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MODELLING THE EFFECT OF A VARIABLE LIGHT EXTINCTION COEFFICIENT AND LEAF DISPERSION ON LIGHT PARTITIONING BETWEEN SPECIES IN A GRASS-CLOVER MIXTURE

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ABSTRACT

Light partitioning in a grass-clover mixture was studied using a general competition model. The model assumes a fixed extinction coefficient (*k*) and no leaf dispersion. This was compared with modelling the effect of different k of both species over height as well as the effect of type of leaf dispersion. These new assumptions led to a better estimation of the light partitioning between both species. For grass the effect of variable k and leaf dispersion was similar and in both cases the total absorbed light was lower than under default conditions. For clover the new assumptions led to a higher absorbed radiation than in the original model. However, in this case the effect of leaf dispersion was more important.

KEYWORDS

Modelling, light partitioning, leaf dispersion, extinction coefficient, perennial ryegrass, white clover

INTRODUCTION

Partitioning of light between species in mixtures is the most important part of simulation models for competition under potential production conditions. Leaf area density distribution, leaf angle distribution and leaf dispersion are the three major geometrical characteristics of species in a mixed canopy, which together can explain the patterns of light absorption (Sinoquet, 1993). INTERCOM (Kropff, 1993) is an eco-physiological model for simulation of plant competition under potential as well as water or nutrient limited conditions. In the model, a leaf area density function is defined for calculation of the leaf area index (LAI) of species at any depth within the canopy. The light absorbed by each species at any height is calculated based on the cumulative LAI and extinction coefficient (*k*) of both species. Previous work showed that in grass-clover mixtures both species have variable extinction coefficients (Nassiri et al., 1996a) and different types of leaf dispersion (Nassiri et al., 1996b) with height in the canopy. In this paper, the light profile in the canopy and light partitioning between species are simulated with the model INTERCOM, and the results are compared (1) without and (2) with introducing the variable *k*-values or (3) with introducing different patterns of leaf dispersion in the model.

METHODS

Data needed for simulation were obtained from a field experiment during 1995 at Wageningen, The Netherlands with mixtures of a large-leaved white clover (*Trifolium repens* L.); (cv. Alice) and a tetraploid perennial ryegrass (*Lolium perenne* L.); (cv. Condesa) (Nassiri et al., 1996a,b,c). The PAR (photosynthetically active radiation) flux at height *h* (cm) (I_h, J m^{-2} ground s^{-1}) in the mixed canopy (equation 1) and the light absorbed by species *i* at height *h* ($I_{a,h,i}$, J m^{-2} leaf s^{-1}) within the canopy (equation 2) were calculated following the procedure used in the INTERCOM model (defaults) and after introducing the new parameters (equations 3 and 4):

$$I_h = (1\text{-}\rho)I_0 \exp(-\ \acute{Y} k_i . L_{h,i}) \qquad \text{(Eq. 1)}$$
$$I_{a,h,i} = k_i\, (1\text{-}\rho)I_0 \exp(-\acute{Y}\, k_j . L_{h,j}) \qquad \text{(Eq. 2)}$$
$$I_{a,h,i} = k_{h,i}\, (1\text{-}\rho)I_0 \exp(-\acute{Y}\, k_{h,j} . L_{h,j}) \qquad \text{(Eq. 3)}$$
$$I_{a,h,i} = k_i . \varepsilon_{h,j}\, (1\text{-}\rho)I_0 \exp(-\acute{Y}\, k_i . L_{h,j} . \varepsilon_{h,j}) \qquad \text{(Eq. 4)}$$

where I_0 (J m^{-2} ground s^{-1}) is the flux at the top of the canopy, ρ the reflection coefficient of the canopy, $L_{h,i}$ the cumulative LAI of species *i* above height *h*, $k_{h,i}$ the extinction coefficient of species *i* at height *h*, $\varepsilon_{h,i}$ a parameter which shows the effect of leaf dispersion of species *i* at height *h* and the index *j* (*j*=1,...n) stands for plant species in the mixture.

RESULTS AND DISCUSSION

The model was run with the assumption of (1) fixed *k*-values, without leaf dispersion, (2) variable *k*-values and (3) with leaf dispersion. The profile of absorbed PAR density (% PAR m^{-2} ground s^{-1} cm^{-1} h) for both species (Figure 1) shows that under all conditions a higher proportion of light was absorbed by clover. The default model led to underestimation of absorbed PAR for clover and overestimation for grass. By introducing a variable *k* and an effect of leaf dispersion, the estimation was improved. In both species, simulation with a variable *k* or leaf dispersion had a similar result on radiation absorption. In grass variable *k* and dispersion resulted in absorption of 15.3 and 16.5% of total PAR, respectively, compared to 20.9% estimated by the original model. However, in clover absorbed PAR was underestimated by original model (70.1%) in comparison to simulation where the effects of variable *k* and leaf dispersion were taken into account(76.1 and 77.3%, respectively). Clover had a higher proportion of its leaf area at top layers of the canopy than grass had (Nassiri et al., 1996b). This observation, together with the regular leaf dispersion (Nassiri et al., 1996c) and the higher *k*- value at top layers (Nassiri et al., 1996b), resulted in a large increase in the density of absorbed PAR by clover, which reached its maximum at 18 cm height, but sharply declined at lower heights (Figure 1). In grass the maximum PAR density occurred at the same height as in clover. However, it decreased slowly with height (Figure 1). This slow reduction can be explained by the linear increase of the *k*-value of the grass with increasing LAI (Nassiri et al., 1996a).

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Figure 1

Comparison of absorbed PAR density (% PAR m^{-2} ground s^{-1} cm^{-1} height) for grass and for clover simulated by the models with fixed k without dispersion; with variable k, and with dispersion in a grass-clover mixture. Absorbed PAR density indicates the percent of light absorbed by species per cm of height that is, the total area under the curves gives the total absorbed PAR (%) for each species.