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Impact of climate scenarios on soybean yields in Southern Brazil

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ABSTRACT

Soybean is a very important crop, cultivated mainly as feedstock for animal production, but also for other uses like biodiesel. Brazil is the second largest producer of soybeans, and the main exporter. About 10% of the Brazilian total production is aimed for biodiesel production. The aim of this work is to assess the impact of climate change scenarios on soybean yield and evaluate two simple adaptation strategies: cultivar and planting date. Tests were done for soil profiles from two important producing regions: Chapecó – Red Oxisol, and Passo Fundo – Rodic Hapludox. Two commercial soybean cultivars (CD202 and CD204) and seven regional circulation models (RCM) were used. All simulations were done with DSSAT. After model calibration, eleven planting dates were run for two periods (2011-2040 and 2071-2100) using the RCM`s. The cultivars did not showed differences among them. For Chapecó, the majority of RCM`s projected yield reductions, with few RCM`s projecting increments, and for only few planting dates (November). The pattern of response for both time periods was identical, although the end-of-century period presented a further yield reduction. The main reason is due reduced water holding capacity from soil, high temperatures and changes in rainfall distribution along the cropping season. For Passo Fundo, 2011-2040 yields are distinct, depending on the RCM. Simulated yields tend to follow the actual yield pattern along the different planting dates, besides discrepancies. For 2071-2100, all but one RCM indicate yields equal or lower to actual levels. Regarding planting dates, no significant changes were identified, although reductions are observed in the early planting dates (August-September). The scenarios suggest that soybean yields will be reduced, jeopardizing the viability of this crop and biodiesel production in the studied regions.

KEYWORDS:

Climate change, crop model, adaptation.

Increasing the prediction capacity of climate change impacts for stakeholders has become a major challenge in Southern Brazil, which economic wealth strongly depends on agriculture (AQUASTAT, 2010). In this region, the agricultural landscape have faced major changes during the last 30 years due to new technologies for crops, to a strong increase in cereal and oil crop world demand and also to favorable climate conditions with increases of about 20%-30% in annual precipitation over large parts of the region (Magrin *et al.*, 2005).

Crop models can be a useful tool to assess the influence of climatic and other environmental or management factors on crop development and yield (Reidsma *et al.*, 2010). The Decision Support System for Agrotechnology Transfer – DSSAT v. 4.5 contains the CROPGRO – Soybean model (Banterng *et al.*, 2010), and can be used to determine best planting dates, fertilization strategies, and to investigate potential impacts of climate change on

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agriculture. In the embedded model the development and growth of the crop is simulated on a daily basis from the planting until the physiological maturity. The model calculations are based on environmental and physiological processes that control the phenology and dry matter accumulation in the different organs of the plant. The DSSAT also has other embedded models that can simulate the flow of nutrients and water balance in the soil.

In order to run simulations for soybeans data from field experiments and literature were used. For simulation in the Brazilian sites data from literature was obtained from Dallacort et al. (2008), which conducted experiments in Parana State evaluating four soybean cultivars. The cultivars were characterized, calibrated and validated for the CROPGRO – Soybean. The four cultivars, namely CD 202, CD 204, CD 206 and CD 210, were tested for both Brazilian sites using census data and generic agronomic management. The two cultivars with lowest RMSE for yield were selected to run further analysis.

After calibrating and validating the genetic parameters and the model itself, scenarios provided by CLARIS LPB Project WP5 (2011-2040 and 2071-2100 periods) were downloaded and formatted for the DSSAT standard using Weatherman Software (Wilkens, 2004). From the CLARIS-LPB Project Data Archive Center seven weather series of RCM`s (and matching the same location of the study sites weather stations) were downloaded, converted and adjusted to be used as weather input for DSSAT using Weatherman software (Wilkens, 2004). The RCM`s are RCA1, RCA2 and RCA3, from the Rossby Centre Regional Climate model (Samuelsson *et al.*, 2011); PROMES, from Universidad de Castilla-La Mancha (Domínguez *et al.*, 2010); LMDZ version 4 Configuration South America with IPSLA1B and EC5OM-R3 boundaries, from Laboratoire de Meteorologie Dynamique (Hourdin *et al.*, 2006); and ETA, from Instituto Nacional de Pesquisas Espaciais (Marengo *et al.*, 2012). The crop model was run with each one of the seven RCM`s for the target periods (2011-2040 and 2071-2100).

The resulting analysis (Figure 1) showed the impact of seven RCM`s on the yield of the soybean cultivars CD202 and CD204 in two locations and two time periods (2011-2040 and 2071-2100). It is important to mention that both soybean cultivars, besides having differences in genetic coefficients, presented very similar results.

For Chapecó 2011-2040 period, the majority of RCM`s projected very low yields when compared with actual yields. Only ETA, IPSL and ECHAM5 presented a trend of increase in yields, and after the 01/Oct planting date. Even so, only IPSL could mimic the actual yields for the late planting dates. This assessment is also applicable for the 2071-2100 period, but with a further reduction of projections of all RCMs. An integrated analysis indicates with high level of agreement that early planting dates – prior to 01/Oct – will generate lower yields; planting after 01/Oct shows that three out of seven RCM`s (namely, ETA, ECHAM5 and IPSL) have a tendency to follow the actual yields, while the others remain with very low yields, jeopardizing the viability of this crop in the region.

The results presented for Passo Fundo showed significant difference from the ones of Chapecó, with RCM yields following the trend of actual yield. It also presents a situation where RCMs project even significant increments in yield in the 2011-2040 period. This can be observed especially in the early planting dates, where all but one RCM are equal or significantly higher than the actual yield. For the end-of-century period a generalized reduction of yield was calculated, with exception of IPSL, which showed significant increases. Though a trend of yield reduction, all RCMs presented at least one planting date that did not differ significantly from the actual best yields.

CONCLUSIONS:

Both genotypes tested (CD202 and CD204) did not presented remarkable differences among them when in the same region. Unfortunately, no other suitable soybean data sets are available to calibrate and validate the crop model in the study region, undermining the assessment of the role of cultivar as adaptation strategy. The impact of climate scenarios on soybean yield was directly influenced by location: in Chapecó region yields tend to decrease, while for Passo Fundo region yields can eventually be increased.

BIBLIOGRAPHY:

AQUASTAT (2010). FAO Global information system of water and agriculture. In *www.fao.org*: Online.

Banterng, P., Hoogenboom, G., Patanothai, A., Singh, P., Wani, S. P., Pathak, P., Tongpoonpol, S., Atichart, S., Srihaban, P., Buranaviriyakul, S., Jintrawet, A. & Nguyen, T. C. (2010). Application of the Cropping System Model (CSM)-CROPGRO-Soybean for Determining Optimum Management Strategies for Soybean in Tropical Environments. *Journal of Agronomy and Crop Science* 196(3): 231-242.

Dallacort, R., de Freitas, P. S. L., Goncalves, A. C. A., de Faria, R. T., Rezende, R. & Bertonha, A. (2008). Yield probability levels for four soybean cultivars in five sowing dates. *Acta Scientiarum-Agronomy* 30(2): 261-266.

Domínguez, M., Gaertner, M., de Rosnay, P. & Losada, T. (2010). A regional climate model simulation over West Africa: parameterization tests and analysis of land-surface fields. *Climate Dynamics* 35(1): 249-265.

Hourdin, F., Musat, I., Bony, S., Braconnot, P., Codron, F., Dufresne, J. L., Fairhead, L., Filiberti, M. A., Friedlingstein, P. & Grandpeix, J. Y. (2006). The LMDZ4 general circulation model: climate performance and sensitivity to parametrized physics with emphasis on tropical convection. *Climate Dynamics* 27(7): 787-813.

Magrin, G. O., Travasso, M. I. & Rodríguez, G. R. (2005). Changes in climate and crop production during the 20th century in Argentina. *Climatic Change* 72(1): 229-249.

Marengo, J., Chou, S., Kay, G., Alves, L., Pesquero, J., Soares, W., Santos, D., Lyra, A., Sueiro, G., Betts, R., Chagas, D., Gomes, J., Bustamante, J. & Tavares, P. (2012). Development of regional future climate change scenarios in South America using the Eta CPTEC/HadCM3 climate change projections: climatology and regional analyses for the Amazon, São Francisco and the Paraná River basins. *Climate Dynamics* 38(9): 1829-1848.

Reidsma, P., Ewert, F., Lansink, A. O. & Leemans, R. (2010). Adaptation to climate change and climate variability in European agriculture: The importance of farm level responses. *European Journal of Agronomy* 32(1): 91-102.

Samuelsson, P. A. T. R., Jones, C. G., Willen, U. L. R. I., Ullrstig, A. N. D. E., Gollvik, S. T. E. F., Hansson, U. L. F., Jansoon, C. H. R. I., Kjellström, E. R. I. K., Nikulin, G. R. I. G. & Wyser, K. L. A. U. (2011). The Rossby Centre Regional Climate model RCA3: model description and performance. *Tellus A* 63(1): 4-23.

Wilkens, P. W. (2004). DSSAT v4 Weather Data Editing Program (Weatherman). In *Data Management and Analysis Tools - Decision Support System for Agrotechnology Transfer Version 4.0: DSSAT v4 :Data Management and Analysis Tools*, Vol. 2, 92-151 Honolulu: University of Hawaii.

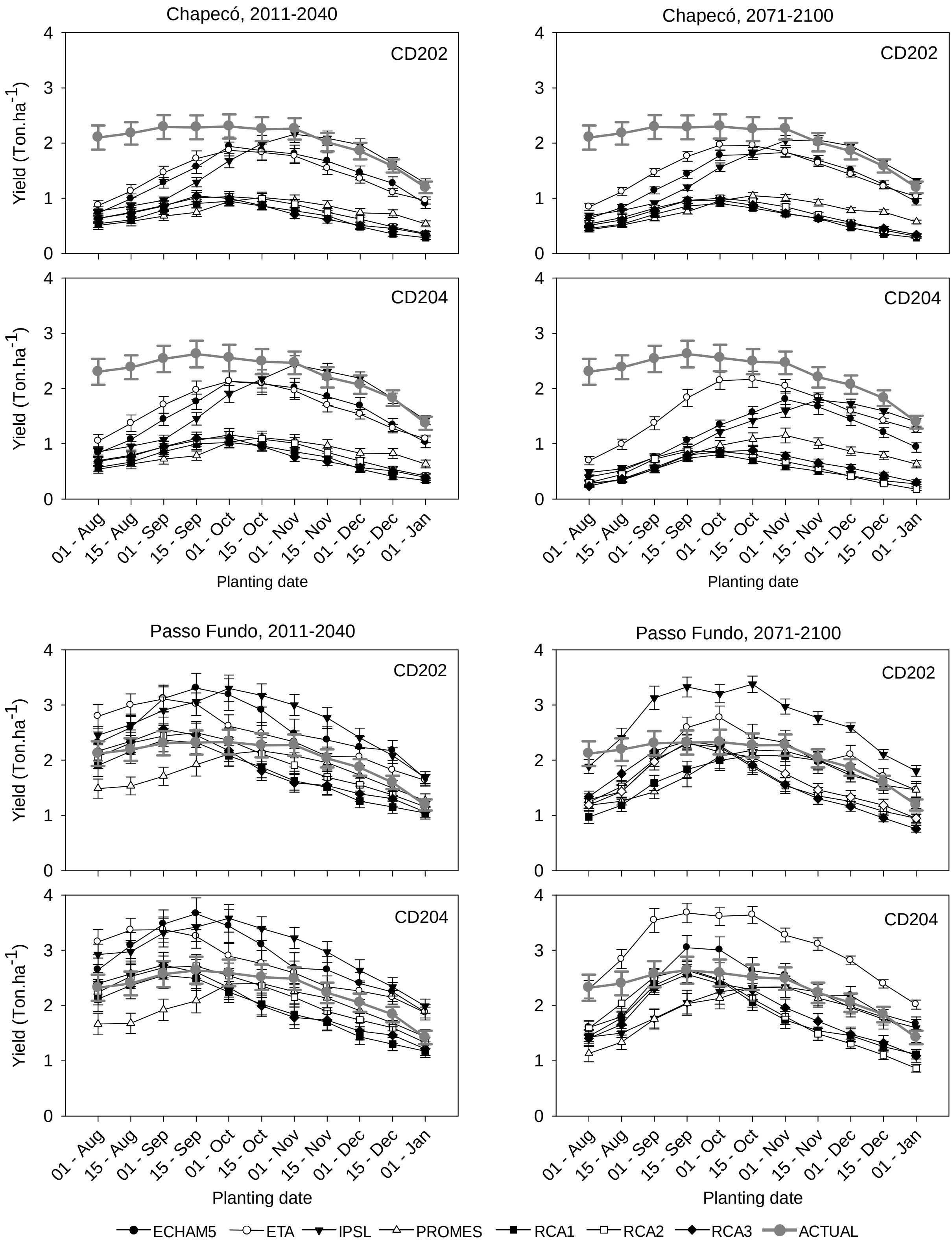

Figure 1. Simulations of the impact of RCM`s scenarios on soybean cultivars (CD202 and CD204) planted in eleven different dates, in two locations (Chapecó and Passo Fundo), and two time periods (2011-2040 and 2071-2100): black lines represent yields simulated with RCM`s and black bars represent the standard error of each planting date; the grey lines represent actual yields with respective planting dates and standard error.