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HYBRID SORREL (*RUMEX TIANSCHANICUS* × *RUMEX PATIENTIA*) A HIGH BIOMASS YIELDING PLANT AS AN INTERESTING OBJECT OF PHYSIOLOGICAL RESEARCH

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Rumex tianschanicus × *R. patientia* is a cross between English spinach (*R. patientia* L.) as a female line and Tien Shan sorrel (*R. tianschanicus* A. Los.) as a male line (Usťak & Usťaková 2004; Havlíčková & Suchý 2010). This hybrid significantly exceeds both the original plants and many traditional feed crops in terms of the quality of feed production and yields of above-ground biomass and seeds. Long-term trials confirmed that the hybrid sorrel is one of the perennial energetic crops with the most potential, suitable for fuel biomass cultivation as a renewable source of energy in European temperate-climate conditions (Usťak & Usťaková 2004). Moreover, *R. tianschanicus* × *R. patientia* can be used for biogas production and also for manufacturing pellets and briquettes (Myšková *et al.* 2011).

Renewable energy sources continue to play an important role in the energy policies of the developed countries (Havlíčková & Suchý 2010). New biotechnological approach showed that energetic plants have also significant application for environment friendly management, mainly in phytoremediation technology. Phytoremediation was presented as a cleanup technology belonging to the cost-effective and environment-friendly biotechnology (Masarovičová *et al.* 2009). According to Zhuang *et al.* (2005), *R. tianschanicus* × *R. patientia* have been proved to be heavy metal tolerant and have potential in phytoremediation of soils contaminated by multiple heavy metals.

The chemical composition of the hybrid dock was examined by Omarova *et al.* (1998). They showed the presence of a high level of biologically active substances e.g.: carotenoids (provitamin A), ascorbic acid (vitamin C), linoleic and linolenic acids (vitamin F), and flavonoids (vitamin P). The hybrid may be of interest not only as a fodder plant, but also as a valuable medicinal raw material.

R. tianschanicus × *R. patientia* is a plant with high ecological plasticity, cold and winter hardiness, and tolerance to salt-stress and increased humidity. Under the conditions of short-term heat stress it has been observed a 2-fold increase of protein content in sorrel seedlings. A short-term cold stress also caused substantial increase in protein content in other plant tissues. Protein synthesis in stress tolerance appears to be considerably more sensitive to temperature stresses, than in ruderals. This may be due to the activation of a stress response mechanism, which in turns upregulates protein synthesis. The effect of temperature stress on protein synthesis in *R. tianschanicus* × *R. patientia* seedlings was more dramatic if compare to another plant species (Kosakivska *et al.* 2008). Indeed, high-temperature stress caused *de novo* synthesis of a 71 kDa polypeptide, an increase in 44, 78 and 109 kDa proteins and the content of heat shock proteins (HSPs) in mitochondria and chloroplast was increased. The differences observed in protein synthesis pattern in hybrid sorrel suggest, that stress response proteins could be useful biomarkers of different ecological strategies, leading to plants acclimation in unfavourable environmental conditions (Kosakivska *et al.* 2008).

Moreover, the role of exogenous selenium (Se) on the growth, antioxidant enzymes activities, osmotic regulation, ultrastructural modifications of leaf mesophyll and root tip cells of NaCl-stressed hybrid sorrel seedlings were investigated by Kong *et al.* (2005). It was observed that treatment with 5 μM of Se positively promoted the integrity of membrane systems and cellular organelles, such as chloroplasts and mitochondria in leaf mesophyll and root tip cells. The obtained results suggest that an appropriate concentration of exogenous Se positively affects the antioxidant and osmoregulatory capacity, and enhance the salt-tolerance in sorrel seedlings (Kong *et al.* 2005).

Our studies concern mainly the histological, scanning electron microscopy (SEM) and cytometric analysis of *R. tianschanicus* × *R. patientia* micropropagated *in vitro* from hypocotyls cultured on media supplemented with BAP and IAA. Histological analysis revealed, that shoot buds arised directly from pericycle cells and also from regenerated leaves (secondary organogenesis), indicating direct organogenesis. SEM studies showed that callus cells were surrounded by a membranous-fibrillar structure, similar to the extracellular matrix (ECM).

Higher biomass production of *R. tianschanicus* × *R. patientia* in comparison to parental lines, suggests enhanced intensity of photosynthesis in hybrid form. Our present experiments focused on the comparison of the efficiency of photosynthetic electron transport in photosystem II (PSII) in *R. patientia* (female line), *R. tianschanicus* (male line) and a hybrid *R. tianschanicus* × *R. patientia* under *in vivo* and *in vitro* conditions.

PSII photochemistry was investigated by means of chlorophyll *a* fluorescence on leaves adapted to darkness for 20-30 min. PSII operating efficiency in the light adapted state (ΦPSII), electron transport rate through PSII (ETR(II)), quantum yield of non-regulated energy dissipation (Y(NO)) and non-photochemical quenching (NPQ) of PSII fluorescence were quantified (Genty *et al.* 1989; Kramer *et al.* 2004; Baker 2008). The results of our preliminary studies concerning chlorophyll *a* fluorescence parameters did not show any significant differences between sorrel hybrid and parental lines growing *in vivo*, indicating similar efficiency of PS II activity.

Significant differences in chlorophyll *a* fluorescence parameters were observed for regenerated hybrid sorrel plants growing *in vitro* before acclimatization, compare to plants acclimated to field conditions. The lower values of ΦPSII and ETR(II) for *in vitro* plants suggest inhibition of photochemical reactions and linear electron transport.

Comparison of selected photosynthetic parameters between growing *in vitro* regenerants and plants acclimated to *in vivo* conditions indicated that photochemical energy conversion and protective regulatory mechanisms are inefficient in plants from *in vitro* culture.

The obtained results suggest that PSII activity in hybrid sorrel plants strongly depends on growth conditions. Photosynthetic activity in regenerants cultured *in vitro* requires further more detailed studies.

References

Baker N.R. 2008. Chlorophyll fluorescence: a probe of photosynthesis *in vivo*. *Annu. Rev. Plant. Biol.* **59**: 89–113.

Genty B., Briantais J.-M., Baker N.R. 1989. The relationship between the quantum yield of photosynthetic electron transport and quenching of chlorophyll fluorescence. *Biochim. Biophys. Acta* **990**: 87–92.

Havlíčková K., Suchý J. 2010. Development model for energy crop plantations in the Czech Republic for the years 2008–2030. *Renew. Sustain. Energy Rev.* **14**: 1925–1936.

Kong L., Wang M., Bi D. 2005. Selenium modulates the activities of antioxidant enzymes, osmotic homeostasis and promotes the growth of sorrel seedlings under salt stress. *Plant Growth Regul.* **45**: 155–163.

Kosakivska D., Klymchuk V., Negretzky D., Bluma D., Ustinova A. 2008. Stress proteins and ultrastructural characteristics of leaf cells of plants with different types of ecological strategies. *Gen. Appl. Plant Physiol.* **34 (3-4)**: 405–418.

Kramer D.M., Johnson G., Kiirats O., Edwards G.E. 2004. New flux parameters for the determination of QA redox state and excitation fluxes. *Photosynth. Res.* **79**: 209–218.

Masarovičová E., Kráľová K., Peško M. 2009. Energetic plants – cost and benefit. *Ecol. Chem. Eng.* **16 (3)**: 263–276.

Myšková R., Obršálová I., Langášek P. 2011. Economic, environmental and social aspects of renewable energy using for small sources of heating. *WSEAS Trans. Envir. Devel.* **8 (7)**: 244–253.

Omarova M.A, Artamonova N.A., Chasovitina G.M. 1998. Chemical composition of the hybrid *Rumex* K-1. *Chem. Nat. Compd.* **34 (4)**: 426–428.

Usťak S., Usťaková M. 2004. Potential for agricultural biomass to produce bioenergy in the Czech Republic. In: Parris K. (ed.), Biomass and agriculture: sustainability, markets and policies: 229–239. OECD, France.

Zhuang P., Ye Z.H., Lan C.Y., Xie Z.W., Shu W.S. 2005. Chemically assisted phytoextraction of heavy metal contaminated soils using three plant species. *Plant Soil* **276**: 153–162.