IDENTIFYING PARAMETERS FROM MORE THAN 20 YEARS OF EXPERIMENTS TO BETTER IDENTIFY NITROGEN OPTIMUM FOR CEREALS

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INTRODUCTION:

In Denmark, nitrogen (N) fertilizer application is regulated based on economic optimum principles for specific crops and soil types, forming the foundation of the N norm system. These norms are derived from data from field experiments investigating yield response to increasing N application rates, which have been conducted since 1987. SEGES Innovation maintains comprehensive databases, including results from 472 field trials with winter wheat going more than 30 years back. Similar data sets exists for other crops as well.

METHODS:

A total of 99 field trials with increasing nitrogen (N) application rates were analysed to assess variation in the economic optimum N rate. Each trial was designed as a randomized block with four replicates and included a minimum of four N levels, starting from 0 kg N/ha, with at least 50 kg N/ha intervals.

The economic optimum was calculated using two price ratios: 6.5:1 and 20:1. For example, a 6.5:1 ratio implies that 6.5 kg of N must be applied to produce 1 kg of cereal to break even.

The trials span the entire country and cover the period 2005–2024, selected due to data completeness. Although data exists from the past 30 years, the last 20 years provided the most reliable and complete dataset.

For each trial, the following data were recorded as a minimum:

- Sowing date
- Soil type
- Preceding cropping history
- Total soil N and mineral N
- Maximum recorded yield
- Fertilization history

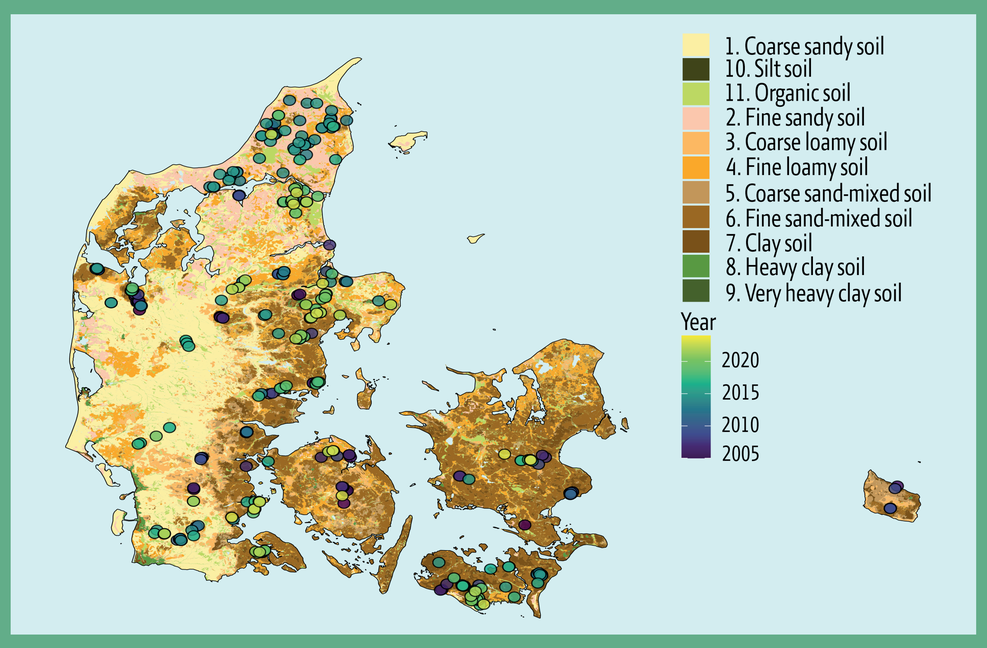
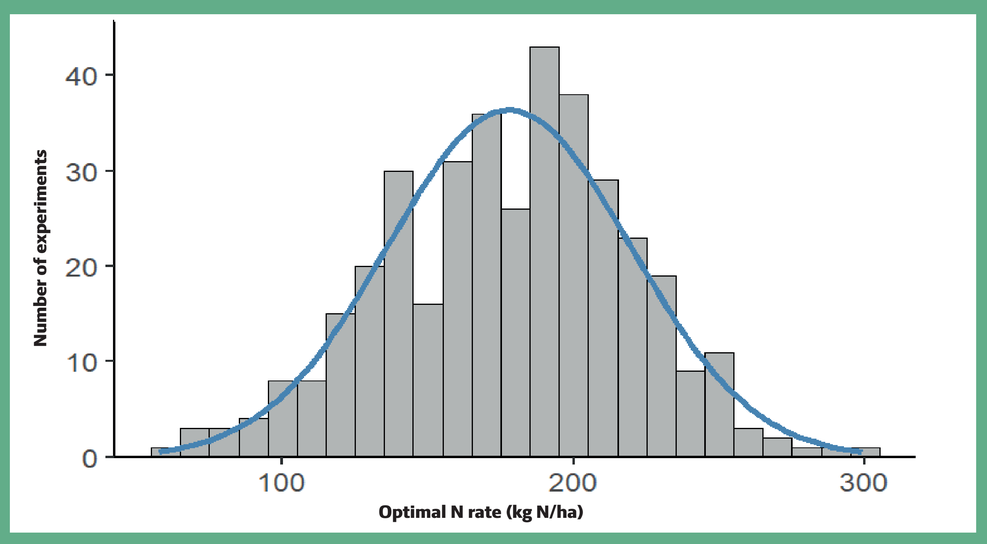


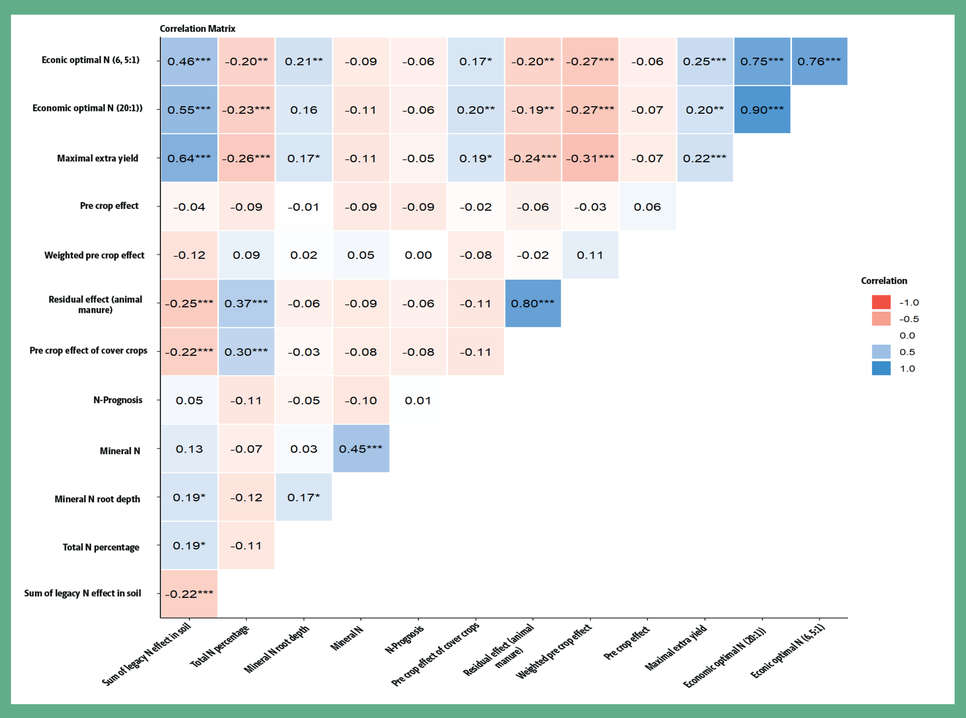
Figure 1: location of increasing N rate experiments. The dots indicted soil types according to the Danish soil classification system (JB-system).

RESULTS:

Figure 2 shows the economic optimal N rate across all winter wheat trials, illustrating a wide range of optima. This underscores the importance of adjusting N rates to the specific field conditions and growing season.



- The correlation matrix in figure 2 shows the correlation between the different parameters
- The economic optimal N rate is strongly positive correlated with the yield, N in soil and the pre cropping N effect



The full model, initially including all variables, was systematically reduced using likelihood ratio tests to evaluate the significance of each parameter.

The final reduced model for economic optimal N (at a 6.5:1 price ratio) is:
Economic optimal N ~ Residual effect (animal manure) + N prognosis + yield relative to standard yield + precrop effect + mineral N + total N (%) + (1 | city) + (1 | year) + (1 | trial ID)

Table 1 below summarizes the raw effect sizes (β) in kg N/ha, along with the corresponding 95% confidence intervals and p-values for each fixed effect, followed by the random effects.

Parameter	Estimate	95 % CI	P-value
	kg N/ha		
Residual effect (animal manure)	-0.70	-1.3, -0.11	0.019
N prognosis	0.37	-0.09, 0.83	0.11
Yield level compared to standard	0.93	0.71, 1.20	<0.001
Residual effect of previous crop	-0.87	-1.1, -0.62	<0.001
Measured mineral N	-0.24	-0.41, -0.08	0.004
Total N	9.8	3.3, 16	0.003

OUTLOOK:

Improved identification of the optimal nitrogen rate across different crops and soil types is a key step toward more efficient N use and improved farm profitability. The results highlight the importance of adjusting N application based on:

- Expected crop yield level
- Crop and soil type
- Nitrogen legacy effects (e.g. preceding crops, cover crops, and animal manure)
- In-season soil mineral N levels

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