Quantifying the value of fertilization advice strategies under weather uncertainty

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Project description

Too little nitrogen can limit crop development, while excessive fertilization is costly and may have negative environmental effects. The quality of a fertilization strategy cannot be judged from the realized crop outcome alone, since this outcome also depends strongly on uncertain future weather conditions.

CropConsult, a company that provides advice to farmers, has collected field data containing soil measurements, fertilization advice, actual fertilizer applications, measurements of (potato) crop biomass and nitrogen status, weather data, and information about tuber development. These data contain different fertilization decisions made under a range of environmental conditions.

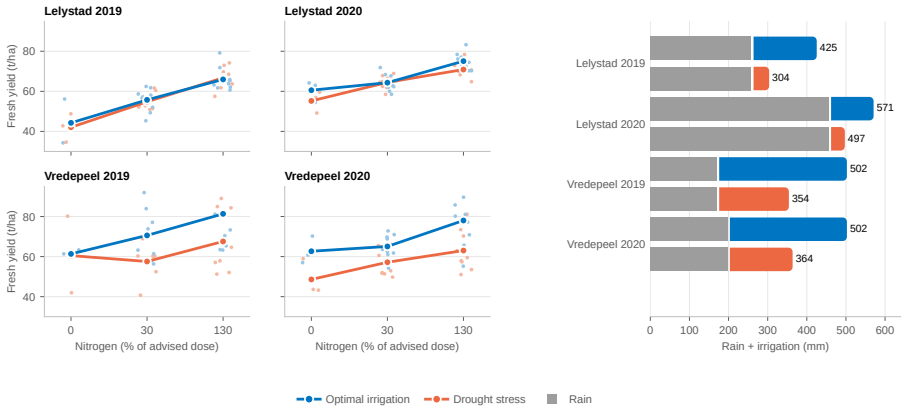


Figure 1. Fresh yield versus nitrogen level (% of advised dose) under optimal irrigation and drought stress per site and year (left), and seasonal rainfall plus irrigation (right). Data: ten Den et al. (2024).

A natural mathematical description in this context is the following:

$$\mathbb{E}[Y \mid \mathbf{N}, \mathbf{x}, \mathbf{U}_{\text{future}} = \mathbf{u}] = f(\mathbf{N}, \mathbf{x}, \mathbf{u}), \tag{1}$$

where Y is the crop yield, $\mathbf{N}$ describes the amount and timing of nitrogen application, $\mathbf{x}$ contains the information available at the time of the fertilization decision, and $\mathbf{U}_{\text{future}}$ represents the uncertain future weather conditions.

The expected crop yield under the distribution of possible future weather conditions should be considered. This can be expressed as

$$\mathbb{E}[Y \mid \mathbf{N}, \mathbf{x}] = \int f(\mathbf{N}, \mathbf{x}, \mathbf{u}) p(\mathbf{u} \mid \mathbf{N}, \mathbf{x}) \, d\mathbf{u}. \tag{2}$$

where $p(\mathbf{u} \mid \mathbf{x})$ describes the distribution of possible future weather conditions given the information available at the time of the decision. The project will use this framework to quantify how much precision fertilization advice improves expected crop yield, and under which conditions this added value is largest.

Reference for colloquium

T. Gneiting and M. Katzfuss, "Probabilistic forecasting," *Annual Review of Statistics and Its Application*, 1, 125–151, 2014.

Other references

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T. ten Den, I. van de Wiel, F. van Evert, M. van Ittersum, A. de Wit, and P. Reidsma, "Agronomic dataset on potato growth and yield in the Netherlands," *Open Data Journal for Agricultural Research*, 10, 1–13, 2024.