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L. Bastiaans : Incorporation of damage mechanisms of leaf blast into the crop growth model MACROS.

Incorporation of Damage Mechanisms of Leaf Blast into the Crop Growth Model MACROS.

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Some well-documented growth models for rice have been recently developed (Penning de Vries et al. 1989; Alocilja 1988). In this study the MACROS-model was used to quantify yield reduction due to *Pyricularia oryzae* based on the pathogen's effect on plant physiological processes. This approach is characterized by the use of knowledge at the process level to explain phenomena at the systems level.

Pyricularia oryzae is the causal organism of rice blast. During the vegetative phase of the rice crop infection results in the formation of elliptically shaped lesions, mainly on the leaves. After flowering, infection of the neck or parts of the panicle occur, thereby directly effecting kernel yield. The present study was only on the effect of leaf blast on various basic processes was studied.

A pathogen may interfere with plant growth processes or existing biomass in various ways (Boote et al. 1983; Rabbinge and Bastiaans 1989). For *P. oryzae* on rice four potential damage mechanisms were identified. A reduction in assimilation rate of infected leaves is the first mechanism. Due to the formation of lesions the photosynthetically active part of the leaf is reduced. With some pathosystems this reduction in green leaf area fully explains the reduction in assimilation rate (van Roermund and Spitters 1990). However, in other pathosystems the effect on the pathogen is not limited to the lesions (Rabbinge et al. 1985).

A second damage mechanism is an enhanced respiration rate. This effect can be attributed to a combination of fungal respiration and an increased metabolic activity of the plant. A third damage mechanism is the use of photosynthetically produced assimilates for growth and reproduction of the pathogen. Finally, the longevity of infected leaves may be shortened as a result of the presence of the pathogen.

Quantification of all these effects would be too time consuming. Therefore a classification of the damage mechanisms on the basis of the expected contribution to yield reduction was made. First priority was given to the reduction of the photosynthetic capacity of infected leaves, since the pathogen is able to produce toxins and through this, its effect may exceed the boundaries of the lesion. To elucidate the relation between the fraction of visibly diseased leaf area (severity) and reduction of leaf photosynthesis, measurements in the greenhouse were done. These measurements demonstrated that the influence of the pathogen is not restricted to the visibly affected part of the leaf. In fact, it was shown that the reduction due to a single lesion is comparable to elimination of leaf area, 3 to 4 times larger than the lesion. If more lesions are present the ratio between real and visibly affected leaf area is reduced, comparable to the effect of overlapping lesions.

Introduction of this reduction into the crop growth model was the next step. With the MACROS model, daily crop assimilation is calculated by integrating momentaneous rates of photosynthesis of several leaf layers over canopy height and over the day. Momentaneous rates of photosynthesis are calculated from the amount of absorbed radiation by the leaf layers and the photosynthesis-light response curve of individual leaves. This procedure enables a straightforward introduction of the pathogen's effect on leaf photosynthesis. This effect can be introduced by including the experimentally determined relation between severity and the parameters that describe the photosynthesis-light response curve.

After introduction, comparison of models results with field experiments must clarify whether growth and yield reduction is sufficiently explained by this damage mechanism. If this is the case, the model can be used to improve quantification of yield reduction caused by the pathogen under various circumstances. On the other hand, when growth and yield reduction is not simulated properly, introduction of another mechanism will be needed to increase correspondence between simulation and field experiments. Collection of data for validation thus continues.

Results of model calculations indicate that an epidemic in the vegetative phase causes a reduced formation of leaf and root dry weight. However, the effect on final kernel yield is negligible as long as the green area index around flowering exceeds a value of four. In situations with ample water and nutrients, such a value can only be reduced through very high severity levels. Further, the model shows that an epidemic which continues after flowering affects kernel yield directly since a reduced supply of assimilates in that phase reduces kernel filling.

REFERENCES

Alocilja, E.C. 1988. The analytical structure of the CERES-Rice simulation model. p. 23-41. *In* E.C. Alocilja and J.T. Ritchie (eds.) Upland rice simulation and its use in multicriteria optimization. Research Report Series 01. International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT), Department of Agronomy and Soil Science, College of Tropical Agriculture, University of Hawaii, Honolulu, Hawaii.

Boote, K.J., J.W. Jones, J.W. Mishoe, and R.D. Berger. 1983. Coupling pests to crop growth simulators to predict yield reductions. Phytopathology 73:1581-1587.

Penning de Vries, F.T.W., D.M. Jansen, H.F.M. ten Berge, and A. Bakema. 1989. Simulation of ecophysiological processes of growth in several annual crops. PUDOC, Wageningen, Netherlands.

Rabbinge, R., and L. Bastiaans. 1989. Combination models, crop growth and pests and diseases. *In* R. Rabbinge, S.A. Ward, and H.H. van Laar (eds.) Simulation and systems management in crop protection. Simulation Monographs 32: 217-239. PUDOC, Wageningen, Netherlands.

Rabbinge, R., I.T.M. Jorritsma, and J. Schans. 1985. Simulation of yield reduction by leaf rust in winter wheat, applied to the analysis of genetic variation in partial resistance. Netherlands Journal of Plant Pathology 96:17-28.

van Roermund, H.J.W. and C.J.T. Spitters. 1990. Simulation of yield reduction by leaf rust in winter wheat, applied to the analysis of genetic variation in partial resistance. Netherlands Journal of Plant Pathology 96:17-28.

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