MODELLING LIGHT INTERCEPTION IN HETEROGENEOUS CANOPIES

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Introduction

To quantify the growth of plants requires a precise estimation of the amount of intercepted radiation. Existing approaches to model light interception in spatially heterogeneous canopies have either restrictions with respect to canopy structure (Gijzen & Goudriaan, 1989) or are inflexible due to complex geometric formulations (Norman & Welles, 1983). Since the leaf area in vegetable crop canopies is usually not homogeneously distributed, the objective of this study was to develop a model that calculates of light interception in such spatially heterogeneous canopies based on simple and easily adaptable relationships. This information is particularly valuable to evaluate the light competition between crops and weeds.

Methods

The basic idea was to structure the complete canopy volume in cubic subunits, which can be either empty or filled with leaf area. Leaf area can be distributed in any geometric solid positioned anywhere in the model domain (Fig. **Errore. L'argomento parametro è sconosciuto.**). Through this domain, solar rays are followed from top to ground level and their absorption is calculated using generally accepted theories (Goudriaan, 1977). The incoming photosynthetically active radiation (PAR) is divided into a direct and a diffuse component, taking reflection and scattering (direct beam only) into account. To access the dynamic radiation environment over the diurnal course, a number of solar rays are selected and their transmission is integrated using a Gaussian integration routine (Goudriaan, 1986). The model was evaluated with data from field experiments

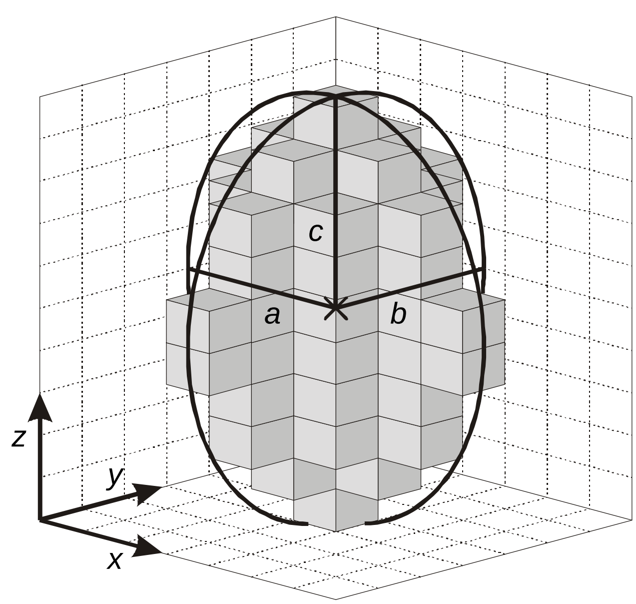

Fig. ***Errore. L'argomento parametro è sconosciuto.****. Schematic representation of a subsection of the model domain. The semi-axes* a, b *and* c *originating in the centre of the ellipsoid (×) define the solid in width, depth and height (*x, y, z*). The complete model domain is divided into cubic subunits, but only the cubes inside the foliage envelope are shown.*

with cauliflower (Röhrig et al., 1999). The required input derived from these data were the plants' position, their height and diameter and the leaf area index.

Results

The assumption of an ellipsoidal foliage envelope for cauliflower plants resulted in a good correspondence between measured and simulated canopy transmission (Fig. **Errore. L'argomento parametro è sconosciuto.**). An overestimation at high transmissions, e.g. when

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Fig. ***Errore. L'argomento parametro è sconosciuto.****. Measured and simulated daily canopy transmission,* T*, in cauliflower.*

plants are small, could possibly be remedied by making the foliage envelope dependent on the developmental stage of the crop. Scenario calculations were conducted to evaluate the light interception characteristics of spatially heterogeneous canopy architectures. The output of the model tallied with results from earlier modelling efforts, confirming that the model gives qualitatively consistent information.

Conclusions

The outline of the spatial leaf area distribution in the canopy is easily adaptable without changing the program code for the simulation of light interception. Furthermore, the cubical shape of the basic units allowed to describe the path of solar rays in comparatively simple algebraic terms. The model thus meets the requirement of flexibility and simplicity. Due to the details of light absorption in heterogeneous canopies given, it provides useful information particularly relevant to quantify the distribution of light absorption in mixed canopies. A direct application in models for crop growth or light competition, however, seems not feasible since the simulation requires abundant computing time. Consequently, it should be used as a reference model to identify and calibrate simplifications in the estimation of light interception in heterogeneous canopies.

References

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