BARLEY-AGING, DISEASE AND PROTEIN

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High-protein barley can cause serious processing problems for the maltster and the brewer, and it may be discounted heavily on the grain market. High protein levels are caused by certain cultural practices, high fertility levels, temperature and moisture effects, time of seeding, and other factors. Barley diseases have been implicated in protein alterations but without substantial experimental evidence. Also, natural senescence or ageing of the barley plant is known to affect the protein level of the harvested kernels. The relationship of several common foliar diseases, natural senescence, and the nitrogen content of the barley plant was studied in the NDSU Pathology Department. This paper reports the results of that study.

EXPERIMENTAL

Eight barley varieties and advanced breeding lines were grown in replicated field plots at Fargo. The plots were: 1) inoculated with three barley foliar disease organisms, 2) treated with a fungicide, or 3) untreated (therefore exposed to natural infection). The plants were harvested at maturity and analyzed for nitrogen content. Similar analyses were made of both greenhouse-grown plants and plants grown under "germ-free" conditions. Slides were prepared of leaf sections from healthy, diseased, and senescing barley plants. These slides demonstrated the changes that occur in leaf tissue either as a result of disease or the ageing process.

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RESULTS AND DISCUSSION

Barleys sprayed with disease organisms or exposed to natural infection had a higher nitrogen level than the plants protected with a fungicide. Tests proved that the lower nitrogen level was caused by the absence of the disease fungi and not by the fungicide itself.

Other tests showed that the nitrogen content of infected barley leaves varied with the location of the disease organism. The yellowed portions of diseased leaves had the least amount of nitrogen. Brown leaf portions (containing the body of the pathogen) had a higher nitrogen content. The green tissue at a distance from the diseased area had an even higher nitrogen content; while the green tissue immediately adjacent to the disease site possessed the highest nitrogen level. Since the yellow leaf color indicates the destruction and loss of nitrogen-containing chlorophyll, this reduction in nitrogen is to be expected. The higher nitrogen level in the dead leaf is probably due to the combination of barley and fungal nitrogen. The higher nitrogen level in the green tissue adjacent to the disease site suggests that the fungus causes nitrogen to move from other portions of the leaf to the area of infection.

The reduction of nitrogen in ageing tissues is well known. As the plant matures, nitrogen is transported from the

stems and leaves to the developing grain head. This decrease in foliar nitrogen is accompanied by an increase in yellowing — a phenomenon associated with both natural senescence and disease. Additional similarities between senescence and the disease process exist at both the macroscopic and the microscopic level:

Macroscopic

Yellowing

Death of tissue

Flowering and fruiting

Moisture loss

Microscopic

Chloroplasts breakdown

Brown pigment produced

Disorganized structures

Vacuoles formed

Vascular dysfunction

Nuclei disintegrate

Young barley leaves, infected by certain fungus pathogens, resemble ageing leaves; they display all of the properties of senescent leaves, despite the difference in "age." Under the microscope it is difficult to distinguish infected young or mature leaves from uninfected senescent leaves.

Based on the results of these experiments, a new hypothesis was developed to account for the interrelations of disease, senescence, and protein levels in barley. This hypothesis states that barley foliar diseases, such as Spot Blotch, Net Blotch, and Septoria Leaf Blotch, cause infected plants to age prematurely. The presence of the pathogen causes the plant to take up more than normal amounts of nitrogen from the soil. This nitrogen accumulates at the site of fungus infection on the leaves (the "spots" of the disease). The infected plant matures at an accelerated rate, and the nitrogen is carried to the developing grain heads. The nitrogen in the developing barley kernels is transformed into protein, at a higher level than that found in uninfected plants.

This research has provided an explanation for the elevated protein levels found in barleys grown in some areas in North Dakota. It also explains why Dickson, a variety with resistance to certain foliar diseases, has consistently shown a lower kernel protein level than some disease-susceptible varieties. It further suggests that fungicidal applications may someday be recommended to enhance both yield and quality of the malting barley crop. At present, normal recommendations for the control of barley foliar diseases, combined with sound agronomic recommendations, will maintain barley protein at a desirable level. Finally, this study has shed new light on the disease process, and has indicated some promising new areas of investigation.