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Metabolomic analysis and effects of meteorological factors on phenolic and non-phenolic chemotypes of *Thymus pulegioides* L. cultured in the same locality

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ABSTRACT

The effects of meteorological factors on the amount of secondary metabolites of essential oils and their main compounds in different chemotypes of *Thymus pulegioides* L. cultured in the same locality were studied. Three individual plants of *T. pulegioides*, belonged to three different chemotypes – geraniol (G), linalool (L) and carvacrol (C), were vegetatively propagated and grown in an open ground under the same environmental conditions. The essential oils of chemotypes were isolated by hydrodistillation, the analyses of the main compounds of essential oils (geraniol, nerol, geranial, neral, linalool, carvacrol, *p*-cymene and γ-terpinene) were carried out by GC–FID and GC–MS annually. The highest variations of the amount of essential oils during the study period were detected in non-phenolic G and L chemotypes (CV = 23% and CV = 24%, respectively); the temperature and sunshine duration positively influenced the accumulation of the essential oils ($r = 0.90$, $p < 0.05$ and $r = 0.83$, $p < 0.05$, respectively). The C and L chemotypes were characterized as chemotypes with the most stable amounts of essential oils and the main compound linalool, respectively. The temperature and photosynthetically active solar radiation had significant influence on the yield of geraniol in G chemotype ($r = 0.89$, $p < 0.05$ and $r = -0.83$, $p < 0.05$, respectively). Higher temperature influenced the increase of the amount of *p*-cymene ($r = 0.94$, $p < 0.05$), however, none of the investigated meteorological factors significantly not influenced the amount of carvacrol in C chemotype. The results demonstrated that the meteorological factors differently influence the accumulation of essential oil and its main compounds not only in different essential oil bearing species, but also in different chemotypes of the same species.

1. Introduction

The raw material of essential oil bearing medicinal and aromatic plants of the genus *Thymus* (Lamiaceae) is used in food industry as species and natural antioxidants, in pharmaceutical industry for manufacturing of pharmaceuticals, in perfume and cosmetic industry as aromatizers. For high commercial request, the plants of this genus are not only collected from natural habitats, but also are cultured.

Two groups of chemotypes are distinguished in the species of the genus *Thymus*—phenolic (thymol and carvacrol) and non-phenolic (mostly geraniol and linalool)—characterized and named according to a dominant compound in the essential oil. These compounds are used in different branches of industry and all are commercially important. The acyclic monoterpene alcohol linalool is used widely in the food, fragrance and pharmaceutical industry: it is added to processed food and beverages, to cosmetics and perfumes for its floral or sweet lemony odour (subject to enantiomeric composition of linalool); its medicinal use is based on some of its known antibacterial, antifungal, anticonvulsant and sedative activities; it is also a key compound in the synthesis of vitamins A and E (Boelens et al., 1993; Dorman and Deans, 2000; Bauer et al., 2001 Bauer et al., 2001). Another commercially important acyclic monoterpene alcohol geraniol with flowery-rose-like odour is a fragrance ingredient usable in multiple cosmetic products, and it is characterized by antibacterial activity against food borne pathogens (Burt, 2004; Lapczynski et al., 2008; Chen and Viljoen, 2010). The monoterpenic phenol thymol together with isomer carvacrol has wide spectrum of antimicrobial and antioxidant activity, therefore, are widely usable in food and pharmaceutical industry (Zheng and Wang, 2001; Baser, 2008). Although these compounds

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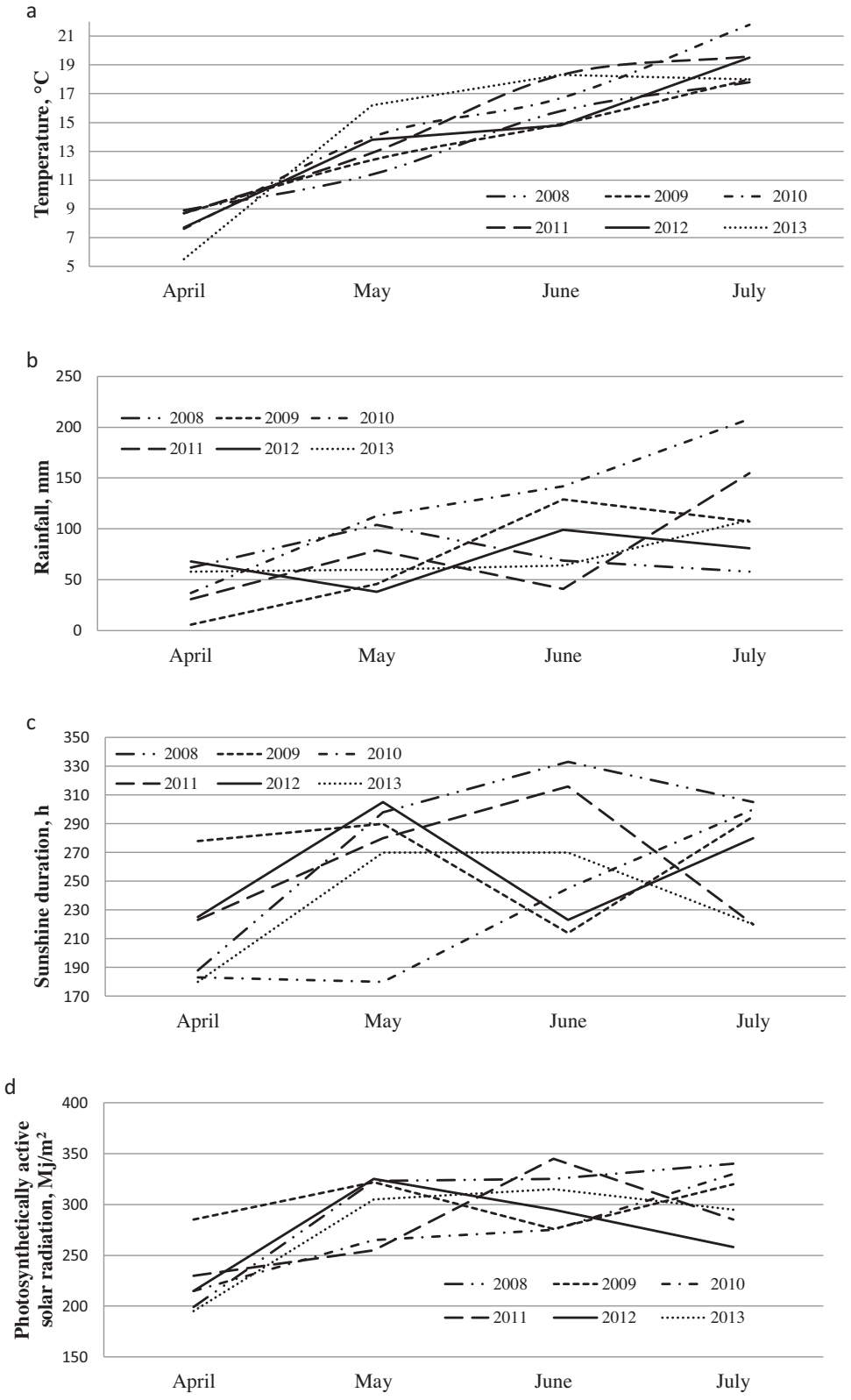

Fig. 1. Average temperature (a), rainfall (b), sunshine duration (c) and photosynthetically active solar radiation (d) in April–August of 2008–2013.

can be made synthetically, the flavour, food and pharmacy markets have undergone a tremendous "back-to-nature" demand, which is illustrated by the consumers' preference to natural substances instead of synthetic compounds (Demyttenaere, 2001).

If chemical polymorphism enables the wide use of *Thymus* species, it prevents the sampling of chemically homogeneous raw material from wild populations. Therefore, only the cultivation of individual chemotypes separately can enable to grow the raw material standardized according to some foregoing chemical compounds