Use of a sensitivity analysis to critically evaluate a model of cereal growth

G.A. Whelan and D.L. McNeil

Plant Science Department, Lincoln College, Canterbury, New Zealand

Computer simulation models often do not closely predict the growth and development of crops in contrasting environments. This may be due to incorrect assumptions, incorrect input parameter values or unrealistic model structure. This paper reports on a critical evaluation of the structure of an existing physiological model of wheat growth. It examines changes in simulated plant growth in response to alterations in physiological and environmental inputs.

Methods

The mode1 used was developed for wheat in the U.K. (1,2). It consists of 5 submodels describing; (i) reproductive development, (ii) leaf and tiller growth, (iii) root growth, (iv) light interception and photosynthesis, (v) dry matter partitioning and grain growth. The mode1 requires daily values of max. and min. temperature, solar radiation and daylength.

The sensitivity of model output to + 30% and + 15% changes in input parameters was assessed for 29 parameters. In a sensitivity run all parameter values were held constant except for the one under test. The standard values used were those determined experimentally for wheat in the U.K. (1). Model runs were made for two sets of environmental data which gave crops emerging on 25 September and 20 December. Meterological data used for all simulations was that collected for the 1986 year at Lincoln College.

Results and discussion

Canopy development is central to models of crop growth as photosynthesis is dependant on radiation interception by green crop organs. Current models of canopy development are highly empirical and give little consideration to the mechanisms involved or their plasticity.

The mode1 produced 4 major sets of predicted plant behaviour.

A. Model output was sensitive to changes in parameters which altered the pattern of canopy growth relative to reproductive development. Changing the rate of leaf appearance or growth stage at which leaves ceased to appear altered grain yield by between +30 and -75%. Therefore these parameters had a major role in controlling the amount and duration of green leaf, and assimilate supply available for grain growth in the model.

B. The mode1 was much less sensitive to changes in parameters in the light interception and photosynthesis submodel. These changes only resulted in small (<20%) changes in grain yield.

C. Canopy development (number and size of organs) was largely controlled by temperature and stem density in the model. There was no feedback mechanism on leaf growth due to changes in assimilate supply.

D. The mode1 treated canopy development and dry matter growth as separate processes, with up to a two-fold variation in the ratio of leaf area to leaf dry weight.

We are now testing whether real plant behaviour agrees with the 4 mode1 predictions. If the 2 sets of data agree the mode1 is a good predictor of reality, if not, a refined model will be produced.

1. Weir, A.H., Bragg, P.L., Porter, J.R., Rayner, J.H. (1984), J.Agric.Sc. Camb. 102, 371-382.

2. Porter, J.R. (1984), J.Agric.Sc. Camb. 102, 383-392.