MODELLING FRENCH BEAN (*PHASEOLUS VULGARIS* L.) GROWTH AS INFLUENCED BY COMPETITION AND BIOTIC STRESS

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Abstract

Reliance on pesticides for management of pests in French bean production is not sustainable and alternative strategies are urgently required. Plant growth analysis was undertaken with the view to providing a basis for rationalized pest management in French bean production systems. Five field experiments were carried out between November 2001 and November 2002 to assess the effect of competition (canopy types of either French bean grown as sole crop or intercropped with carrots) and biotic stress (pest management strategies) on growth of French beans. Ultimately, a model for simulation of French bean growth for coupling to a phytopathological model was developed.

Canopy type at three levels and pest management strategies at five levels, in the first three experiments and two in the last two were included in the study. Canopy types and pest management strategies were considered to influence rust and thrips hence their inclusion. The experiments were laid out in a split plot design with canopy type as the main plot factor with three blocks and pest management strategies as the sub plot factor. Canopy type consisted of French beans grown alone (Sole) or intercropped with carrots. In the intercrop, either each row of French beans was alternated with a row of carrots (Rows) or four rows of French beans were alternated with four rows of carrots (Strips). Pest management strategies were either rust alone (Fungicide), thrips alone (Insecticide) or both rust and thrips (Pesticides) managed by application of chemical pesticides. In addition, a control treatment where chemicals for management of rust and thrips were not applied (No Pesticides) and an integrated pest management (IPM) treatment where chemical pesticides were restricted to the vegetative stage of plant growth was included. In the last two experiments only Pesticide and No Pesticide treatments were included. Furthermore, in the 4^{th} experiment only two blocks were assessed since one block was destroyed by wild animals.

Base temperatures of French beans were 1.88 °C and 6.83 °C for emergence and vegetative growth, respectively. The thermal time required between sowing and emergence was 145.38±2.83 °Cd while from sowing to flowering was 550.33±8.95 °Cd. The time trends of leaf area index were best described by a Gaussian curve with three

parameters: the maximum leaf area index (LAI_m), thermal time at which LAI_m occurs (TS_m) and a shape parameter, b_1. The total plant dry weight followed a logistic curve. Light use efficiency ranged from 1.02 to 2.12 g MJ^{-1}. The SLA ranged between 183 and 348 cm^2 g^{-1}. Yields were 6470±2320 kg ha^{-1} in the 3rd and 2320 kg ha^{-1} in the 4th experiment. No significant variation occurred due to intercropping. Carrots did not affect French bean growth probably because of its slow growth. French bean growth did not differ among the various pest management treatments. The rust and thrips levels were not high enough to allow for the effects of the pesticides to be observed. Resistance to chemical pesticides used could also result in lack of differences. The simulation model to describe bean growth was developed using parameters from the 3rd experiment while the other experiments provided data for evaluation of the model. The model fitted data from the 3rd experiment well. There was also a fair fit of data from the 2nd and the 5th experiments but poor in the case of the 1st and 4th experiments. Sensitivity analyses revealed that the model prediction was sensitive to light use efficiency, specific leaf area and light extinction coefficient. Therefore, these parameters require to be estimated accurately for reliable model prediction. The initial leaf area index on the other hand did not seem to exert much influence on model predictions. Improvements in the simulation of leaf senescence and dry matter partitioning are required.

The study established that bean growth is influenced by weather conditions and is not significantly affected by intercropping with carrots or by the rust and thrips management strategies. Costs incurred through application of pesticides for thrips and rust management are, therefore, not justified. The modelling exercise highlighted gaps in the research knowledge about the growth of French beans. These include leaf senescence and partitioning of dry matter.

Keywords:
Modelling, plant growth analysis, specific leaf area, SLA, light use efficiency, LUE