Assessing Nitrogen Fertilisation Strategies According To Climate Variability: A Modelling Approach

Dumont Benjamin*, Basso Bruno, Bodson Bernard, Destain Jean-Pierre, Destain Marie-France

Introduction

Crop models are powerful tools to study the effects of variable inputs, as management practices, agro-environmental conditions or weather events, on harvestable organs.

It has been proven that the sequencing of weather events was really important on the crop response.

On the other hand, to improve the farm-management decision process, the impacts of practices should be known with accuracy.

This paper exhibit a methodology that studies the yields prediction linked to different management practices, in interaction with climate variability.

Material & Methods

The STICS soil-crop Model

The STICS crop growth model used in this study simulates the water, carbon and N dynamics in the soil-plant-atmosphere system on a day-by-day basis. It allows the effect of water and nutrient stress on development rate to be taken into account. It requires daily weather data inputs (i.e., minimum and maximum temperatures, total radiation and total rainfall, vapour pressure and wind speed). (Brisson et al. 2009).

The LARS-Weather Generator

The historical 30-years weather data base (WDB) was analysed with the LARS-WG, which computed the daily max., min., mean and std. values of each climatic variables, the frequency distributions of rain, and the seasonal frequency distributions for wet and dry series (Semenev et al., 2002).

The LARS-WG was then used to generate synthetic data (#300) which have the same statistical characteristics as the observed historical weather data.

Assessing N strategies

Different N management strategies were simulated and compared, splitting the total N amount either in two or three equal doses (Table 1).

<table>
<thead>
<tr>
<th>Fertilisation level (in kg N/ha)</th>
<th>60-60-60</th>
<th>75-75-75</th>
<th>0.892</th>
<th>80-80-80</th>
<th>0.612</th>
<th>90-90-90</th>
<th>0.000***</th>
<th>105-105-105</th>
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The Pearson’s system

Pearson developed an alternative system of density functions that takes a wide variety of forms. This research focuses on the Type I:

$$f(x) = \begin{cases} 0 & x < a_1 \\ \frac{1}{(x-a_1)(b_1-a_1)(b_2-a_1)} & a_1 < x < a_2 \\ 0 & a_2 < x \end{cases}$$

Pearson also developed the coefficient of skewness under the different N protocols (3 applications) and drawn out of 30 synthetic climates (CDF-axe).

Table 1: Comparison of N management strategies

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Results

Grain yield distribution analysis

Fig. 1 shows the type-I distribution adjusted to the observed grain yield (GY) distribution by the method of the moments. Theoretical and experimental curves are very close.

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<th>Skewness</th>
<th>Kurtosis</th>
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<td>α1</td>
<td>β1</td>
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The grain yield response surface

Fig. 3 shows the GY response surface obtained under the different N protocols (3 applications) and drawn out of 300 synthetic climates (CDF-axe).

Distribution inter-comparison

The wilcoxon test was used to intercompare the GY distributions (Table 1).

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Discussions

Our results showed that:

- Under no N application, the distribution was considered as being not different than a Gaussian distribution.
- The higher the N practice, the higher the expected mean yield!
- With N increase, the probability to achieve a yield at least superior to the mean increases.
- For a total N practice superior to 120 kgN/ha, 30 kgN/ha could systematically be saved by splitting the total N dose in 3 fractions.

Yields become higher but also more frequent!

Conclusion

The proposed methodology:

- Highlights the importance to consider the first four moments of order.
- Allows to study the yields over a wide variety of local climatic conditions.
- Offers the response curves evolution under any practices.
- Quantify immediately and precisely the risk for farmers.

It has the potential to stand as basis to develop formal DSS that could be used in Precision agriculture.

Contact information

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