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Evapotranspiração da Soja: Comparação entre o Método da Covariância dos Vórtices Turbulentos e a Estimativa do Modelo CROPGRO-Soybean

Evapotranspiration Soybean: Comparison between eddy covariance method and the estimate of CROPGRO-Soybean model

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Resumo

O desempenho do modelo CROPGRO-Soybean para simulação da evapotranspiração da soja foi avaliado por meio de dados decorrentes de experimentos de campo que utilizam a técnica de Covariância dos Vórtices Turbulentos conduzidos pela Rede Sulflux (Rede Sul Brasileira de Fluxos Superficiais e Mudanças Climáticas) em Cruz Alta, Estado do Rio Grande do Sul - Brasil, (28 ° 36'S, e 53 ° 40'W e altitude 409 m), no ano agrícola de 2009/2010. Os resultados indicam que o modelo superestima a evapotranspiração ao longo do ciclo da cultura, provavelmente, por não representar de forma realística os resíduos culturais, indicando necessidade de ajustes em parâmetros do balanço de água no solo em sistema de plantio direto.

Palavras-chave: DSSAT. Plantio direto. Balanço de água no solo.

Abstract

The performance of CROPGRO - Soybean model for soybean evapotranspiration simulation was assessed using data derived from field experiments using eddy covariance method conducted by Network Sulflux (Brazilian South Network Surface Flows and Climate Change) Cruz Alta, Rio Grande do Sul State - Brazil , (28 ° 36 'S , 53 ° 40'W and altitude 409 m), in the agricultural year 2009/2010 . The results indicate that the model overestimates evapotranspiration throughout the crop cycle, probably it does not represent realistically the crop residues, indicating a need for adjustments in water balance parameters in the soil in no-till system.

Keywords: DSSAT . Till. Water balance in soil.

1 Introduction

To quantify water losses of cultivated areas into the atmosphere, there are many used methods such as Bowen ratio, eddy covariance method and other (Pereira et al., 1997) for the estimates of evapotranspiration. The eddy covariance method is able to directly measure the latent heat fluxes in the atmosphere in crops (Baldocchi, 2003; Neves, 2006).

In turn, simulation models for growth and development of crops are tools that are designed for multiple applications in agricultural research (Jones et al., 2003). The use of simulation models to predict the soybean yield in water use efficiency can be very helpful in managing applications of deficit irrigation in agricultural crops**.** In this context, the CROPGRO-Soybean model (Crop Environment Resource Synthesis-) simulates the vegetative and reproductive soybean development to a certain place and climate, and it is an excellent alternative for information to assist in planning and management of water use in agricultural projects (Boote et al., 1998).

Mavromatis et al. (2003) and Boote et al. (2003) performed simulations of CROPGRO-Soybean model and considered satisfactory under conditions of seasonal water stress irrigated and in drought (). However, the need for research to test the water balance model used requires research in trial fields, monitoring of environmental conditions and adjustments to the model when necessary and possible. Thus, the evaluation of the template with data measured in the field using the eddy covariance method may give a better understanding of the model and its applications. In this way, we developed this study with the primary objective of evaluating the quality of the estimates of the soybean crop evapotranspiration generated by CROPGRO-Soyben model with the data of latent heat fluxes measured under field conditions through the eddy covariance method in Rio Grande do Sul.

2 Materials and methods

We used the CROPGRO-Soybean model (Crop-Environment Resource Synthesis) that is inserted in the system DSSAT (Decision Support System for Agrotecnology Transfer), version 4.0.2.0 (HOOGENBOOM, 2004), which simulates the growth, development and productivity of soybeans (*Glycinemax*L. Merill), Figura 1. The simulations were performed to the conditions obtained in Experimental field of the Foundation Center of Experimentation and Research (FUNDACEP/FECOTRIGO), located in Cruz Alta, Rio Grande do Sul, with the following geographical coordinates: 28°36' South and 53°40' West and altitude 409 meters. The soybean cultivars Fundacep 53RR were selected as the crop material. The planting date was December 14, 2009 and April 28, 2010 for the harvest. During the experiment, in addition to the input of soil, crop and meteorological variables of the model, it was also monitored the latent heat flow (LE), using the eddy correlation technique of Sulflux Network.It was made using the following sensors at site: an three-directional 3D sonic anemometer (Campbell – CSAT3 3-D) and an open-path infrared CO_2/H_2O gas analyzing system (LiCor – LI7500), Figure 2. The procedure used to compute fluxes is discussed in Moncrieff et al. (1997). The evaporation rate of the culture was obtained dividing the latent heat flow by the latent heat of vaporization, considered as constant (2.45 MJ kg -1). The tests used in the comparison of model estimates was the correlation coefficient (r), agreement index (d) (Willmott et al., 1985), and reliable index (c) proposed by Camargo and Sentelhas (1997), root mean square error (RMSE) (Loague and Green, 1991), the mean bias error (MBE) and statistical test- t.

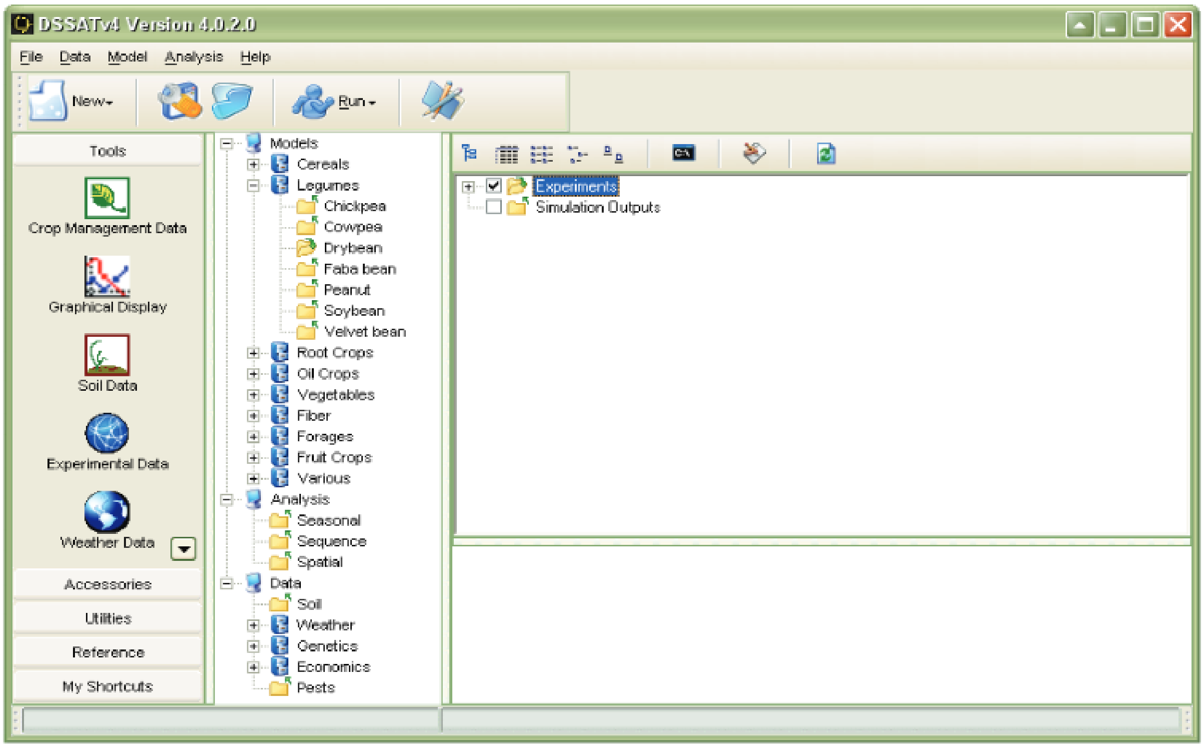

Figure 1 - Window illustrating the atmosphere-soil-plan database system for the CROPGRO-Soybean simulation in DSSAT

Figure 2 - System eddy covariance in micrometeorological tower of Cruz Alta, RS

3 Results and discussion

The performance of model was evaluated by comparing the evapotranspiration simulated by CROPGRO-Soybean model with micrometeorological measurements of the latent heat flux by the eddy covariance method (Figure 3). We realized that the soybean crop had maximum evapotranspiration in the growing season, with peak of 6.58 mm day^{-1} during the V13 stage, with maximum leaf area index. For its turn, the model simulated a maximum daily intake of 8 mm of water at the beginning of the growing season In other words, significant contribution of evaporation in loss of water through the soil surface (Figure 4). However, from the evolution of leaf area index of the crop, the model has come to represent satisfactorily the soybean evapotranspiration, with values close to 6 mm day^{-1} in the period of maximum development of the crop. Suyker and Verma (2010), found maximum values of evapotranspiration of soybean like 5.8 and 6.9 mm day^{-1} during this period, in conditions of dryland and irrigated, respectively. Suyker and Verma (2008), obtained ETc peaks like 7.3 and 6.5 mm for soybean and LAI maximum of 5.7 and 4.4, respectively. In the Amazon region, Souza (2010) found maximum peak of 4.1 mm day^{-1} during the grain filling. In Rio Grande do Sul, Berlato and Bergamaschi (1979) obtained a meddium daily consumption of 5.8 mm to cultivate Bragg. This consumption, expressed by the daily evapotranspiration, ranged from 2.2 mm to sub-period plantation-emergence, up to a maximum of 7.4 mm, reached the sub-period between the beginning of flowering and the maximum rise of pods.

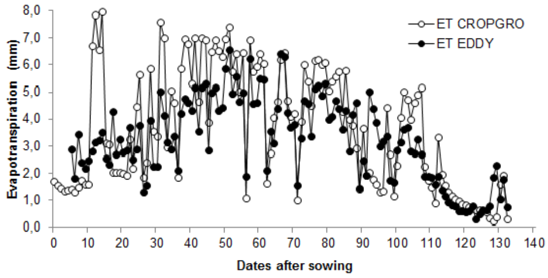

Figure 3. Daily evapotranspiration of soybean (Fundacep 53 RR), observed (ET EDDY) and simulated (ET CROPGRO). Sulflux network, Cruz Alta (RS), harvest 2009/10.

The daily transpiration and evaporation seasonal pattern of soil in CROPGRO-Soybean (Figure 4) indicates that, at the beginning of the cycle, the evaporation values were, sometimes, more than 6 mm day^{-1}. Due to the increase in leaf area, ie, at the beginning of pod, we realized that the transpiration of plants presents higher evaporation on the soil, reaching values of 6 mm day^{-1}.

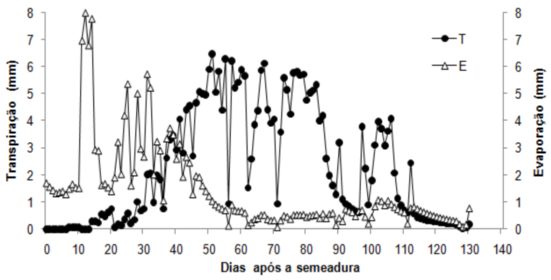

Figure 4. Transpiration simulation (T) of soybean (Fundacep 53 RR) and evaporation (E) to the soil surface at CROPGRO-Soybean model. Sulflux network, Cruz Alta (RS), harvest 2009/10.

The simulated accumulated evapotranspiration standard during cultivation of soybean station corresponded well with the measured values (Figure 5), although some differences between simulated data that occurred at the beginning and end of soybean growing season. The model reasonably simulated total evaporation, with an overestimate of 13.1% when compared to that observed in the field. These data are superior to those reported by (Dogan et al., 2007), who observed a percentage difference between measured and simulated values of about 5.30%. Results obtained by Nielsen et al., (2002), using the model RZWQM soy, have also found an overestimation of 4.0% in simulated evapotranspiration. The comparison of the observed and simulated evapotranspiration with the regression testing did not indicate a significant relationship between the simulated values for soybeans (Figure 6). These results show the need for adjustments in water-balance settings on the ground to consider the no-tillage system.

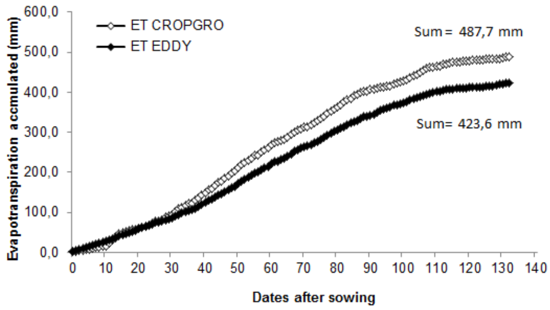

Figure 5. Comparison between the observed and simulated about the accumulation of evapotranspiration during the soybean crop cycle 2009/2010, Cruz Alta, RS

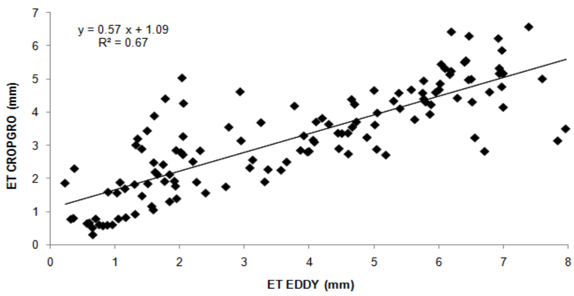

Figure 6. Linear relationship between observed and simulated of daily evapotranspiration during the soybean crop cycle 2009/2010, Cruz Alta, RS

By comparing the results of evapotranspiration, simulated by CROPGRO-Soybean (Table 1) and those obtained by the eddy covariance method, we observed that at the end of the cycle, the average evapotranspiration was 0.3 mm day^{-1} higher to those observed in the field, equivalent to 3.7 mm day^{-1} of the simulated evapotranspiration.

Table 1 - Mean values of ETc daily and total for each phase of the soybean cycle, from the field (EDDY) and simulated by the model (CROPGRO)

Phases	EDDY		CROPGRO	
	ETc daily (mm day^{-1})	ETc total (mm)	ETc daily (mm day^{-1})	ETc total (mm)
S – V2	3.7 (± 0.79)	40.7	3.0 (± 0.69)	45.7
V2 – V13	3.8 (± 0.22)	152.2	4.8 (± 0.34)	190.3
R1 – R2	4.2 (± 0.57)	46.4	4.7 (± 0.84)	51.8
R3 – R4	4.5 (± 0.37)	62.5	5.1 (± 0.43)	71.1
R5 – R6	2.8 (± 0.22)	108.6	3.0 (± 0.29)	118.5
Maturation	0.9 (± 0.20)	13.2	0.7 (± 0.16)	10.4
Cycle	**3.3**	**423.6**	**3.7**	**487.7**

S - V2 - Soybean emergence, the first fully expanded leaf; V2 - V13 - First fully expanded leaf at the end of the growing season; R1 and R2 - Flowering; R3 and R4 - Development of the pod; R5 and R6 - Grain development; Physiological maturation - harvest and soybean cycle.

Statistical analysis of CROPGRO-Soybean model performance in simulating evapotranspiration throughout the crop cycle is presented in Table 2. There was a reasonable model performance in simulating the soybean evapotranspiration, with correlation index "r" of 0.82, of agreement index "d" above 0.86 and 0.71 of reability.

Table 2. Statistical analysis results of soybean evapotranspiration simulated values compared with those obtained by those obtained by the covariance method of turbulent vortex, for the crop development cycle. Sulflux network, Cruz Alta (RS), harvest 2009/10.

MBE	RMSE	r^2	r	d	c	t(calc)	t (5%)
mm day^{-1}							
-0.46	1.41	0.67	0.82	0.86	0.71	3.94	2.06

In general, the CROPGRO-Soybean model simulated evapotranspiration reasonably throughout the crop cycle. Except for the beginning of the cycle, highlighting the need for improvements in this process during the stages of incomplete closure of the canopy. The problem in representation of the model, which is more pronounced at the beginning of the cycle, should be the result of the presence of the straw layer formed by crop residues on the surface in no-till system, making the model runs evaporating more if compared with the indicative of the observed data.

5 Conclusions

Evapotranspiration throughout the crop cycle was reasonably simulated by CROPGRO-Soybean model, possibly due to the effects of covering of the soil surface by crop residues, especially at the beginning of soybean development cycle, resulting from no-till system.

It wasverified, based on the results, the need to incorporate the effects of surface coverage by crop residues, decurrently of no-till management, about the water balance approximation in the soil of CROPGRO-Soybean model.

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