Projected wheat and maize yields in Germany in 2050 – a meta-analysis

Bittner, Marlene; Riedesel, Ludwig; Feike, Til

Julius Kühn Institute (JKI) – Federal Research Centre for Cultivated Plants, Institute for Strategies and Technology Assessment, Kleinmachnow, Germany.
Email of corresponding author: marlene.bittner@julius-kuehn.de

Climate change constitutes a major threat to the future of our planet. To be able to adapt to climate change and develop climate resilient cropping systems it is crucial to first assess climate change impact on crop production. With more and more studies published over the past two decades, increasing evidence is available regarding the potential impact of climate-related changes on agricultural productivity. However, there is a lack of an integrated assessment of the current state of knowledge regarding climate change impact on crop yields in 2050 in Germany. Therefore, this study aims to summarize and analyse all relevant literature that project yields of winter wheat and silage maize in Germany in the mid-21st century conducting a meta-analysis.

Twenty peer-reviewed papers and reports were selected following a systematic literature review. Available data were extracted from all studies covering change in yield, temperature, precipitation and CO2 level, as well as information on the study location, modelling approach and considered climate scenario. In total 328 and 478 data points on yield change available for maize and wheat, respectively. Descriptive analysis was used to display relative yield changes according to crop, region, modelling approach and whether or not CO2 effects were included. Furthermore, a local linear quantile regression model and linear mixed effects model were conducted to describe the relationship between relative yield changes and changes in mean temperature, mean precipitation, and CO2 level and to determine and quantify the effect of the three climate variables on yield change.

The descriptive analysis shows that the vast majority of projected changes in average yields in 2050 vary from -10% to +10% for both crops, while wheat yields tend to increase and maize yields tend to slightly decrease. Moreover, maize is projected to experience mostly negative mean yield changes in eastern and southern Germany. Also statistical models project merely negative yield developments for maize. On the other side, yield increases are projected all-over Germany for wheat. Quantile regression revealed more distinct relations of CO2-, temperature- and precipitation-change on future yields in wheat compared to maize. The linear mixed-effects model confirmed these results with regard to precipitation showing a strong positive relation with wheat yields but a rather indistinct effect on maize yields. Accordingly, no effect was found for temperature change on maize yields, but an exponentially negative effect on wheat yields, i.e., slight temperature increase acted positive, while an increase >2°C acted negative on future yields. An increase in CO2 level excerpts positive effects on yields for both crops, with the increase more prominent for wheat than for maize.