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

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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 (Semenov 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.

Material & Methods

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 1 : *Fertilisation calendar for the nitrogen practices where N is split in three equal fractions*

Treatment	Fertilisation level (in kg N/ha) Tillering	Redress	Last leaf	Total
#	Z23	Z29	Z30	
T1	0	0	0	0
T2	10	10	10	30
T3	20	20	20	60
...	...	...	...	...
T11	100	100	100	300

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 :

$$f(x)\begin{cases} = k.(x-\alpha_1)^{m1}(x-\alpha_2)^{m2} & ,\alpha_1 < y < \alpha_2 \\ = 0 & ,y \le \alpha_1 \quad or \quad \alpha_2 \le y \end{cases}$$

Pearson also developed the coefficient of shape to characterize distributions :

$$Skewness = \frac{m_3}{m_2^{3/2}} = \frac{m_3}{\sigma^3}$$

$$Kurtosis = \frac{m_4}{m_2^2} = \frac{m_4}{\sigma^4}$$

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.

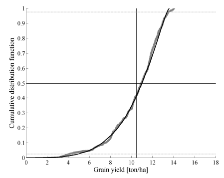


Fig. 1 : E*xperimental distribution and computed Type-I distribution obtained under 60-60-60 kgN/ha*

Fig. 2 shows the evolution of the skewness under the different N protocols. The maximum of asymmetry was reached where 60-60-60 kgN/ha were applied.

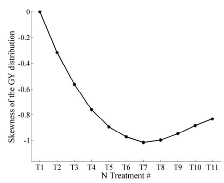
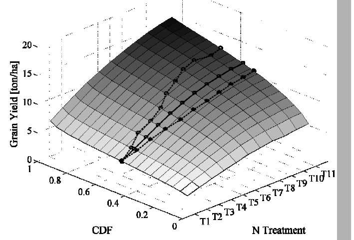


Fig. 2 : *Skewness evolution*

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).

Fig. 3 : *Grain yield as function of N fertilisation management and cumulative probability density function (CDF). The mode (--o--), the mean (--*--) and the median (-□-) were numerically derived*



Distribution inter-comparison

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

Table 1 : Comparison of N management strategies

Treat.	120-120	105-105	90-90	75-75	60-60	45-45	30-30	15-15
80-80-80	0.001***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
70-70-70	**0.643**	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
60-60-60	0.000***	**0.773**	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
50-50-50	0.000***	0.000***	**0.176**	0.001***	0.000***	0.000***	0.000***	0.000***
40-40-40	0.000***	0.000***	0.000***	**0.003****	**0.009****	0.000***	0.000***	0.000***
30-30-30	0.000***	0.000***	0.000***	0.000***	0.000***	**0.123**	0.000***	0.000***
20-20-20	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	**0.612**	0.000***
10-10-10	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	**0.892**

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 moment 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.

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