Variability in the Accumulation of Amino Acids and Glycinebetaine in Wheat and Barley under Environmental Stress

by

Bodapati Purushothama Naidu
B.Sc.Ag., M.Sc.Ag.(Agronomy) (APAU, India)

Department of Plant Physiology,
Waite Agricultural Research Institute,
The University of Adelaide,
South Australia

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SUMMARY

This investigation aimed to study (1) changes in amino acid and glycinebetaine content in response to the nature of stress imposition under laboratory conditions and (2) possible effects of environmental factors on variability in the content of proline and glycinebetaine in barley and wheat seedlings. Proline, asparagine, glutamine, glycine, valine, γ-amino butyric acid, and glycinebetaine accumulated in response to a reduction in leaf water status whereas glutamic acid, aspartic acid, and alanine levels declined; the overall effect was a net increase in amino acid content. However, the concentrations of accumulated amino acids varied markedly with the nature and rapidity of water stress. A rapid water stress imposed by withholding water or by PEG application at normal or high temperature resulted in the accumulation of amides to a level comparable to or more than that of proline. Progressive water stress resulted in the accumulation of proline and glycinebetaine while other amino acids accumulated to a lesser extent. The relief of a moderate water stress resulted in complete disappearance of the accumulated proline within 1 day. Most stress-induced metabolic changes returned to normal upon water stress relief with some exceptions, such as the metabolism of the accumulated glycinebetaine. Changes in metabolism induced by low temperature were independent of changes in RWC, Ψ, and Ψp, but resembled those induced by water stress except for the accumulation of aspartic acid and alanine.

Barley seedlings with different temperature histories showed different abilities to accumulate proline and glycinebetaine during subsequent water stress at a common temperature (20°C). The investigation to find the cause for this response revealed that both compounds respond to low temperature whereas glycinebetaine alone responded to high temperature in the absence of changes in leaf water status. The critical temperature required for the accumulation of glycinebetaine fell between 25 and 30°C. The rate of increase in glycinebetaine content was more than that for proline content with increase in temperature during water stress.
Wheat seedlings from two cultivars grown from seed matured at cooler temperatures generally accumulated more solute than seedlings grown from seed matured at a warmer temperature. Seed size also varied with parent temperature, and elimination of seed size differences by selection of similar size ranges eliminated the previously observed differences in proline content. The glycinobetaine content of the two wheat cultivars showed a residual effect of parent temperature, however. The proline and glycinobetaine content of 3 barley cultivars also varied with parent seed size. Excelsior seedlings grown from small seed accumulated more proline than Proctor grown from seeds of the same size but the opposite was true when the cultivars were grown from large seed. The glycinobetaine content of these cultivars showed no reversal in response with seed size.

Water stressed seedlings grown from two seed sources of barley cultivar Norbert, obtained directly from Canada (CN) or grown for two generations and subjected to selection pressure in Australia (AN*) showed differences in the ability to accumulate proline, but not glycinobetaine. This difference in response was the result of genetic differences due to selection pressure, in the absence of such selection no differences in proline content were found between the two seed sources.

A high VPD during seedling growth or water stress resulted in the accumulation of more proline and glycinobetaine. These effects of VPD during plant growth were independent of changes in leaf water status, an effect similar to 'hardening', but the effect of VPD during water stress may have been a result of the rate of water loss. Four barley cultivars grown at a high or low VPD and subsequently water stressed at a common VPD regime had different abilities to accumulate proline and glycinobetaine, such that the proline accumulating capacities of Excelsior and Proctor were in the reverse order in the two VPD regimes.

These results demonstrated the effects of experimental conditions on the metabolism of amino acids and glycinobetaine and offer an explanation for the conflicting responses of the two barley cultivars, Excelsior and Proctor, to proline accumulation when studied by two different groups (Singh et al., 1972; Hanson et al., 1977).