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# ROLE OF METABOLIC EVENTS INDUCED BY WATER STRESS IN BARLEY (HORDEUM VULGARE L.)YIELD CONSERVATION

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***Summary***

This paper evaluates sensitiveness of selected physiological characteristics in screening barley genotypes for their tolerance to drought. the plants were cultivated in pots in natural climatic conditions up to the growth stage of anthesis and then exposed to slow dehydration to evoke metabolic changes resulting in leaf turgor and growth maintenance and finally in yield conservation. During slow plant dehydration the osmotic potential of mature leaves and free proline accumulation were measured and final yield components were analysed. The results give information related to the role of tissue osmotic adjustment in water conservation during period of drought that might be essential for higher yielding in tolerant compared to sensitive genotypes. The detailed analysis of ear structure is also presented and relationship between the physiological and production criteria is discussed which could be useful in screening biological material tolerant to drought.

***Key words:*** drought tolerance, osmotic adjustment, free proline content, barley, productivity

## *Introduction*

Grain yield of small-kernel cereals is a complex trait which is influenced by a range of physiological mechanisms and is characterized by low heritability especially in conditions of water stress. Efficiency of selection for this trait my be increased by indirect selection for morphophysiological traits related to yield which are highly heritable, positively associated with yield, and quickly and easily measured (Blum, Zhang, Nguyen 1999).
According to Gunasekera et al. (1994) wild genotypes of barley which had a greater response to water stress also had a greater osmotic adjustment capacity under water stress and came from areas with low water availability. The major yield benefits derived from tissue osmotic adjustment in different crop species under drought predominantly lie in the maintenance of proper water supply from sub-soil during reproductive phase of growth, cooler canopy and growth processes (Gonzales, Martin, Ayerbe 1999) those generally producing higher dry matter and seed yield.

As stated by Morgan (1992), carbon seems to be a significant component of effective osmotic adjustment which means that OA may be considered as a competitive sink for assimilates comparing to other sinks. Therefore, carbon allocation for osmotic adjustment is to a large extent a function of whole plant response to drought stress and the balance between carbon assimilation, allocation to and utilization by various sinks. On the other hand, OA which depends on accumulation of ions or specific metabolites (glycinbetaine, proline, etc.) might be relatively independent of whole plant growth interactions, thus a correlation of this characteristic with a higher yield could be found (Cantero-Martinez et al. 1995, Olšovská et al. 2000).
The objective of this work was to study adaptive responses of plants to drought by means of metabolic changes in cells leading to changes in ear structure and final plant productivity.

## *Material and methods*

The three ecologically distant genotypes of barley (Hordeum vulgare L.), such as Kompakt (Slovakia), Dobla and Albacette (Spain) were cultivated in natural climatic conditions in 25 l plastic pots with loam soil substrate supplemented by mineral nutrients up to the level of 1:0,88:2,01 (N:P:K). The pots (40 plants per one pot) were placed to simulate a compact canopy. Additional pots eliminated the marginal effect of canopy. The plants were watered regularly to maintain the 70 % of total available water. At the end of anthesis the pots were hydrated to maximal level 100% and from this moment the plants were subjected to 9-day dehydration by withholding water.
During a long-term dehydration we measured water ($\Psi_w$) and osmotic ($\Psi_S$) potentials in MPa by psychrometer Wescor (Wescor, Logan, Utah, USA) and relative water content RWC (from fresh, saturated and dry mass weights) of the same leaves. After harvesting the main yield components as well as detailed characteristics of ears were analysed.

## *Results and discussion*

Adaptation to drought appears to be a result of numerous anatomical, morphological, physiological, and biochemical characteristics, constituent or inducible, which interact in order to make possible the keeping of growing and development processes.
While plants loss their water gradually, a positive turgor is important to maintain mechanical properties of tissues, leaf growth and cell metabolic activity. When plant tissue water potential decreases, a change in osmotic potential may be essential to maintain turgor pressure at a water potential that would otherwise result in turgor loss. This situation occurs frequently during the vegetation season (mainly during slow changes of water availability), but also over a diurnal period (Brestič, Olšovská, unpublished). According to our results cv. Dobla of Spanish provenience kept its leaf water potential and turgor higher for the first 5 days of water stress while osmotic potential was decreased to the largest extent comparing to cvs. Kompakt and

Albacette. Figure 1 shows that this decrease in Ψs was caused mainly by free proline accumulation for all the period of water stress which acted as an osmoprotectant adjusting water relations in cells and balancing concentration state of cytoplasm and vacuol (Nanjo, Kobayashi 1999). Tissue metabolic adjustment was related to final yield and was found to have a positive effect on average grain weight per 1 ear in stressed comparing to control plants. Cv. Dobla attained the highest stress index (SI) calculated as a ratio of average grain weight in stressed to control plants, however the final grain yield of Dobla did not exceed the yield of productive cv. Kompakt (tab. 1). Also the ear structure was determinated differently in studied cultivars indicating a higher production potential of Kompakt which compensated for a negative effect of water stress via stem reserves mobilisation and accumulation into the central ear modul and on the other hand, indicating a higher stress index in cv. Dobla representing yield stability.
According to Arraudeau (1989) yield potential and yield stability of barley are largely independent of each other, so this traits can be manipulated independently in a breeding program. As seen from our results, cultivars with high yield potential under optimal water supply can be converted into a drought tolerant one by selective incorporation of drought resistant factors such as better osmotic adjustment, accumulation of different compounds, earliness, etc. But the opposite is also possible, and a drought tolerant line can be improved for its yield potential by selective incorporation of yield factors.

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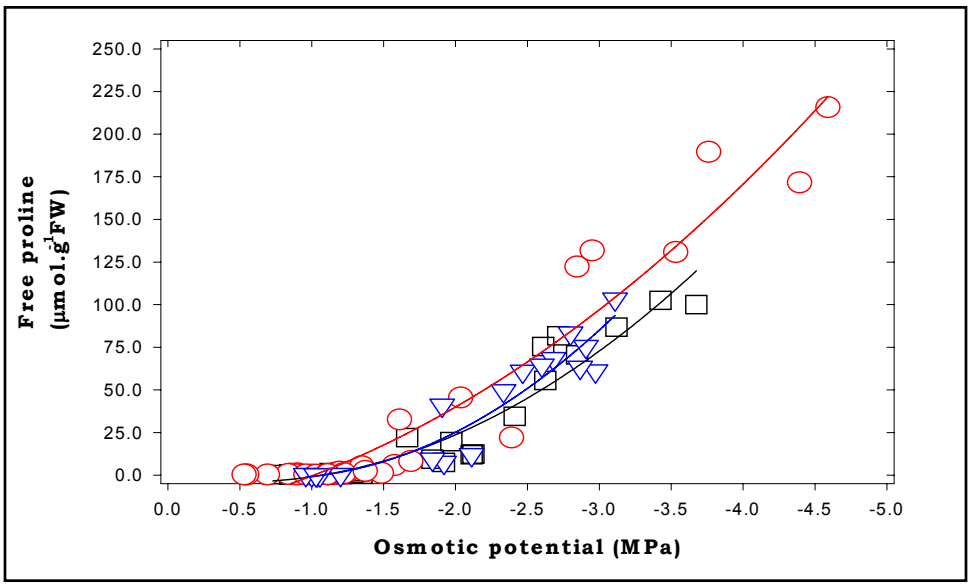


Figure 1: Nonlinear relationship between decreasing leaf osmotic potential and free proline accumulation during period of slow plant dehydration (circle – Dobla, square – Kompakt, rhombus – Albacette)

Tab. 1: Yield parameters from final yield analysis after applied water stress (K – watered plants, S – stressed plants, HS – main stem, ODN – tillers, SI – stress index)

| Cultivar | Var. | Part of a plant | Grain number in aver. ear | | % reduced grain number | Grain weight in an aver. ear in (mg) | SI %) |
|---|---|---|---|---|---|---|---|
| | | | forming | reduced | | | |
| Kompakt | K | HS | 20,12 | 4,18 | 17,19 | 802,2 | - |
| | | ODN | 17,06 | 7,94 | 31,76 | 644,8 | - |
| | S | HS | 17,64 | 3,33 | 15,87 | 600,2 | 0,748 |
| | | ODN | 13,47 | 6,9 | 33,87 | 329 | 0,51 |
| Dobla | K | HS | 18,48 | 12,92 | 41,14 | 239,8 | - |
| | | ODN | 27,83 | 29,75 | 51,66 | 188,1 | - |
| | S | HS | 14,77 | 15,08 | 50,51 | 196,9 | 0,821 |
| | | ODN | 11,75 | 17,46 | 59,77 | 123,2 | 0,625 |
| Albacette | K | HS | 11,66 | 4,23 | 26,62 | 159,9 | - |
| | | ODN | 10,32 | 7,36 | 41,62 | 77 | - |
| | S | HS | 3,8 | 29,8 | 88,69 | 37,4 | 0.232 |
| | | ODN | - | - | - | - | - |

## THE INFLUENCE OF THE WEED INFESTATION AND COMPETITION UPON THE WINTER WHEAT YIELD IN RELATION TO DIFFERENT FERTILIZER LEVEL

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***Summary***

Weed infestation is one of the negative factors, which influences a success of crop production in our agriculture. As regards to diversity and flexibility factors, a determination of weed harmfulness is very difficult.
The weed infestation and competition was observed in winter wheat field trials at 5 different fertilizer levels at the Research Station in Vysoka nad Uhom, the Eastern Slovakia, in 1995-1997. The alluvial soil type and arid condition are typical for crop production in this area in the East-Slovakian Lowland. There were used the winter wheat variety HANA and its seedrate 5 million germinating grains per hectare were used. The weed infestation was observed before the stand harvest and the 9 points EWRS Scale was used.
As far as the decrease of fertilizer level is concerned, an average of weed infestation and weed range were going up. The weed density caused the unfavourable decrease of competition and its grain yield. The middle and strong negative correlation, respectively (r = -0,60), is typical between the winter wheat yield and weed density on this crop stand. The variability of weed infestation influenced in average more than 40 % of crop variability in average. These dependences were statistically significant at the level from 1,2 - 1,3 %.

***Introduction***

The decrease of the yields at middle or strong weediness can achieve more than 30 %. The yields losses can achieve 90 % at the weediness (TYR, 1995).
The plant nutrition is the base of competition ability. It was conclude that the trend towards lower level of nitrogen fertilizer application concerning the environment will the favourable for most of the weed species and the composition of the weed populations (WILSON 1986, DAVIES 1987, KUDSK 1989, DYCK et al. 1995).
By BENADA and VANOVA (1985) it is necessery to be real, that relationships between harmful occurrence of weed and crops yields are considerably variable and depend on many factors. Therefore the expression of harmfulness can not be constant, but it must be a range of values, which is responsible for the changeability of actual factor.
The aim of this work is to document the intensity of late summer weed infestation on winter wheat stands in the dependence on intensity of nutrition after using of herbicide in the cropping. The quantification of the influence of weediness with interaction with the different nutrition levels on the yields of winter wheat is the next element.

***Materials and methods***

We solved the problems of the winter weediness in the stationary system of crop rotation. The field trial was established in the experiment working place of OVUA Michalovce in Vysoka nad Uhom on the alluvial soil in the conditions without irrigation, 107 m above sea-level. The locality is situated in the central part of East-Slovakian Slowland. A continental climate is characteristic for this region.