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OILCROP-SUN : A GROWTH AND DEVELOPMENT SIMULATION MODEL OF THE SUNFLOWER (HELIANTHUS ANNUUS L.) CROP.

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SUMMARY

OILCROP-SUN is a functional model of the development, growth and yield of the sunflower (*Helianthus annuus* L.) crop, applicable to agronomic issues such as management strategy evaluation (optimization of fallowing duration, sowing date, crop cycle and density) and estimation of probable yields across sites of varying soil and weather conditions. Required inputs for the model include daily weather data , soil physical characteristics , and values of soil nitrogen and water content at sowing. Cultivars are characterized using five genetic coefficients (three of which relate to development, and the remaining two define grain yield potential). The model simulates the biomass and N contents of plant parts, leaf area index and soil water and nitrogen balances using a daily time-step. The current version of the model has been validated against experimental data obtained at Córdoba , Spain. The results show the model is capable of simulating crop development over a wide range of temperature and daylength conditions which resulted in durations of the emergence- anthesis phase of between 46 and 152 days for cvs. SH-3000, Sungro-380 and 894. The model also generated good estimates of aerial biomass and grain yields over a variety of conditions which determined values for these variables in the ranges 5-15 tn/ha and 1-4.8 tn/ha, respectively.

INTRODUCTION

Simulation models which can be used as crop and farm system management decision tools, and which are sufficiently general as to effectively handle large between-site differences in soil properties and weather conditions, as well as between-cultivar differences in development and yield potential, already exist for a number of field crops (*e.g.* wheat, maize, soybean). This paper describes a model of this kind for the sunflower crop, which we have named OILCROP-SUN. Our model is related to the CERES models which have been developed for cereals (*e.g.* Jones and Kiniry, 1986), uses the same logic and routines to simulate soil water and nitrogen balances, and has been designed for installation in the data management and decision support software package known as DSSAT (IBSNAT, 1989). Here we define the objectives of the model, list the information required to run it, and indicate some of the more salient aspects of sunflower physiology which the model seeks to mimic. Some examples of model validation against data sets which were not used in its formulation are presented, and aspects of the model which need improvement are identified.

MATERIALS AND METHODS

The model seeks to describe crop development (dates of emergence, floral initiation, anthesis, physiological maturity), growth (dynamics of leaf area index, root depth and density, aerial biomass) and grain yield, on the basis of information about the environment (soil and weather), management (sowing date and density, irrigation and N-fertilizer application) and information about the cultivar used. The latter is synthesized by five genetic coefficients which refer to the control of crop development by temperature and daylength (three coefficients) and cultivar potential yield (two coefficients). The aim is a model that will be useful for such applications as identification of optimum sowing dates, selection of adapted cultivars, definition of the length of optimum pre-sowing fallowing, estimation of yield responses to irrigation and N-fertilizer application, etc

The general structure of the model is close to that of CERES-Maize (Jones and Kiniry, 1986), and captures the essential physiological characteristics of the sunflower crop. In the model, crop development prior to anthesis can be affected by temperature (all cultivars) and daylength (daylength sensitive cultivars) (Marc and Palmer, 1978; Rawson and Hindmarsh, 1982; Hammer *et al.*, 1982). Duration of grain filling is a function of temperature (unpublished data of Trapani, Villalobos, de los Rios, Hall, Whitfield and Connor). Leaf area generation depends on thermal time per phyllochron (Villalobos and Ritchie, 1992), potential leaf area as a function of leaf insertion level, a specific leaf area which varies with ontogeny, and the availability of biomass for leaf area generation. A constant thermal time for the expansion of each leaf is assumed (Rawson and Dunstone, 1982), and the number of leaves generated per stem depends on thermal time to floral initiation. Leaf senescence is regulated by degree of shading (pre-anthesis), and nitrogen uptake, stored labile nitrogen and grain nitrogen demand (post-anthesis). The logic and parameters used to simulate root development are based on data provided by Connor and Jones (1985), Sadras *et al.* (1989), and Bremner *et al.* (1986). Radiation intercepted by the crop is estimated using a LAI-dependent value of extinction coefficient (Rawson *et al.*, 1984), and is transformed into biomass

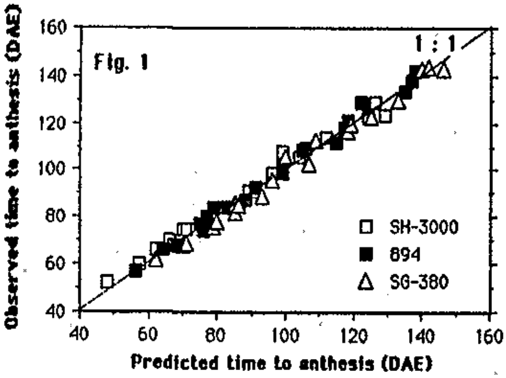

Fig. 1. Predicted/observed relationship for the duration of the emergence-anthesis phase of *cvs.* SH-3000 , 894 and Sungro sown during 1983-4 and 1985-6 at Córdoba (Spain) between December and April.

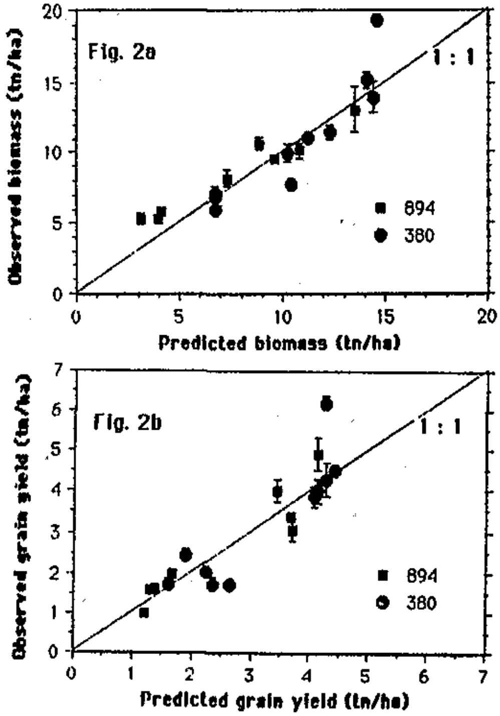

Fig. 2. Predicted/observed relationship for aerial biomass at maturity (Fig. 2a) and grain yield (Fig. 2b) of crops of sunflower (*cvs.* 894 and Sungro-380) grown under different combinations of irrigation and nitrogen at Córdoba, Spain. Vertical bars are standard errors of the mean, and are not shown when smaller than symbol.

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