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THE SENSITIVITY OF CROP MODELS FOR SOYBEAN ON MODEL INPUT PARAMETERS AT THE NORTH-EASTERN PART OF AUSTRIA.

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INTRODUCTION

The development and application of computer models to simulate main processes of crop growth and related aspects (e.g. soil water balance) is growing rapidely. This development has resulted from both the improved knowledge on physical and ecophysiological processes and the rapid expansion of personal computers. Model application needs calibration and validation of the models. Therefore and for practical use of models representative and accurate model input data are of critical importance (ADDISCOT et al., 1995; AGGARWAL, 1995).

The sensitivity of crop models to input parameters not only depend on the model itself but also on the crop and the specific environmental characteristics of the site the crop is growing. (EITZINGER and ZALUD, 1995; EITZINGER und DIRMHIRN, 1994). Especially weather input data should be represenative and accurate to get realistic simulation results (NONHEBEL, 1994, 1995). Generally the most important parameters are precipitation and soil water content, temperature and solar radiation. In this study first results of a project in Groß - Enzersdorf/Vienna is shown. The aim of the project is to find out the most critical (sensitive) input parameters for a practical use of crop growth simulation modells (farm level) on that site. The location of the investigation is representative for the Marchfeld, a main arable farming area in the north-eastern part of Austria. Extensive investigations are done in a field trial on main input and control parameters for crop growth modelling. Plant factors, soil factors and climatic data are collected during the crop growing season 1995. The plant grown is soybean. Two different dynamic crop growth models for soybean (MACROS and SOYGRO) are used for sensitivity analysis on that location. The impact of soil water content and air temperature input (vertical deviation) on simulation results of the two models are presented.

MATERIAL AND METHODS

1 Field measurements

Climatic parameters during the growth period of soybean are measured inside the field in canopy height as well as 2 m above soil surface. The measurements are established in a well irrigated and not irrigated part of the field. All data are measured continuously every second and stored as 15-minute average using a Campelll CR10 datalogger. Climatic parameters measured are Photosynthetic active radiation (Licor sensors), Wind speed, Precipitation, Air temperatures (Thermocouples) and Air humidity (Vaisala sensors). Also Soil temperatures (Pt100 sensors) and Soil water content (Time Domain Reflectrometry method) are measured continously. Physical soil properties (e.g. pF-curve, bulk density, hydraulic conductivity and texture) are measured at the beginning and the end of the growth period for each soil layer. Plant characteristics (e.g. phenology, dry matter distribution, leaf area index) are estimated weekly from the irrigated and not irrigated part. The soybean cultivar grown is "Ceresia" (Maturity group 0).

2. Crop models

Two different dynamic crop models are used for the sensitivity analysis.

The crop model MACROS was developed in Wageningen/Netherlands (PENNING DE VRIES et al., 1989). The daily weather input data in MACROS crop growth simulation model are the following : Precipitation, Minimum- and Maximum Temperature, Global radiation, Air humidity and Wind speed. The second model used in this study is SOYGRO (JONES et al., 1989; WILKERSON et al., 1983). SOYGRO is a well established soybean model from the DSSAT model group (Tsuji et al., 1994). Daily weather input data are Global radiation, Precipitation, Maximum- and Minimum temperature. For this study the models are validated using plant data stets estimated under optimum conditions (no water stress).

RESULTS

1. Soil water content

Inhomogeneous soil conditions can create problems in estimation of representative soil input data for the area of the simulation (e.g. a single field). In some cases soil conditions are variable on a greater extent also on small scales, like at the location of our experiment (SCHWARZ et al., 1996). As an example the variation of the thickness of the A-Horizon on the soybean field is shown in Fig.1.

Inhomogeneous soil conditions results in various soil water storage capacity within the field. Therefore soil data used as input should be estimated by a number of replications related to the inhomogenity and be representative for the site of simulation. The presented simulations are done for the most homogeneous part of the field. Soil conditions are estimated from the same part as the plant data and climatic data are measured. Simulation results are given in section 3.3..

2. Temperature

Air temperature at 2 m height and at (increased) canopy height are measured during the growing period of soybean and used as model input data. The differences of temperature between the two levels are given below (Fig.2).

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Fig.1 : Soil depth of A-Horizon on the Soybean field

Fig.2 : Differences of Air temperature at 2 m and Canopy air temp. of soybean.

The vertical profiles of microclimatic parameters depends on surface characteristics (e.g. canopy structure) as well as on weather conditions (MONTEITH and UNSWORTH, 1990).

Deviations of daily Maximum and Minimum temperature related to the vertical distance of the sensor from a certain surface (canopy) depend especially on cloudiness and wind speed (Fig.2). Generally the deviations of Maximum temperature from

Canopy to 2 m height are decreasing with crop height of soybean. Canopy Maximum Air temperatures are exceeding the Air temp. at 2m up to 4 °C (Average + 1.4 °C). Canopy Minimum air temperatures are less than Air Min. temperature at 2 m (Average - 0.8 °C).

3. Simulation results

3.1. Soil water content

The simulated and measured soil water content is shown in Fig. 3 - 4.

Fig.3.: Simulated and measured Soil water content on Soybean - Irrigated

Fig.4.: Simulated and measured Soil water content on Soybean - Not Irrigated

Under dry conditions both models underestimated the measured soil water content by about 5 percentages of Volume. The Macros model seems to overestimate water loss by evaporation and drainage (deviation in the early vegetation period), whereby the Soygro overestimated water loss more or less by plant uptake (transpiration). Under conditions with no water stress (Fig.3) the differences are less, especially by the Soygro model.

3.2. Leaf area index

The simulated and measured leaf area index is shown in Fig. 5 - 6. For both models canopy temperature and air temperature at 2m were used as input.

Fig.5 : Simulated and measured Leaf area index on Soybean - Irrigated

Fig.6 : Simulated and measured Leaf area index on Soybean - Not Irrigated

The leaf area index is simulated relatively good under irrigated conditions. Only in the scond part of the growth period both models shows different deviation (caused by leaf loss rate calculation). For condition under water stress (not irrigated) the Macros model agrees to measured values, whereby Soygro shows considerable deviation. The calculation are influenced only less by the change in temperature input under irrigated conditions. The MACROS model shows no impact on leaf area calculation under condition of water stress.

3.3. Simulated and real yield

The simulated and real yields of the experiment is shown in Fig. 7.

Fig.7 : Simulated and real yield of Soybean - Groß-Enzersdorf 1995

In all cases both models underestimated the measured yield. The relative (and absolute) deviations increased under the rainfed conditions, where water stress occured. The reason can be found in the deviations of the simulated soil water content compared to the measured values (Fig. 3 - 4). The simulated yield by the MACROS model agrees relatively well with measured values for the irrigated variant, but increased for conditions under drought stress (- 21 %).

The Soygro model also underestimated the yield under irrigated conditions (-23 %) and considerably under rainfed conditions. This may be due to weak validation of the model to the soybean cultivar "Ceresia". Even with the knowledge of the main key plant parameters (WUTZL et al., 1996) it was not possible to adapt the model (genetic input parameters) well enough to that cultivar. Further investigation and validation is necessary to improve the results of the Soygro model for that cultivar.

In both models the change in temperature input to canopy temperatures results in inreasing simulated yields of 2 - 6 % both on irrigated and rainfed conditions.

CONCLUSIONS

The most sensitive factor for simulation results at the Marchfeld is the soil water content and the related physical soil properties and precipitation. Therefore a correct simulation of soil water balance as well as the representativeness to the site of simulation is of critical importance. Further investigations have to be made on spatial distribution of soil parameters. Also on methods for effective estimation of representative soil parameters related to soil heterogenity. The second factor of importance is air temperature, because of considerable differences between canopy air temperatures and air temperatures measured at standard height, especially under hot and dry weather conditions. Model validation and results could be improved by using canopy temperatures as model input. Further investigations should be done on methods for estimating canopy temperatures from standard data related to the crop status and other environmental conditions.

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