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Mais für Ethanol-Produktion: Regionalisierung von Klimaszenarien Einfluss, N-Nutzungseffizienz und Wirksamkeit von Anpassungsstrategien.

(Maize for ethanol production: regionalization of responses to climate scenarios, N use efficiency and effectiveness of adaptation strategies)

Marcos A. Lana[1], Frank Eulenstein[1], Sandro L. Schlindwein[2], Marion Tauscke[1], Edgardo Guevara[3], Santiago Meira[3].

ABSTRACT

Maize, besides a source of food, is also a source of energy. As any other crop, maize yield – and therefore the ethanol produced – is a response to environmental factors such as soil, weather and management. In a context of climate change, understanding responses is crucial to determine mitigation and adaptation strategies. Crop models are an effective tool to address this. The objective is to present a procedure to assess the impacts of climate scenarios on N use efficiency, yield, so as the effect of crop variety (n=2) and planting date (n=5) as adaptation strategy. The study region is Santa Catarina State, Brazil, where maize is cultivated in more than 800000 ha (average yield: 4,63 ton ha-1). Besides not yet expressive in the region, there is a growing tendency for using maize as biofuel source. Allocation of crop land was done using satellite data, allowing the coupling of weather and 253 complete soil profiles in single polygons (n=4135). DSSAT crop model was calibrated and validated using field data (2004-2010 observations). Weather scenarios generated by RCMs were selected according capability of reproducing observed weather. Simulations run for the 2012-2040 period (437 ppm of [CO2]) without adaptation strategies showed reductions of 12.5% in maize total production. By only using the best maize variety for each polygon (soil + weather), total production was increased by 6%; when using both adaptation strategies – variety and best planting date – total production was increase by 15%. The modeling process indicates N use efficiency increment ranged from 1 – 3% (mostly due [CO2] increment, but also due soil properties and leaching). This analysis showed that N use efficiency rises in high [CO2] scenarios, so as that crop variety and planting date are effective tools to mitigate deleterious effects of climate change, supporting energy crops in the study region.

KEYWORDS:

Climate change, crop model, efficiency use.

Crop models are a valuable tool to assess the impact 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 CERES – Maize model (Jones, 1986), and can be used to determine best planting dates, fertilization strategies, nutrients use efficiency and to examine potential effects of climate change on 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

[1]Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) Müncheberg, Eberswalder Straße 84, D-15374 Müncheberg, Email: lana@zalf.de
[2]Universidade Federal de Santa Catarina, Florianopolis, Brasilien.
[3]INTA – Instituto Nacional de Tecnologia Agropecuaria, Pergamino, Argentina.

in the different organs of the plant. DSSAT also contains modules that account for nutrients and water dynamics in the soil.

In order to ensure the DSSAT correct simulation, field experiments were set up in different locations of Brazil to obtain the crops genetic coefficients recommended by He *et al.* (2009) and proceed with the model validation. Four varieties of maize were tested: three open pollinated varieties (MPA01, Ivanir and Fortuna) and one commercial hybrid (AS 1548). The field experiment was conducted according the recommendations of Boote *et al.* (1998) and Soler *et al.* (2007), and the validation was done using observed data from different field experiments (Ogliari *et al.*, 2007; Balbinot Jr *et al.*, 2007) containing all required data set for model validation (Hunt *et al.*, 2001). A standard fertilization scheme was use for each soil (to attend the crop N requirements), ranging from 50 to 120 Kg/N/ha. Results were organized and plotted on GIS maps on areas discriminated as agricultural land use. Yield change in the scenarios was calculated based on recorded yields from the last 30 years (IBGE, 2012). Nitrogen use efficiency was calculated using simulations with past weather as base line, followed by comparisons with efficiency obtained using climate scenarios.

RESULTS:

The main findings from the results are the following:

- Simulations run for the 2012-2040 period (437 ppm of [CO2]) without adaptation strategies showed reductions of 12.5% in maize total production (Figure 1);
- The modeling process indicates N use efficiency increment ranged from -20% to +12% (according the model, mostly due [CO2] increment, but also due soil properties and leaching)(Figure 2);
- By only using the best maize variety for each polygon (soil + weather), total production was increased by 6%; when using both adaptation strategies – variety and best planting date – total production was increase by 15% (Figure 3);
- N use efficiency rises in high [CO2] scenarios, but is also determined by soil and weather in non linear correlations;
- Crop variety and planting date are effective tools to mitigate deleterious effects of climate change, supporting energy crops in the study region;
- The potential for ethanol production will be increased at the Southeastern region, while the West regions will suffer strong reductions in its production potential.

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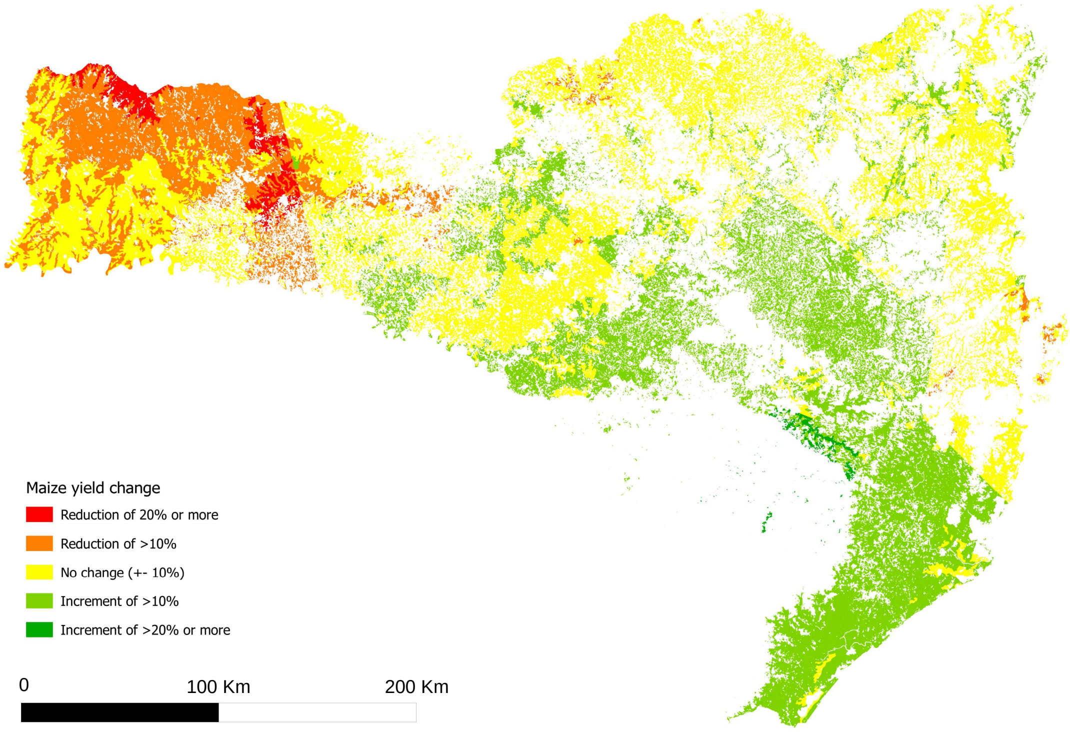

Figure 1. Change in maize yield (%) in Santa Catarina State, Brazil, due impact of climate scenarios without any kind of adaptation strategy (planting date or cultivar, for example).

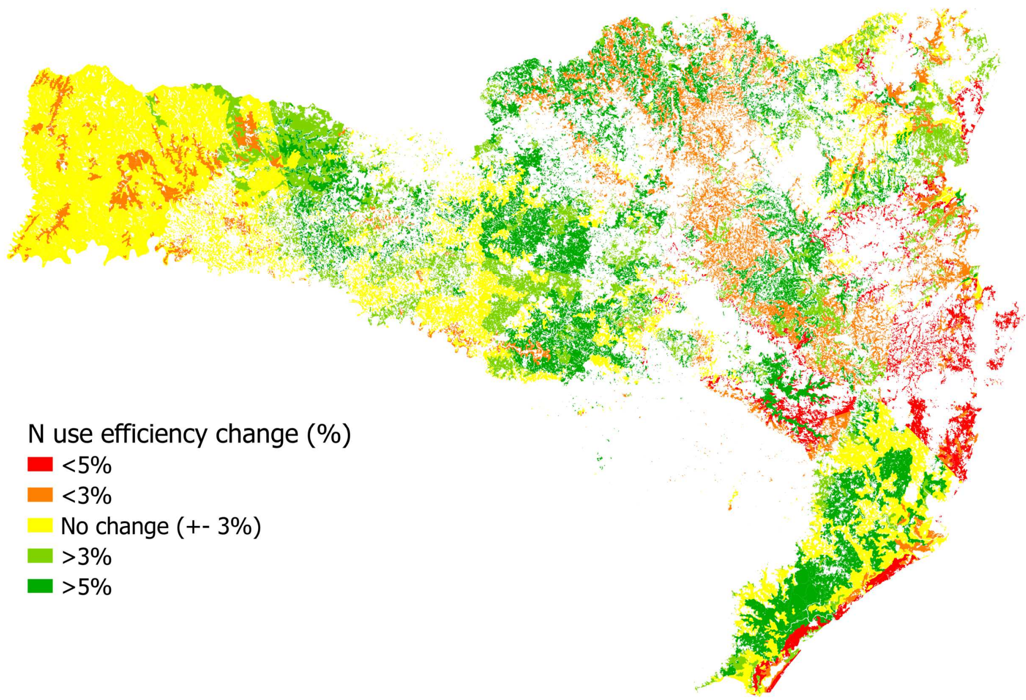

Figure 2. Nitrogen use efficiency change under impact of climatic scenarios for Santa Catarina State, Brazil. Changes are relative to the actual values (baseline calculated with climatic data from the last 30 years).

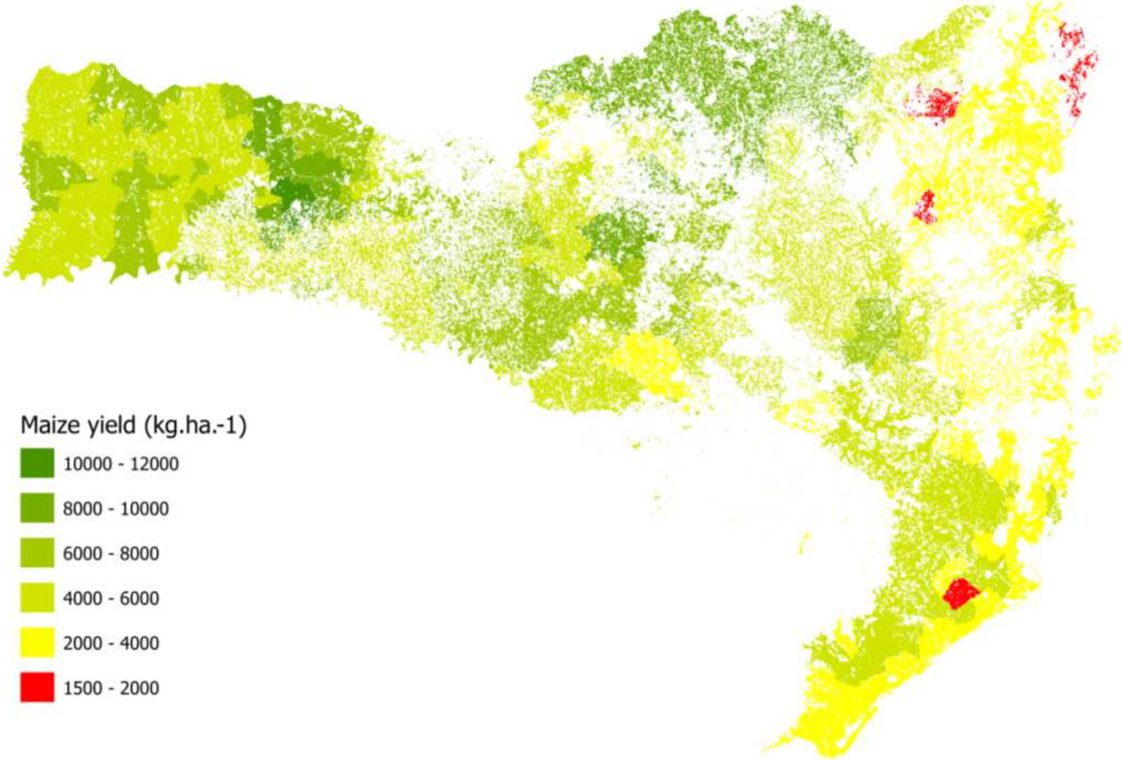

Figure 3. Expected maize yields under climatic scenarios for the 2012-2040 period. When adaptation strategies are employed, yields can potentially raise in many regions, increasing the State`s production up to 15% from actual levels.