CORRELATION OF YIELD REDUCTION IN PERENNIAL RYEGRASS WITH MEASUREMENTS OF STEM RUST SEVERITY

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Introduction

To make good economic decisions about applying disease control measures, it is important to know how the level of disease will affect harvestable yield. If a small amount of disease causes little or no yield loss, then it would be uneconomical to pay for a fungicide application in lightly-infected fields; on the other hand, if a given amount of disease does cause significant yield loss, then it will pay to incur the cost of a fungicide application. One aspect of our current research on grass stem rust is to determine the measures of rust severity that correlate best with yield loss, and to estimate the quantitative relationship between such measures and yield.

The amount of rust in the crop at a single time during the season (for example at flowering, or at early seed fill) may correlate with the amount of yield lost in a given year. But since the amount of disease after that point may increase quickly or slowly, depending on subsequent conditions, this single-point correlation of disease with yield loss may not be generally applicable. The same could be said concerning the level of disease leading up to that single point in time. Therefore a measurement of disease that includes the amount of damage occurring during a substantial part of the growing season may be more useful. We have begun to examine this possibility using data for disease severity and yield loss in two different seasons.

Methods

Data for the 1998 cropping season were obtained from experimental plots maintained at the Hyslop experiment farm. Perennial ryegrass (cv. Morningstar) was grown in replicate plots, each plot 25 x 15 ft. The crop was carbon-band seeded in September 1997, and grown using normal commercial practices except that disease was controlled at different levels by varying the number and timing of fungicide (propiconazole) applications. We also applied nitrogen fertilizer at two treatment rates. Stem rust severity was monitored weekly from March until harvest on July 7. Seed was harvested from a 20 x 6 ft strip from the center each plot, using a small plot harvester. Seed was threshed and cleaned to commercial standards. Average clean-seed yield from five replicate plots per treatment was compared with average measures of rust severity taken at weekly intervals from the same five plots per treatment.

Data for the 1997 cropping season were obtained from a first-year planting of perennial ryegrass (cv. Allaire). These plots, set up in a grower's field and maintained by Ron Burr of Ag Research, Inc., were 8 x 25 ft in size. There were four replicate plots per treatment, and treatments varied in timing and type of fungicide applied (see "Stem rust control in perennial ryegrass", by Pfender and Burr, in 1997 OSU Seed Production Research report). For the current analysis, data from 6 different fungicide treatments and two application timings were used. Four treatments were used to obtain average values for final clean-seed yield, and for amount of disease on 4 dates: May 29, June 15, June 26, and July 7. Plots were harvested on July10, and seed was cleaned to commercial standards before taking weights.

Disease severity data for both years were originally quantified on the "Cobb scale." On this scale the maximum amount of disease possible, which is only about 37% of the actual leaf area covered with rust pustules, is called "100%." Thus a Cobb scale reading of 10% rust is equivalent to 3.7% of the actual leaf area occupied by pustules. In order to correlate yield loss with proportion of plant leaf area affected, we converted Cobb scale readings to actual percentage of leaf area affected. In 1998, the rust was severe enough to kill some plants in the nontreated plots; killed leaves were designated 100% actual area affected.

We graphed the proportion of leaf area affected over time, and compared that with the graph of total leaf area over time (see Figure 1). The complete area beneath each graphed line is the duration**X**area, so that the area under the 'total leaf area' curve is the duration**X**area of all leaves in the canopy, and the area under the 'diseased leaf area' curve is the duration**X**area of nonproductive plant tissue. By subtracting the area under the disease curve for a particular treatment from the area under the total leaf-area curve, we have a measure of the available photosynthetic area for that treatment multiplied by its duration, called the 'Healthy Area Duration' for that treatment (Figure 1). We compared healthy area duration with yield for all treatments in the 1998 data.

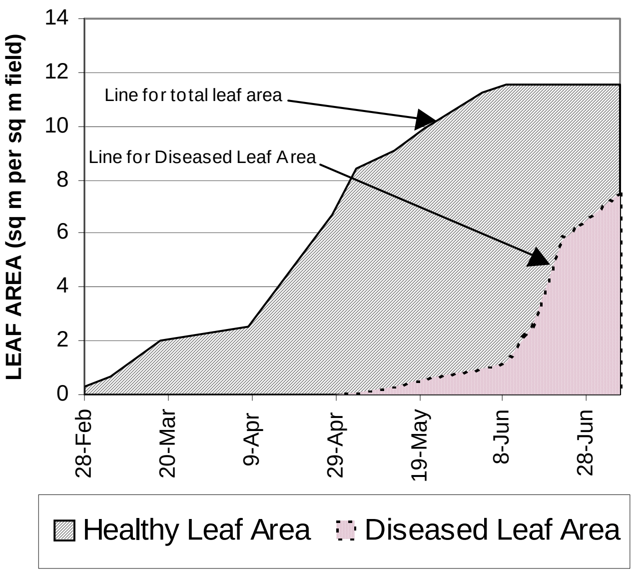

Figure 1. Concept of Healthy Area Duration

In this comparison, we tried various parts of the growing season. When we compared yield to healthy area duration for the entire growing season, the correlation was not very good because a long period of healthy foliage at the beginning of the season did not prevent severe yield depression caused by severe disease later in the season. On the other hand, if we compared yield to the healthy area present during only the final two weeks of the season, plots which had remained healthy up until those final two weeks and then became disease would yield better than plots that were equally diseased during the final two weeks but also had been diseased for several previous weeks. After trying several comparisons, we found the best agreement between yield and the healthy area duration from flowering to harvest. To test this relationship for the 1997 and 1998 data together, we converted the yield data for each year to percent of the maximum yield observed that year. We also converted healthy area duration for each treatment to the percent of the maximum possible leaf area duration from flowering to harvest that year.

Results

As shown in Figure 2, the percent healthy (non-rusted) leaf area duration between flowering and harvest was related in a somewhat consistent way with yield. The greatest variation in yield with healthy leaf area duration is at high levels of both (upper right corner of Figure 2). The two 1998 values at 100 percent leaf area duration are from two nitrogen treatments, and fertilizer had a predictable effect on yields. And whereas the data for 1998 are the result of various rust intensities managed through the use of the single fungicide, the data from 1997 are the result of treatments using a range of fungicides. The higher variability of yields among plots with very little disease in 1997 than in 1998 may be the result of non-target fungicide effects. Despite this variability however, we can see a general pattern: minimal yield reduction at healthy leaf area durations of 90% or better, then a steep decline in yield with decreasing healthy leaf area duration down to about 75%, then a reduced rate of yield decline with disease down to very little yield at very low levels of healthy area duration.

These data were collected from only two years, and analysis of additional data in years to come can be expected to give somewhat different specific results. However, the fact that there is reasonable general agreement between the two years' data, which came from different locations and cultivars as well as different years, indicates that the leaf area duration after flowering may be a good indicator for yield reduction. If this is correct, then the most meaningful measures of damage due to stem rust would be those taken at several intervals between flowering and harvest, so that an evaluation of percent reduction in healthy area duration can be made.

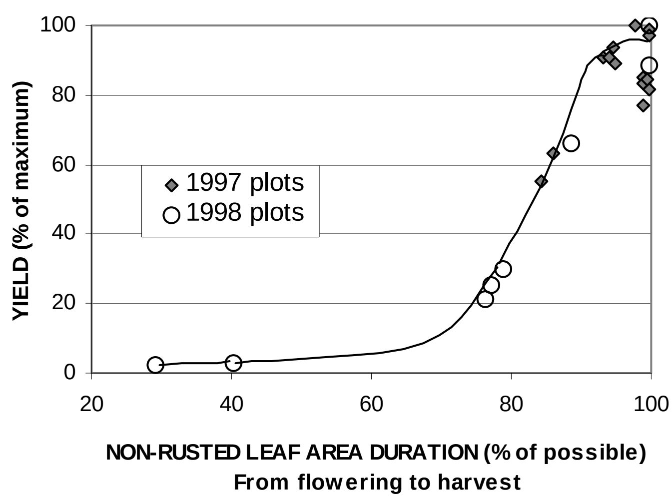

Figure 2. Relationship of seed yield to 'Healthy Area Duration' in perennial ryegrass, 1997 and 1998.

The fact that early-season disease levels may not correlate well with yield reduction does not mean that early-season disease is unimportant. The only way that stem rust levels at flowering can be severe enough to affect yields, is by being present in the stand earlier in the season. So it is important to manage for low rust levels well before flowering, in order to keep rust levels low enough during the flowering-to-harvest period to avoid yield losses. But in evaluating the effectiveness of any particular rust management program, the best measure of success appears to be severity of rust during the time from flowering to harvest.