Introduction

Global climate change leads to more variable and extreme weather conditions that decrease total agricultural production of staple food crops. To cope with less predictable growth conditions under temperate climate conditions during spring and summer, an earlier time point of drilling may be chosen. Cereal plants tiller before winter, and due to an established crown root system the tillers are more resistant against temporary drought stress in spring. After the winter period, however, tillering continues in particular with nitrogen fertilization in spring, even though tiller number might already be sufficient for optimum yield. Thus, there is a need to uncouple tillering from nitrogen supply.

Methodological approach

To investigate the physiological effect of different N forms on tillering, spring barley was cultured in buffered nutrient solution supplied with stabilized nitrogen forms. Plants were harvested at the end of the vegetative growth phase and analysed for biomass, tiller number, concentrations of mineral nutrients and cytokinins. To investigate the effect of nitrogen forms on cytokinin translocation, endogenous cytokinins were determined in xylem exudates or benzyladenine riboside was supplied to the nutrient solution and measured in xylem exudates. Cytokinins were determined by radio immuno assays using specific antibodies.

For field trials winter wheat was fertilized with stabilized nitrogen forms in the starter dressing and analysed at the end of the vegetation period for nitrogen levels, phytohormone levels and yield components.

Results

In hydroponically-grown spring barley, tiller number increased with the amount of nitrate being applied, while urea and ammonium reduced tiller numbers. The influence of N forms on tillering was neither associated with nutrient disorders nor with ammonium or urea toxicity. Instead, we observed that cytokinin translocation rates in the xylem were oppositely affected by nitrate versus ammonium or urea nutrition. External supply of cytokinins was only effective in the presence of nitrate. Supplying the cytokinin analog benzyladenine riboside to the nutrient solution and its detection in the xylem sap allowed assigning opposite effects of these nitrogen forms on cytokinin translocation rates from roots to shoots.

Field trials with winter wheat allowed reproducing the stimulating effect of nitrate on tillering, while tiller numbers were significantly decreased after ammonium or urea supply. In dependence of the seasonal variation from one year to another, this led to higher grain yield especially when water was a limiting factor during maturity and an alteration in yield components.

Conclusion

Our investigations show that the signalling effect of different nitrogen forms in starter dressings can be employed to improve tiller number and yield components in wheat and barley.