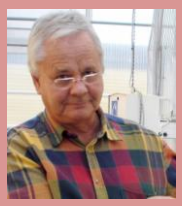

Studies of waterlogging tolerance in Nordic barley cultivars (Hordeum vulgare, L.) using chlorophyll fluorescence on hydroponically grown plants

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Background

Barley (*Hordeum vulgare* L.) is susceptible to waterlogging and reduce grain yield with 20% or more depending of growth stage and length of stress period. Since higher precipitation is expected in certain areas as a result of climate changes more tolerant cultivars are needed. An obstacle is, however, that there is currently no efficient screening method. In this project such a method has been developed based on leaf chlorophyll fluorescence of plants grown in oxygen depleted hydroponics. In the hydroponics many cultivars or plants can be grown and easily screened for waterlogging tolerance by its fluorescence value. The usefulness of the method was evaluated by screening possible sources of waterlogging tolerance in the Nordic barley gene pool.

Material

For the development of the method a reference material of 12 cultivars with partly known waterlogging tolerance from earlier waterlogging studies were used. The final method was then used to study waterlogging tolerance of historical and newer cultivars released in the Nordic countries.

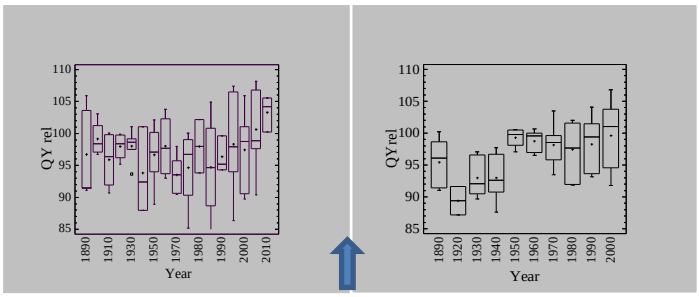
Methods

The shoot growth reduction after 18 days with waterlogging (the stress started after 12 days from sowing) were used as an index for the waterlogging tolerance of the reference material. This index was than used to optimize the protocol for growing plants in hydroponics with and without aeration (conditions of waterlogging) and for the leaf chlorophyll fluorescence measurements. In the final methods the plants were grown for 10 days with aerated nutrient solution and then stressed by ending the aeration for 4 days. When measuring quantum yield (QY) (QY = (M-F)/M, where F is fluorescence yield at ambient light and M is maximum fluorescence yield during a saturation light pulse), the cultivars were arranged in randomized blocks with 8 plants and 4 replication. Twelve cultivars, with Henni as an internal check, were studied in each container.

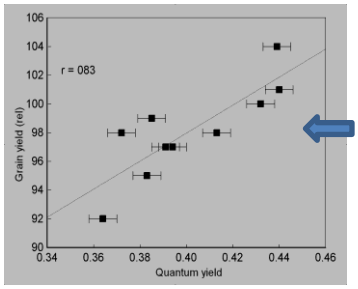
Results

Henni tolerant (left) and Cecilia sensitive (right)

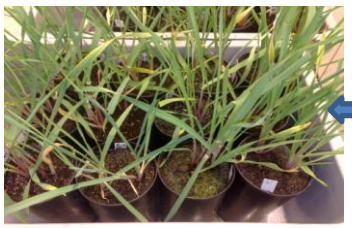
Both root and shoot growth are affected by the low oxygen concentration in the hydroponic system. Seminal root length of stressed plants showed similar correlation with the waterlogging tolerance index as QY. (r=0.82*, df 10), but QY is faster and more easy to use and was therefore selected.**



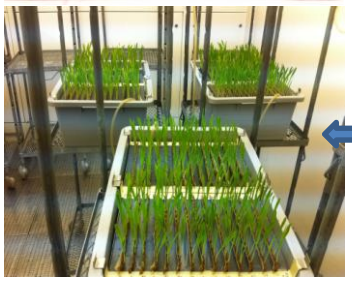
Changes in QY (Henní=100) of cultivars released during a century of barley breeding in Sweden and Denmark (left) and Norway and Finland (right). There is a tendency of increasing QY and hence waterlogging tolerance in cultivars released during the last 30 years



Both OY and the waterlogging index were correlated to grain yield in trials in the official yield testing trials in Sweden. Hence, there are no yield penalties if high waterlogging tolerance is breed for. On the contrarily, there has been an unintended adaptation to a wetter climate (r=0.83 **, df=8).



A waterlogging index of the reference material was calculated as the biomass growth with and without waterlogging x 100 of pot grown plants. This index was used to optimize the hydroponic method for screening of waterlogging tolerance



The plants were grown in a hydroponic system in strips of corrugated papers suspended in frames in 25 liter containers filled with a balanced phosphate-buffered nutrient solution. During the first 10 days the solution was aerated and renewed once. After that followed a stress period of 4 days without aeration.

It is important to measure QY under controlled conditions and at a light intensity above ambient (378±20 µmol $m^{-2}s^{-1}$). The leaves should also be adapted to the ambient light by detaching and lying them with the upper side facing the light source. With this procedure QY was correlated with the waterlogging index (r=0.82*, df=10). The best result was obtained if 24 leaves were measured per cultivar.**

Conclusions

Screening of waterlogging tolerance can be done by measuring leaf chlorophyll fluorescence of plants stressed in oxygen depleted hydroponic systems. It is a method with high capacity for screening cultivars, fixed lines and selection in segregating populations. A study of cultivars released in the Nordic countries revealed large variations and a tendency towards more tolerant cultivars, indicating that adaptation to waterlogging has inadvertently been improved over the past 30-40 years with introduction of new cultivars.

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References

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