YIELD LOSS:DISEASE RELATIONSHIPS IN BARLEY CROPS WITH DIFFERENT YIELD POTENTIALS

H.G. WHELAN and R.E. GAUNT

Department of Biochemistry and Microbiology, Lincoln University, Canterbury

SUMMARY

Effects of foliar disease on loss of yield were measured in four barley crops with healthy yield potentials of 3.5 to 7.6 tDM/ha. The yield loss response in each crop was dependent on yield units used and method of disease measurement. When disease was measured as percent disease severity the amount of yield loss, either as a proportion or as weight of grain varied between crops. When measured as green leaf area the relationship was similar in actual yield for crops with different yield potentials. A single model Yield = 38.7 + 3.27 (area under the green leaf area index curve) described this loss for the crops tested. Reflectance was suggested as an alternative to the time-consuming disease severity and green leaf area measurements for surveys and management.

INTRODUCTION

A common method of estimating yield loss has been to define a disease severity:yield loss relationship in experiments, measure disease incidence or severity in the field and, from these, calculate yield loss (Loomis and Adams 1983). Yield loss is commonly expressed as a proportion of healthy yield, although it may be expressed in actual yield units. In using this method, it is assumed that there is a constant relationship between disease and yield loss, which is not affected by variations in environmental, edaphic and management factors which may influence crop growth and development. Use of proportional-loss models implies more actual loss per unit of disease in crops with high rather than low yield potentials. Use of actual-loss models assumes that the actual loss per unit of disease is the same in all crops, but the proportional loss is lower in crops with high yield potential. These specific assumptions are unlikely to describe the relationship in the field in many situations. If crops of different yield potentials do react differently to disease, yield loss estimates for individual crops will be inaccurate.

The objectives of this study were to investigate whether crop yield potential influenced yield loss caused by disease and to determine whether a single model could be derived which accommodated these interactions.

METHODS

Barley was grown with four management strategies to produce different yield potential crops. Within each crop, 10 leaf rust (*Puccinia hordei* Otth) epidemics of different severity were allowed to develop. Manipulation of crop yield potential and disease epidemics were as described previously (Whelan and Gaunt 1989).

Green leaf area (GLA) was measured on eight plants per plot every 7 to 10 days during crop growth and expressed as green leaf area index (GLAI) as described previously (Whelan and Gaunt 1988). Disease severity (including pustule area, associated chlorotic area and disease induced senescence) was measured on the top three leaves of the main stems of the plants sampled for GLA measurements. Ten 0.1 m^2 quadrat samples were harvested at maturity from each plot, bulked, threshed and the grain dried and weighed. Grain yield was expressed as tonnes of dry matter per hectare (tDM/ha).

The seasonal variations between crops and treatments in disease severity and GLAI are presented as the total area under the disease progress curve (AUDPC) and area under the green leaf area index curve (AUGLAIC) respectively. The AUDPC for each

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epidemic was correlated with yield expressed as a proportion of healthy yield (percent yield) and as actual yield (tDM/ha) by regression analysis (Ryan *et al* 1982). The values for AUGLAIC were correlated with actual yield only. The slope values of the regression equations were analysed for significant differences (P<0.10) between crops by analysis of variance (Anon 1987).

RESULTS

The high, medium and low yield potential crops were termed crop 1, 2 and 3 and 4 respectively. Percent disease severity, expressed as AUDPC, was correlated (P<0.001) negatively with percent yield (Fig. 1a) and actual yield (Fig. 1b) in all crops. The slopes of the regressions of AUDPC and percent yield ranged from −0.024 to −0.045 (Fig. 1a), and several were different (P<0.1-0.01) from each other. For example, crop 3 lost 47% more yield, per unit of AUDPC, than crop 2, and 40% more yield than crop 1. The slopes of the regressions of AUDPC and actual yield ranged from −0.0012 to −0.0020 (Fig. 1b). The slope value for crop 1 was greater than for crop 4 (P<0.05) and crop 2 (P<0.01).

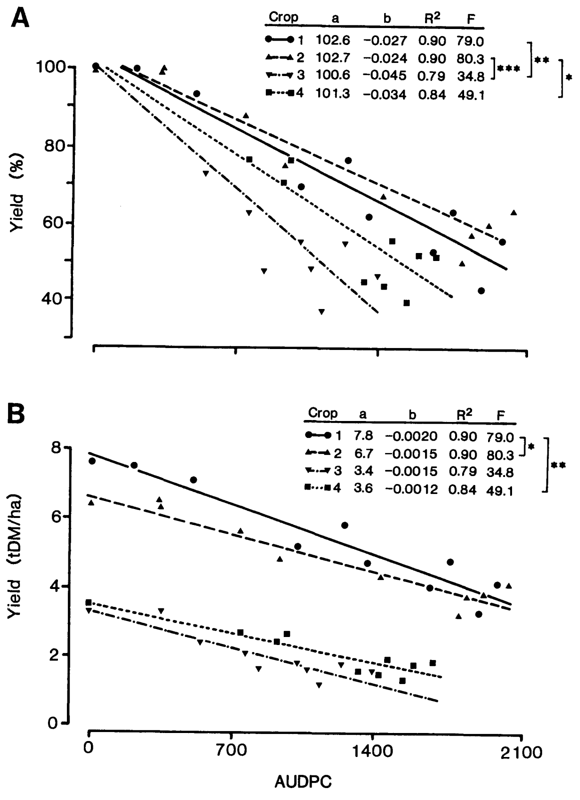

Fig. 1: **Relationship between area under the disease progress curve (AUDPC) and A) percent yield and B) actual yield (tDM/ha) in four barley crops. The intercept (a), slope (b), coefficient of determination (R^2) and F statistic for each regression model are presented. Brackets indicate pairs of crops with slope values which are significantly different (*P<0.1, ** P<0.05, *** P<0.01).**

The AUGLAIC was correlated ($P<0.001$) positively with yield (tDM/ha) in all crops (Fig. 2). Disease reduced the amount of GLAI produced during the season in all crops. The loss in yield ranged from 0.025 (crop 3) to 0.033 (crop 2) tDM/ha per unit of AUGLAIC, but the slope values were not significantly different. Thus actual yield loss was the same in all crops regardless of the potential yield. The response in all crops was described by a single regression model ($P<0.001$):

$$\text{Yield (tDM/ha)} = 38.7 + 3.27\ (\text{AUGLAIC})\quad R^2 = 0.94\quad F = 571.8 \qquad (1)$$

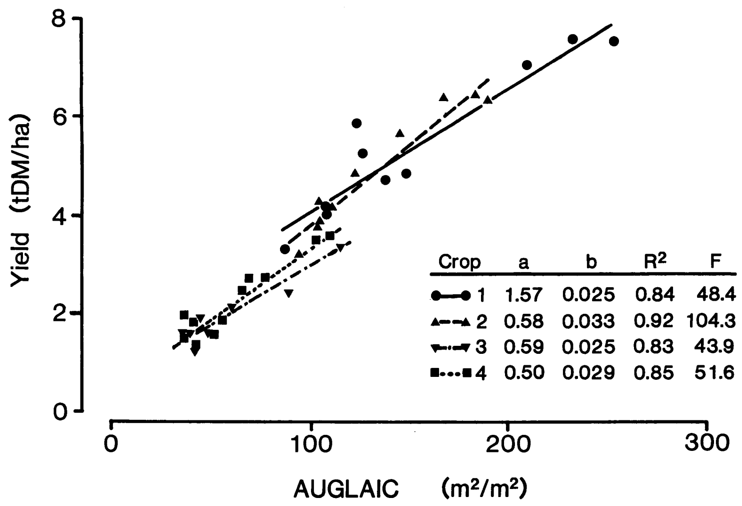

Fig. 2: Relationship between area under the green leaf area index curve (AUGLAIC) and actual yield (tDM/ha) in four barley crops. The intercept (a), slope (b), coefficient of determination (R^2) and F statistic for each regression model are presented. Slope values for each crop were not significantly different ($P>0.1$).

DISCUSSION

The relationship between yield loss and disease was influenced by the yield loss units used and the method of measurement of disease. When disease was measured as AUDPC, both percent yield loss and actual yield loss were influenced by the crop yield potential. For example, crop 3 lost up to 47% more yield per unit of AUDPC than other crops. Crop responses also differed when correlated as single point models of percent disease severity at specific growth stages with percent yield and actual yield (Whelan 1990). Models based on these variables are specific to the yield potential of crops within the range of 3.5 to 7.6 tDM/ha, and cannot be used to give accurate estimates of loss in individual fields.

In contrast, the relationship between actual yield and disease expressed as AUGLAIC accounted for the yield potential of the crop, and a single model (equation 1) could be applied to crops in the yield potential range tested. This model was tested in three additional crops grown in the next season (1988/89) with different yield potentials. The slope values for these crops were similar to the four crops grown in 1987/88 and to the single general model (Whelan 1990).

The measurement of GLA and calculation of AUGLAIC is time consuming and better suited to physiological studies of yield loss than routine surveys or management. However, near infrared reflectance was correlated significantly with GLAI (Whelan and Gaunt 1988) as reported by Daughtry *et al* (1980) and Redelfs *et al* (1987). Collection of reflectance data is considerably less time-consuming and labour intensive than either disease severity or green leaf area measurements (Nutter *et al* 1990). Thus reflectance could replace GLA or disease measurements, and be used in a summary model independent of yield potential. Such models were derived using measurement of reflectance at growth stages 65 to 85. These models could be suitable for surveys of yield loss or management of disease.

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