Coupling a Growth Model to a Peanut Rust Model

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Introduction

Peanut rust and leaf spot are two major foliar diseases of peanut in western Africa. A first attempt was made to build a simulation model for peanut rust which is a newcomer in this part of the world. This work was undertaken as part of a cooperative project between ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer), and the Wageningen Agricultural University (Savary et al. 1990).

Structure of the Model

The system under study is a square meter of peanut crop infected by rust. The time step used is one climatological day. Processes with time coefficients smaller than one day are incorporated into daily input features. The model has two main units: crop growth and development, and rust epidemic, coupled together. The latter includes two subunits: rust lesion development, and rust multiplication. In the development of the model, due attention was given to leafspot, which affects crop growth and the rust epidemic.

The model used to simulate crop growth is SUCROS (Van Keulen et al. 1982). Four categories of organs are considered: roots, stems, leaves, and pods, represented by their respective dry weights. The parameters used were estimated from field data (e.g., partition coefficients), or collected from literature.

The infection cycle of peanut rust is simulated according to an early systems model by Zadoks (1971) with four categories of sites: vacant, latent, infectious, and removed lesions. Descriptions of lesion development incorporate cultivar resistance characteristics. Simulation of the canopy spore content involves temperature and cultivar effects on spore production, and a loss of spore due to rain leaching. Three phases are considered to simulate spore dispersal: liberation, deposition, and infection. Each have time coefficients smaller than one day and are incorporated into daily input features. Maturation and survival of deposited spores is also described.

Coupling

Coupling the two units of the model implies:

a) reconciling the dimensions used in each of them (dry matter and LAI units vs. sites and spore numbers)

b) describing the damage caused to the crop by rust and leafspot,

c) describing the interaction between host growth and rust epidemic

d) describing the effect of leaf spot on the host, and on the rust epidemic.

The coupling between the host and the parasite submodels is provided by two couplers (Zadoks and Rabbinge 1985): in the LAI to SITE direction: SITECO, the number of sites per LAI unit, and in the SITE to LAI direction: PSIZE, the leaf area occupied by one pustule.

Two rust damage components are considered: a reduction of photosynthetically active leaf area, and a flow of carbohydrates used for spore production, which is directly derived from the net photosynthetic rate before any partitioning to the growing organs. Three leaf spot damage components are considered: a reduction of photosynthetically active leaf area, defoliation, and compensation for defoliation.

Crop growth affects the rust epidemic in three ways: the trapping surface of the canopy varies with its LAI, canopy growth makes new sites available for infection, and defoliation reduces the amount of available and occupied sites.

Multiplication and radial growth of *Cercospora* lesions leads to destruction of occupied sites, which is represented by additional terms for the rates of rust lesion mortality in their various stages. This effect is superimposed on that of defoliation.

Model Performances

Evaluation of the model involves verification runs, and comparisons of model outputs with observed data (Teng 1985).

Variations of the daily multiplication factor (Zadoks 1971) and of the pustule spore content with varied weather conditions were found to correspond to the rules introduced in the model. Both variables are in balance, within a range of values which fits estimated values in the field. Various combinations for the values of the varietal coefficients produced a hierarchy of components of resistance which corresponds to observed results from a range of peanut cultivars, and agrees with previous simulation results using similar system designs for the pathogen unit (Zadoks 1971; Teng et al. 1977).

Simulated outputs were compared to actual data representing three separate epidemics, using the living leaf area index and rust severity as reference variables. The similarity between simulated and observed curves, with respect to the timing of the peaks, the day of epidemic upsurge, and the slope of the curves, is encouraging.

In view of its relative simplicity, the performance of this peanut rust simulation model may be considered to comply with the requirements which should be expected from a preliminary model. Several improvements, especially in the crop growth unit, may be considered to increase the explanatory value of the model, and allow its further development.

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WORKSHOP ON MODELING PEST-CROP INTERACTIONS

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