley. The yield trials provide data about the performance in the region, in addition to the yield trials in Crookston, Morris, Stephen and Roseau.

In conjunction a seeding rate trial for wheat was initiated at the Northwest Experiment Station. Traditionally, recommendations for optimum seeding rates have been the same for all varieties. With some of the newer releases, questions about whether that recommendation held any water kept resurfacing.This prompted us to look further into the questions. Nine recent releases were planted at five seeding rates, and two planting dates. Initial results indicate:

- There are different optimum seeding rates for each variety.
- The response for each variety in delayed planting differs with each variety.

We will continue this trial at least one more year and we hope to make variety specific recommendations next fall.



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