Impact of fertilization on crop yield anomalies in the long-term experiment Dikopshof

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Background and Methodology

Introduction

- While it is well agreed in the scientific literature, that fertilization has a major impact on crop yields, little knowledge is available so far on the impact of different fertilization treatments on magnitude and direction of yield anomalies.

Study site

- The long-term experiment Dikopshof was established in year 1904 in Wesseling (16 km north of Bonn) to investigate the impact of different fertilizers on crop development, crop yields and soil properties.
- Fertile soil (Haplic Luvisol which developed from a 1 m deep loess layer); atlantic climate (mean annual precipitation 633 mm, mean annual temperature 10.0 ℃).
- Each of the five crops is cultivated in 24 plots representing different combinations and applicaton levels of synthetic fertilizer and farmyard manure (Figure 1).

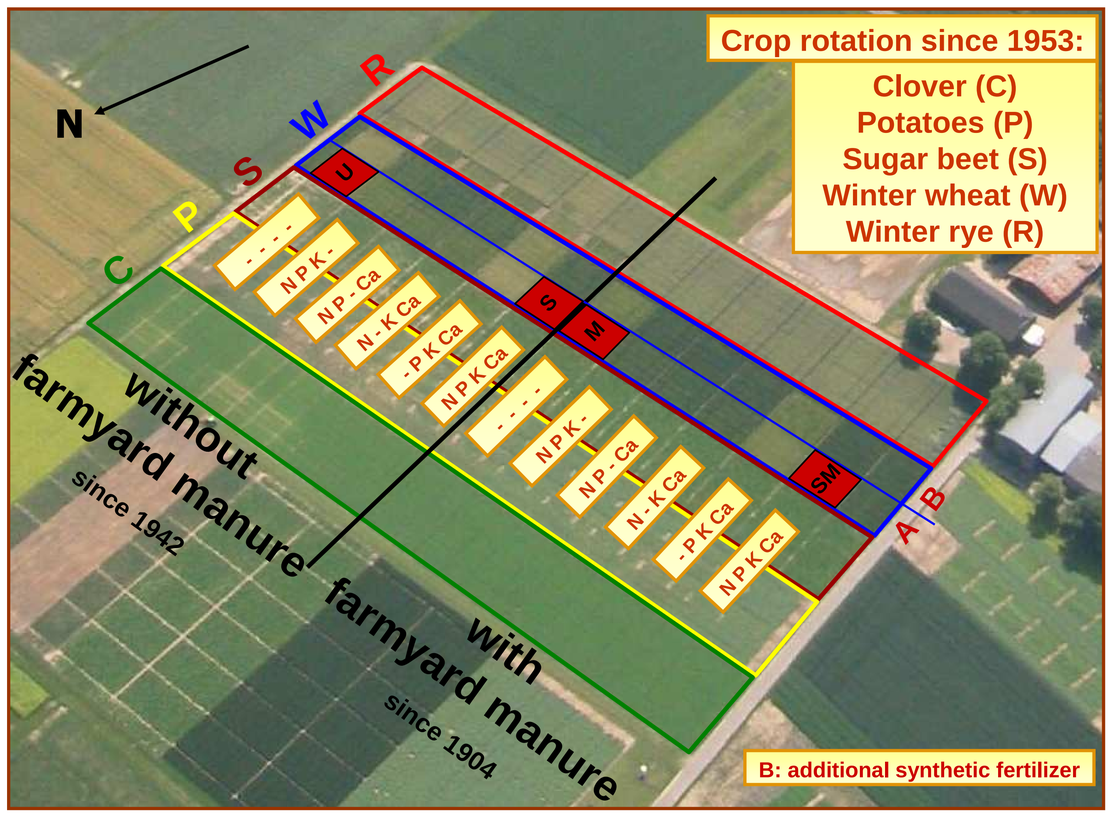

Figure 1. Aerial photograph showing the experimental design of the long-term experiment Dikopshof. In this study yield anomalies in the treatments zero fertilization (U), solely synthetic fertilizer (S), solely farmyard manure (M), and synthetic fertilizer and farmyard manure (SM) were investigated.

Data analysis

- Crop yields of winter wheat, winter rye, sugar beet, and potatoes observed in the period 1953 - 2009 (Figure 2) were used to calculate yield anomalies for the different fertilizer treatments SM, M, S, and U (Figure 1) compared in the study.
- Crop yield anomalies in absolute (t ha^{-1}) and relative (%) terms were calculated as the difference of crop yield in the current year to the corresponding 11-year moving average yield.
- Variabilities and trends of yield anomalies were compared for crops and fertilizer treatments.
- Yield anomalies for specific years were plotted in order to compare magnitude and direction of anomalies between fertilizer treatments.

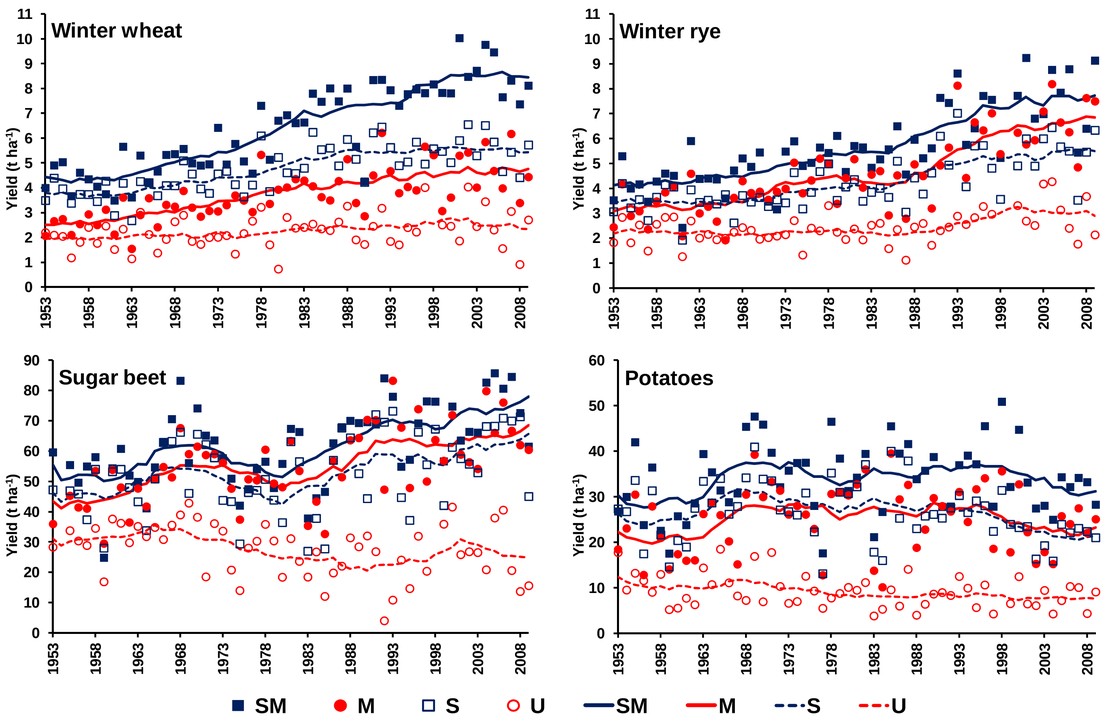

Figure 2. Yields of winter wheat, winter rye, sugar beet, and potatoes observed for different fertilizer treatments in period 1953 to 2009. 11-year moving averages are indicated by trend lines.

Results

Fertilization impact on magnitude and direction of yield anomalies

- Magnitude and direction of yield anomalies for specific years were strongly affected by fertilization with the largest disagreement in yield anomalies between the unfertilized treatment (U) and the treatment with synthetic fertilizer and manure SM (r^2 = 0.09 - 0.17, Figure 3).

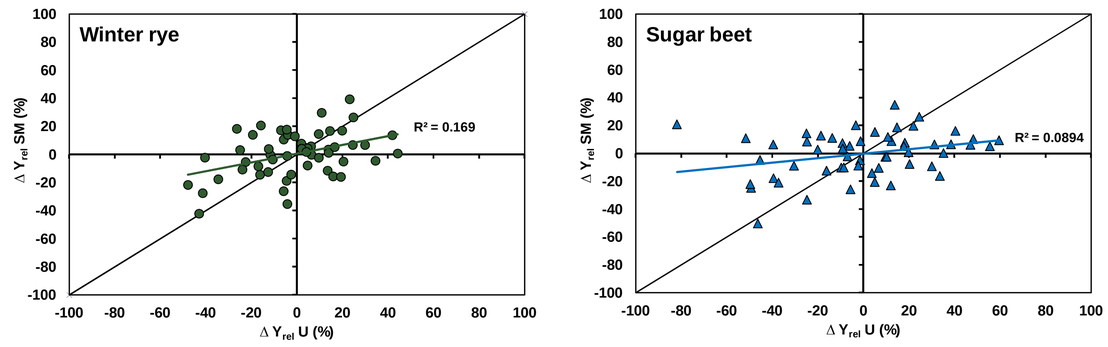

Figure 3. Comparison of relative yield anomalies between SM and U treatments for winter rye and sugar beet in period 1953 to 2009.

Trends and variability of absolute yield anomalies

- No consistent trend in absolute yield anomalies.
- Absolute yield anomalies were larger for crops with higher yields (sugar beet, potatoes).
- Long-term mean and variability of absolute yield anomalies (t ha^{-1}) differed between crops but were quite similar for the fertilization treatments (Figure 4).

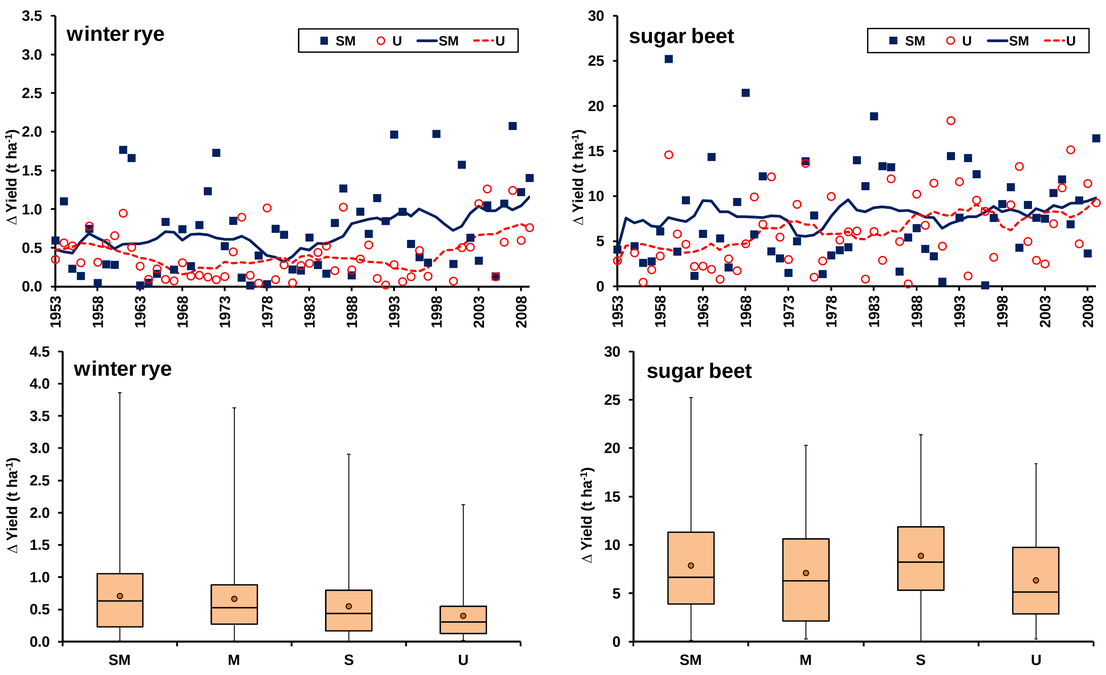

Figure 4. Absolute yield anomalies (t ha^{-1}) for winter rye and sugar beet for period 1953 to 2009, lines indicate 11-year moving averages (top). Mean, median and variability of crop yield anomalies in dependence of different fertilizer treatments shown as box plots (bottom).

Trends and variability of relative yield anomalies

- Increasing trend of relative yield anomalies for sugar beet in unfertilized treatment only.
- Long-term mean and variability of relative yield anomalies (%) were similar except of the unfertilized treatment of sugar beet (Figure 5).

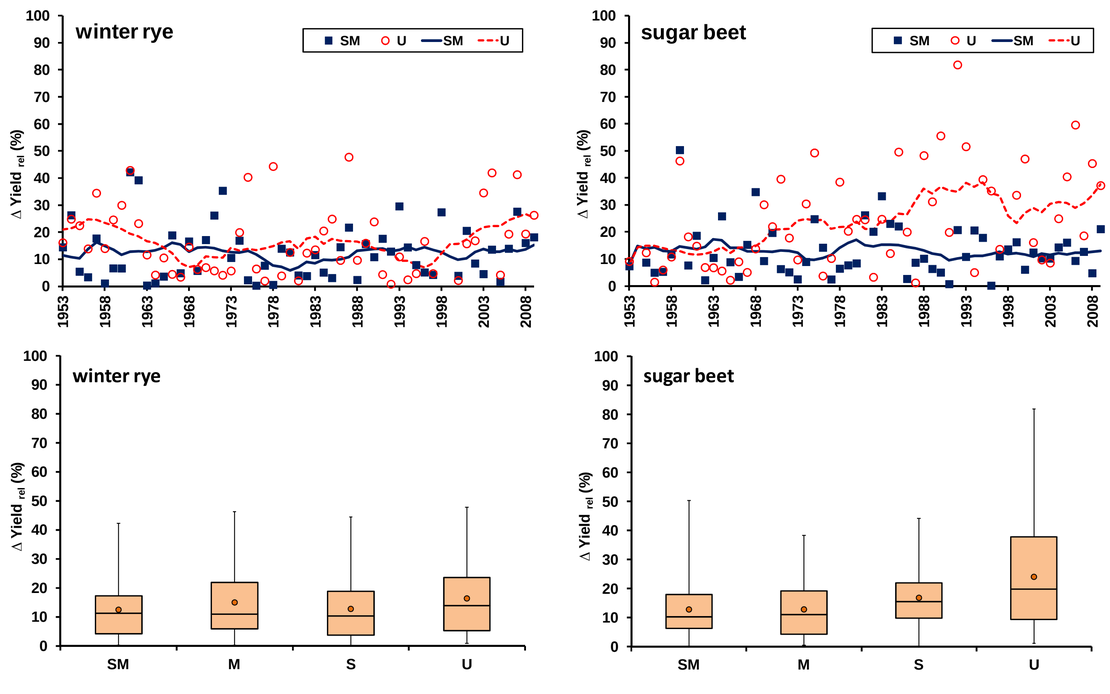

Figure 5. Relative yield anomalies (%) for winter rye and sugar beet for period 1953 to 2009, lines indicate 11-year moving averages (top). Mean, median and variability of crop yield anomalies in dependence of different fertilizer treatments shown as box plots (bottom).

Acknowledgements

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Conclusions

- The impact of yield-determining factors like climate or occurrence of weeds, pests or diseases on crop yield anomalies is strongly modified by fertilization.
- This needs to be considered in assessments of yield variability.
- Further research is required to explain the mechanisms behind the impact of different fertilization types on yield anomalies.