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What Drives Fertilizer Management Decisions? Evidence on Climate Attitudes, Precision Agriculture, and Structural Farm Characteristics in Denmark

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Abstract.

In Denmark, the strict environmental regulations imply that farmers need to adopt advanced technologies and reconsider nutrient management strategies to be able to navigate the stringent fertilizer and agricultural policies. It is therefore important to understand how climate and sustainability concerns, together with precision farming perceptions shape farmers fertilizer management decisions. With the objective of understanding fertilizer use practices, and identifying fertilizer management challenges and barriers, this study used survey data collected from 240 Danish farmers. The findings indicate that fertilizer application and management decisions are associated with structural barriers, behavioral and sustainability related factors. We therefore recommend targeted advisory services and incentive-based programs aimed at enhancing nutrient management practices to facilitate the uptake of climate-smart and precision agriculture technologies.

Keywords.
Foliar and Granular Fertilizers, Precision and Climate Concerns, Correlation Matrix, OLS Regression, Danish Agriculture and Nutrient Management Behaviour

1.0 Introduction

Denmark provides a compelling setting for research on climate and precision farming because agriculture is intensive and occupies a large share of the country's land area. Approximately 2.6 million hectares (62%) of Denmark's total land area are used for agricultural production (Searchinger et al., 2021). Danish farmers have relatively high levels of technology adoption compared to many other European countries, with widespread use of GPS-guided machinery, digital field mapping, and software-based nutrient management systems (Lowenberg-DeBoer & Erickson, 2019). These technologies offer opportunities to improve fertilizer efficiency and farm profitability while helping farmers respond to increasing environmental regulations and climate-related challenges (Pedersen & Lind, 2017). The combination of advanced technology adoption and stringent environmental policies makes Denmark an ideal context for examining how climate and sustainability concerns, together with precision farming perceptions, influence farmers' fertilizer management decisions. Although precision agriculture is widely promoted as a means to optimize nutrient use and reduce environmental impacts (Pedersen & Lind, 2017), limited

evidence exists on how farmers choose different fertilizer application modes such as granular, liquid, foliar, and manure/slurry fertilizers in crop production.
This study investigates how climate concerns, perceptions of precision agriculture, and other farm characteristics influence fertilizer choice and allocation on Danish arable farms. The findings contribute to the literature on precision agriculture, climate concerns, and nutrient management while providing insights for the development of more effective fertilizer decision-support tools and policies in Denmark.

2.0 Study Methods

A pre-tested semi-structured questionnaire was used as an instrument to collect cross-sectional primary data for the study. The data was collected between November and December 2025 across five regions of Denmark. We conducted web-based survey with questionnaire comprising of questions related to fertilizer use practices, fertilizer management challenges, and barriers to foliar fertilizer use in Denmark. The questions were designed in SurveyXact and administered through Computer Assisted Web Interviewing (CAWI). In total 253 farmers returned the questionnaire with about 240 farmers proving complete responses to all the questions. Farmers included in the interview were full-time farmers with at least 150 hectares of arable land and comprised of dairy farmers, pig farmers and crop farmers to ensure representativeness. The data was analyzed by using a correlation matrix of climate smart and precision agricultural variables and fertilizer types, including granular, foliar, liquid and manure/slurry fertilizer proportions. Given that the fertilizer application allocation among granular, foliar, liquid and manure/slurry were measured as proportions, we reduced them to a single fertilizer use index variable to be able to apply a simplified model to identify the factors that influence fertilizer application in crop production. Therefore, a composite fertilizer index variable was generated through principal component analysis to obtain a dependent variable for the analysis. Subsequently OLS model was fitted to explain the factors influencing fertilizer application decisions.

3.0 Results and Discussion

A summary of the fertilizer application proportions revealed that granular fertilizers still dominate fertilizer application in Denmark. In fact, all farmers in this sample (240) use an average proportion of about 0.681 while only 9.6% of the farmers apply foliar in a relatively small proportion of 0.011. Table 1 provides details of the various fertilizers and their relative proportions used in the country based on the farmers included in this study.

Table 1: Distribution of Fertilizer Types

Fertilizer	Total Proportion	Relative Proportion	Freq	% Farmer
Granular	163.44	0.681	240	100.0
Foliar	2.65	0.011	23	9.6
Liquid	11.46	0.048	75	31.3
Manure Slurry	62.45	0.260	151	62.9

(Source: Web-survey in Denmark, 2025)

Figure 1 also presents a regression model of the factors that influence the use of fertilizers by Danish farmers. The results show that the model explains a substantial share of the variation in fertilizer management decisions ($R^2 = 0.754$, $F(19,220) = 51.54$, $p < 0.001$) and hence the farm, regional dummies, behavioural, climate and precision variables have accounted for about 75.4% of the differences in fertilizer management decisions. In summary, variables such as farm type, region, nutrient management concerns, perceived structural barriers, and perceived knowledge and profitability barriers all have reducing or negative associations with fertilizer use index which is a proxy for fertilizer management decisions among the farmers. However, a larger share of legumes allocation to farmland is positively associated with fertilizer index values and could reflect better nutrient management planning among the farmers. The regression results are presented

in figure 1

Figure1: OLS regression model of factors influencing fertilizer use

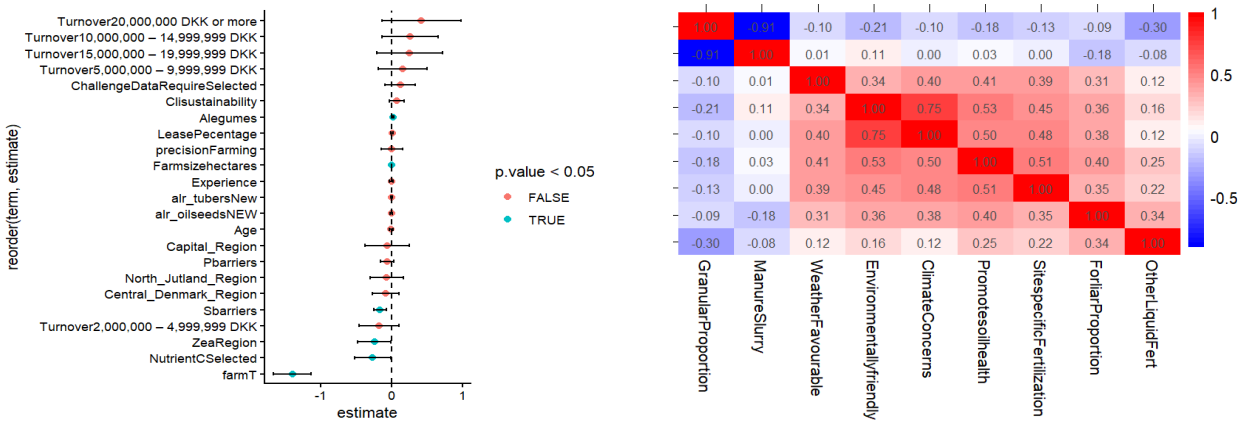

Figure 2: Correlation matrix of variables related to climate smart and precision Agriculture Technology and influence on fertilizer application (Note: -0.5 – 1 represents correlation coefficient for the different variables)

Figure 2 presents a correlation matrix of the variables related to climate smart and precision agriculture technologies such as site-specific fertilizer applications and the proportions of fertilizer use in crop production in Denmark. More specifically figure 2 shows a correlation matrix of climate smart and precision farming practices in relation to granular soil-based fertilizer, foliar fertilizer as well as liquid and manure/slurry fertilizers used on farmlands. The results show that farmers who allocate more fertilizers to granular are less concerned with promoting soil health, environmental sustainability and climate change. However, there is positive correlation between foliar fertilizer as well as liquid fertilizer application shares and each of these variables. This implies that farmers who allocate fertilizer share to foliar and liquid are probably strong advocates for promotion of soil health, environmental sustainability, site-specific fertilizer application and issues of climate change.

4.0 Conclusion and Recommendation

In conclusion, the findings of the study reveal that fertilizer management and application decisions are more influenced by structural barriers, behavioral and sustainability related factors. We therefore recommend targeted advisory services and incentive-based programs aimed at reducing adoption barriers and enhancing nutrient management practices to facilitate the uptake of climate smart and precision agriculture technologies.

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