INVESTIGATION OF BARLEY GENOTYPES FROM THE DOUBLE HAPLOID POPULATION UNDER DIFFERENT NITROGEN SUPPLY

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Abstract: The main goal of our research was to investigate some physiological parameters of barley genotypes under optimal and a quarter amount of nitrogen contents. Nitrogen fertilization even is a powerful tool in increasing grain yield in cereals. Agrarians have to optimize the application of nitrogen fertilizers to avoid pollution by nitrates parallel with preserving their economic margin. The price of nitrogen fertilizer is getting continuously growing. Hence, the supply of nitrogen is crucial for plant growth and development. The role of nitrogen in plant production is closely connected with photosynthesis. The main participators of photosynthesis are contains large amount of nitrogen, such as rubisco and chlorophylls. Several researches focused on investigating mainly the intensity and products of dark reaction of the photosynthetic pathway, but we no have sufficient information about light reaction affected by genotypic and nitrogen supply variations. Chlorophyll fluorescence induction method was used to examine potential photochemical activity (Fv/Fm) and other parameters of fast and slow phase of chlorophyll fluorescence induction curve. During our experiments relative chlorophyll content measurement was applied to follow the total chlorophyll contents of genotypes. The measured parameters help choosing efficient barley genotypes of the double-haploid population to breed more productive barley lines under lower but sufficient nitrogen supply.

Keywords: nitrogen, barley, chlorophyll, chlorophyll fluorescence

Introduction

Nitrogen is one of the most expensive nutrients to supply to crops, and chemical fertilizers represent the major cost in plant production. Insufficient application causes reduction in plant production mainly because results in smaller leaf area and lower leaf photosynthesis, chlorophyll content and biomass production (Zhao and Oosterhuis, 2000). Excessive use of N fertilizer increases not only production cost but also environmental pollution (Jaynes et al., 2001). To maintain sustainable agriculture together with growing food demand represents an outstanding challenge for the mankind. Hence, lowering of chemical fertilizer input and breeding plants with better nitrogen use efficiency is one of the main goals of research on plant nutrition. Several improved methods have been proposed for non-destructive estimation of plant nutrition, including leaf colour charts, chlorophyll meter, reflectance spectra, and chlorophyll fluorescence (Shukla et al., 2004, Huang et al., 2008, Nguyen and Lee, 2006). Since nitrogen is an essential part of the chlorophyll molecule any lack of it in the nutrient supply of the plant should result in a supression of chlorophyll formation. Chlorophyll meter equipments such as Soil-Plant Analyses Development (SPAD, Minolta, Japan) are designed to determine chlorophyll concentration of leaves, and have become a popular method for estimating leaf relative chlorophyll contents (Netto et al., 2005) and amount of N (Huang et al., 2008). Measurement of the chlorophyll a fluorescence is a quick, precise and non-destructive technique, widely used in investigating the efficiency of photosynthetic system by various types of stresses (Govindjee, 1995). The main goal of this research was to investigate 7 barley genotypes to identify their photosynthetic activity under two levels of nitrogen supply. To select for barley from a double haploid population having strong photosynthetic activity under lower nitrogen supply give substantial results for plant breeder.

Materials and methods

The plant material used in the experiment was 7 genotypes from the double haploid population, which have been originated from the different part of the world. Genotypes were connected to the project "Improved Nitrogen Use Efficiency in Wheat and Barley" founded by Grain Research and Development Corporation, project leader is Professor Zed Rengel. Barley genotypes were grown from a double haploid population in a glasshouse at the University of Western Australia, Perth, Australia. The soil was originated from Katanning (WA). This soil is low in essential nutrients. Investigated cultivars were grown under optimal nitrogen content and a quarter of it. The actual amount of dry matter in the case of shoot and root were determined by thermal-gravimetric analysis. Chlorophyll meter (SPAD-502, Minolta, Japan) was used to measure relative chlorophyll contents. 5 readings were taken along the middle section of the leaf, and mean was used for analysis (SPAD units). The parameters of *in vivo* chlorophyll fluorescence were detected with a PAM 2000 (Walz, Germany) modulated light fluorometer as described by Schreiber *et al*. (1986). The number of repetition was 3. The measurements were taken in anthesis phase (GS 69, according to the Zadoks scale). All the physiological measurements were taken on the last fully developed leaves. The results were analyzed by Microsoft Excel 2003 and SigmaPlot for Windows 8.02.

Results and discussion

It is widely accepted that improved information on the factors controlling the acquisition and utilization of N by crops will help to identify the constraints to developing more effective strategies of N fertilization. Nitrogen nutrition has significant effects on root and shoot relations (Lioert et al., 1999). Nitrogen deficiency increased root surface area, increased consumption of assimilates, reduced the amount of nitrogen transported to shoot, decreased shoot growth, and resulted in an increased R/S ratio. As Table 1 shows, dry weight of seven barley genotypes were compared under two different nitrogen supply conditions.

Table 1 Dry weight (g $shoot^{-1}$) of different barley (AC METCALFE, ALEXIS, BAUDIN, BULOKE, DHOW, SLOOP, VALMINGH) genotypes' shoots under altering nitrogen conditions (optimal nitrogen supply (opt N) and quarter of it (¼ N)) at growth stage of anthesis. n=4 ±s.e. $p<0.05$*, $p<0.01$**

	AC METCALFE	ALEXIS	BAUDIN	BULOKE	DHOW	SLOOP	VALMINGH
opt N	4.839 ±0.51	4.977 ±1.08	2.941 ±0.55	2.143 ±0.15	2.750 ±0.16	2.737 ±0.33	5.892 ±0.09
¼ N	2.007	2.169	2.071	2.986	2.112	2.169	3.454

	±0.20 **	±0.15*	±0.18	±0.37	±0.24	±0.19	±0.49**

Three of the investigated genotypes – AC METCALFE, ALEXIS, VALMINGH – have larger amount of shoot dry weight, than the others. In these cases the lower nitrogen supply application caused significantly lower dry weight of shoots. In four genotypes – BAUDIN, BULOKE, DHOW, SLOOP – no differences were found between optimal and lower nitrogen supply treatments.

Table 2 Relative chlorophyll content (Spad index) of different barley (AC METCALFE, ALEXIS, BAUDIN, BULOKE, DHOW, SLOOP, VALMINGH) genotypes under altering nitrogen conditions (optimal nitrogen supply (opt N) and quarter of it (¼ N)) at growth stage of anthesis. n=5 ±s.e. p<0.01**, p<0.001***

	AC METCALFE	ALEXIS	BAUDIN	BULOKE	DHOW	SLOOP	VALMINGH
opt N	52.3 ±1.3	53.0 ±0.74	62.0 ±1.1	49.4 ±0.8	54.9 ±1.5	60.0 ±0.3	52.4 ±0.6
¼ N	35.1 ±1.0***	40.9 ±1.22***	47.4 ±0.6***	44.9 ±0.8**	45.2 ±0.9***	46.6 ±0.7***	40.5 ±1.6***

Lower amount of nitrogen supply resulted in lower relative chlorophyll (generally about 23% less) contents with genetically alternation (Table 2). In the case of genotype BULOKE only 10 % less Spad index was determined under quarter amount of nitrogen, than under optimal nitrogen nutrition.

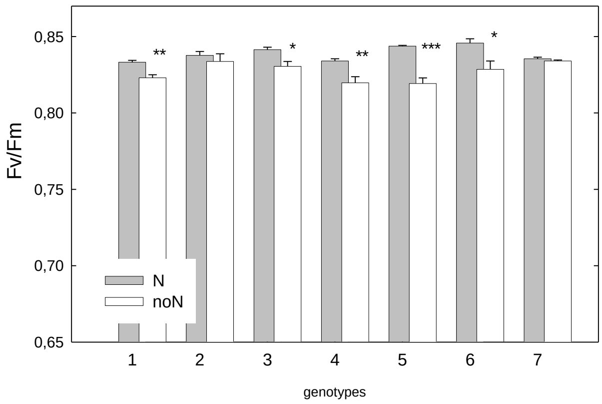

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Figure 1 shows the results of optimal photochemical activity (Fv/Fm) of seven barley genotype measured early in the morning. The 0.83 is the approximate optimal value for most plant species, lowered values – under 0.79 – indicating plant stress. The measurements were taken in a glasshouse at early morning, when the temperature and the light intensity were relative low, which did not mean stress for plants. Under these conditions the lower nitrogen supply did not cause stress for genotypes. Moreover, some genotypes, like VALMINGH was able to maintain similar potential activity under the two different nitrogen treatment.

Conclusions

It is widely accepted that improved information on the factors controlling the acquisition and utilization of N by crops will help to identify the constraints to developing more effective strategies of N fertilization. These in turn could increase the efficiency of N use to the benefit of the environment. Genotypes of double haploid population, which are able to produce similar dry weight and similar optimal photochemical activity under lower nitrogen supply, than optimal one, are a good basis of plant breeding program.

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