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The fundament of food, crop protein production, is threatened by climate change

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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

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Income growth, urbanization, and changes in lifestyles and food preferences combined with continuing population growth lead to increasing demand for plant protein production worldwide. All the proteins we eat are produced by crops, including the proteins we get from animals, which initially come from crops through animal feed.

In-season weather variation and changing long-term averages threaten crop growth and the final harvestable crop protein. Crops cannot seek shelter for strong wind or shade when it is hot. As the climate is expected to be more unpredictable and warmer, protein production is endangered. Estimating the consequences of projected future climate conditions on the production of crop protein is therefore crucial in order to evaluate if and how we can feed the growing world population. We have, in Ingvordsen *et al*. 2016, investigated how elevated temperature and atmospheric carbon dioxide (CO_2) affect the protein production of 108 different varieties of barleys. The varieties were a mix of barley types stored in genebanks (known as landraces) and barley types grown by farmers from the 1960s and up until 2015.

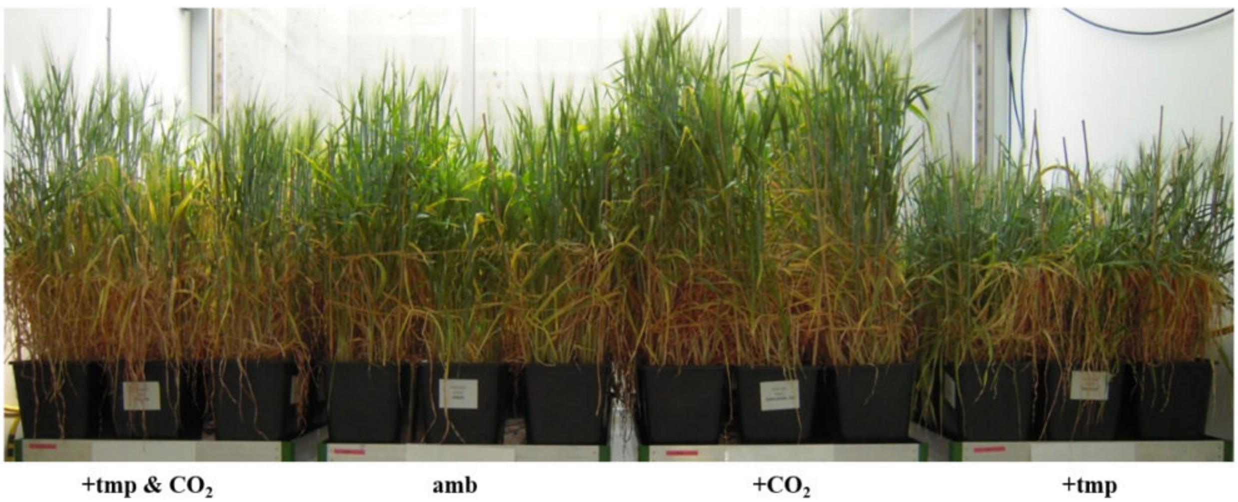

Fig. 1. The visual effect of the climate treatments on barley varieties. Treatments from left to right are the combination of elevated temperature and CO2 (+tmp & CO2) with 24/17°C, day/night and 700ppm; ambient treatment (amb) mimicking the Nordic climate of today with 19/12°C (day/night) and CO2 at 385ppm; elevated carbon dioxide (+CO2) with 700ppm; and elevated temperature (+tmp) with 24/17°C, day/night.

The 108 barley varieties were grown in chambers, where we manipulated the levels of temperature and CO_2 as single factors and in combination corresponding to the projected levels of these factors in Southern Scandinavia in 2075 (IPCC 2013). We harvested the crops at maturity and measured the grain protein. Initial indications were positive: elevated temperature increased the percentage of protein in the grain and the concentration was higher in the future scenario with elevated temperature and CO_2 than in the climate of today. However, when we included the effect of temperature and CO_2 on the amount of grain harvested, a decrease in harvested grain protein was found. Our data overall predict that in the projected future climate of 2075, we will harvest 23% less grain protein. This is alarming news as the world demand for grain protein increases.

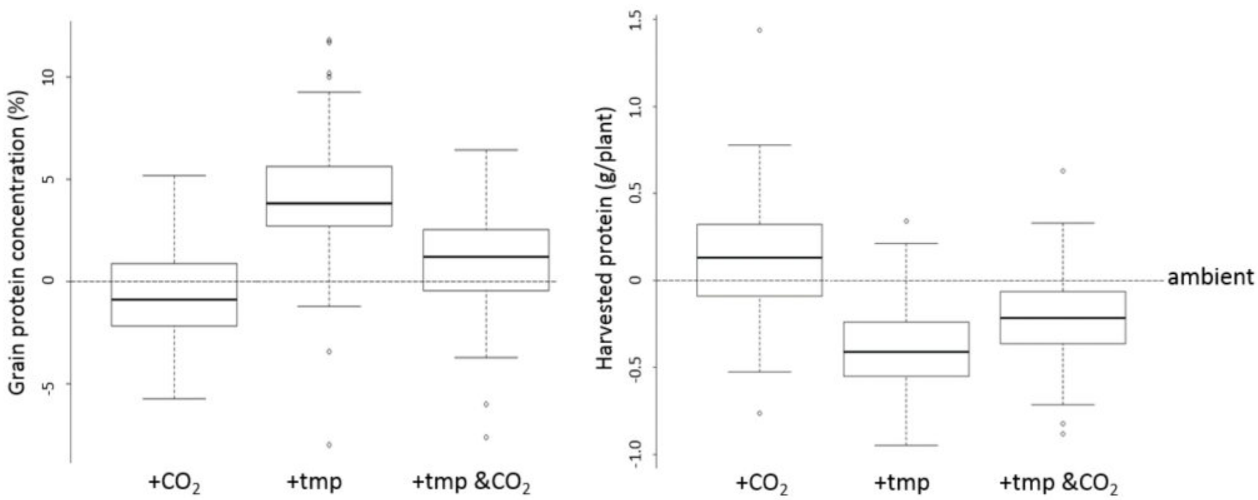

Fig. 2. Boxplots showing the average (thick line) of grain protein concentration (left) and harvested protein (right) from data of all 108 barley varieties compared to performance in ambient conditions (dotted line). Ambient treatment: 19/12°C (day/night) and CO2 at 385ppm; +CO2: 700ppm (+315ppm); +tmp: 24/17°C (day/night); and +tmp & CO2: the combination of +5° and +315 ppm. The upper and lower whisker (or) shows the variation within the 108 barley varieties, circles outside are outlier barley varieties, the best of which can be used in plant breeding programs to develop barley varieties with high harvested protein under projected future climate conditions.

Even though the data overall predict a 23% decrease in harvestable grain protein, there were a few barley varieties that maintained or increased their grain protein and grain yield, as can be seen on the boxplot. In our study a modern Danish barley named Jacinta and two old barleys from the genebank named Kushteki and Moscou were the ones with highest grain protein production under elevated temperature and CO_2. These three barleys can be cultivated to achieve high grain protein production, and their genes leading to high protein can be transferred to new barley varieties in plant breeding programs, where varieties with different advantageous responses to the environment are crossed to combine these good characteristics in an even better barley variety.

The results of the present study were shared with plant breeding companies shortly after identification, where they should be used to secure our future production of grain protein to meet our growing demand.

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Publication

Grain protein concentration and harvestable protein under future climate conditions. A study of 108 spring barley accessions.
Ingvordsen CH, Gislum R, Jørgensen JR, Mikkelsen TN, Stockmarr A, Jørgensen RB.
J Exp Bot. 2016 Apr