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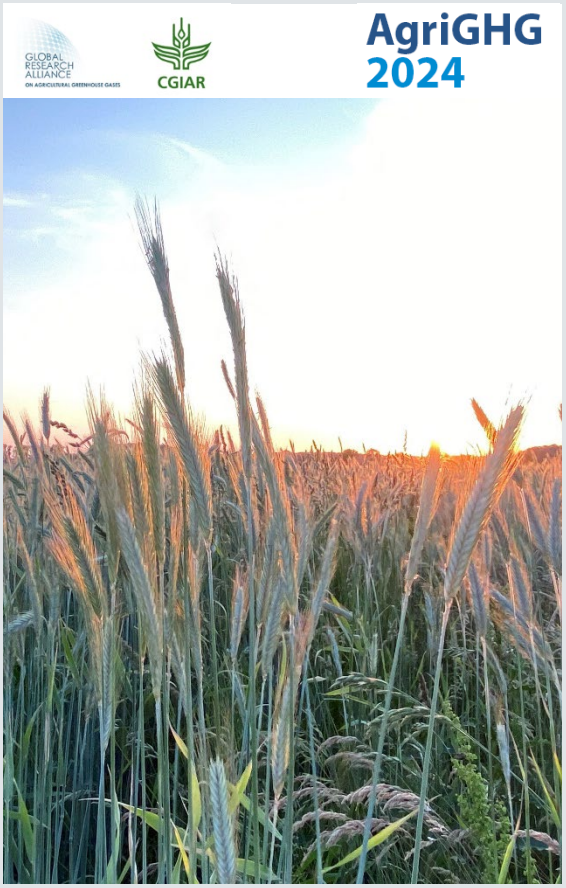

Claudia Heidecke, Harry Clark, Louis Verchot, Til Feike, Nina Grassnick, Andy Reisinger, Claudia Ringler, Tania Runge, Wei Zhang (Eds.)

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What drives recent trends of nitrogen use efficiency and mineral fertilizer consumption in Germany?

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An efficient use of nitrogen is crucial for reducing climate impacts of agricultural production while ensuring food security. In Germany, new national fertilization policies aim at optimizing nitrogen use efficiency (NUE) (e.g. amending fertilizer application ordinance while enhancing principles of good fertilization practice in 2020, or a novel ordinance on nutrient budgeting on farm-gate level in 2018) (Löw et al. 2021) and recent trends in agricultural nitrogen flows point to increasing NUE. However, studies find substantial differences in mineral fertilizer consumption, the main nitrogen input source, and NUE at regional and farm type-level (Löw und Osterburg, 2024; Zinnbauer et al., 2023). Multiple drivers potentially impact on nitrogen management in German agriculture between 2017 and 2023, including extreme drought events in 2018 and 2019 (Klages et al. 2020; Schmitt et al. 2022), volatile input and output prices due to geopolitical conflicts and an increasing role of carbon pricing for fertilizer industry as part of the EU Green Deal (Osterburg 2024). Since these multiple drivers are likely to change in future, we investigate their lasting influence on nitrogen management across different farm types and how effectively policies support the increasing NUE trend.

In order to identify drivers of changes in NUE and mineral fertilizer consumption between 2017 and 2023, we calculate NUE by considering nitrogen input and output parameters at “farm-gate” as system boundary (Quemada et al. 2020; Löw & Osterburg 2024) and use farm-specific and invoice-based fertilizer consumption documentation, based on farm data of the German Farm Accountancy Data Network. Covering around 25,000 observations between the years 2017 and 2023, we develop a multiple regression model to identify effects of regional (e.g. soil fertility), farm-structural (e.g. livestock farming, organic vs. conventional) and individual market-related (e.g. fertilizer prices) characteristics. In addition, we control for initial levels of NUE and compliance with nitrogen policies as well as location in nitrate polluted areas.

The results reveal an increasing trend in NUE for all farm types, from 56% to 77% at sectoral level. Growth rates were most significant in 2021 and 2022, following minor differences previously. Simultaneously, mineral fertilizer consumption decreased notably: from -44% (-27 kg N/ha) for other cattle farms, to -22% (-19 kg N/ha) for pig and poultry farms and -18% (-23 kg N/ha) for arable farms. First results from our multiple regression analysis indicate significant interrelations between increasing NUE and independent variables, such as high soil fertility, organic farming or specific winter grain species in crop rotation. Despite improvements in nitrogen pollution at state and federal levels (LWK Niedersachsen 2024; Umweltbundesamt 2023), there are still farms with excessive nitrogen inputs. Our analysis reveals that farms with a net soil-surface budget above 50 kg N/ha (a regulatory threshold for farms in Germany until 2020) reduced nitrogen fertilizer inputs by 34% over time, their input remains 27 kg N/ha higher and NUE 15% lower than the average for all farms in 2023. Thus, we highlight the need for comprehensible nitrogen policies accompanied with reliable and easily monitored agri-environmental indicators to address farms which are not yet utilizing their NUE potential to the fullest. The analysis contributes to better understand multi-dimensional agri-economical linkages and supports policymakers in designing effective policy measures.

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