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Relation between hypericin content and morphometric leaf parameters in *Hypericum* spp.: a case of cubic degree polynomial function

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Highlights

- Model for hypericin biosynthetic capacity in *Hypericum* spp. was designed.
- The hypericin accumulation capacity in the dark nodules relies on leaf characters.
- Five characters were included in calculation of leaf morphometric parameter (*M*).
- Relation between hypericin content and *M* is expressed by cubic-degree polynomial.

Key words
Hypericum, hypericin, plant biotechnology, secondary metabolite, cubic polynomial

Abstract

Higher plants often accumulate secondary metabolites in multicellular structures or in secretory reservoirs. Biotechnological production of such compounds by cell cultures lacking proper morphological structures is difficult, therefore possibilities for an efficient increase of their formation by organ cultures are being searched. The genus *Hypericum* comprises many species that store photoactive and phototoxic naphthodianthrones in the dark nodules on their above-ground parts. To date, the relation between the content of hypericins and their proto-forms accumulated in the nodules, and morphological characters of the plant parts containing these structures has not been sufficiently explained. The content of hypericins and leaf morphology characters were measured in 12 selected diploid seed-derived *Hypericum* species cultured *in vitro*. The leaf volume and the volume of the nodules per leaf were calculated. Based on these data, a cubic degree polynomial regression model with high reliability was constructed. The model enables an estimate of the biosynthetic capacity of the cultures, and may be useful in designing the experiments aimed at elicitation of these unique secondary metabolites in shoot cultures of *Hypericum* spp. An analogous model may be developed for interpretation of experimental results for other plant species which accumulate metabolites in specialized morphological structures.

1. Introduction

Over the past few decades, the *Hypericum* genus attracted a sustained attention due to the presence of valuable compounds, specifically naphthodianthrones ('hypericins' including hypericin and pseudohypericin), acylphloroglucinol derivatives (hyperforin, adhyperforin), flavonoid glycosides and biflavones, xanthones, essential oil components and others [1,2]. Consequently, the *Hypericum* genus, especially represented by *H. perforatum,* ranks among the top herbs on the Global Herbal Supplements and Remedies Market. In the *Hypericum* phytocomplex, the naphthodianthrones represent a unique class of bioactive secondary metabolites which are not present in any other plant genera. As recently reviewed by Jendželovská et al. [3], hypericin and pseudohypericin are known natural photosensitizers with a potential applicability in the photodynamic therapy and diagnosis of cancer cells. In plants, the undesirable autophototoxic damage of tissues is avoided by accumulation of hypericins in the specialized secretory structures known as 'dark nodules'. Even though the dark nodules have been associated with the presence of naphthodianthrones based on earlier anatomical and histochemical studies [4,5,6,7,8,9],