
Ex-situ stability of morphobiochemical properties of common caraway (*Carum carvi* L.)

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Carum carvi L. is an officinal and spice plant of the family *Apiaceae*, which is on the verge of extinction in Lithuania. *In situ* and *ex situ* studies of the species diversity of *Carum carvi* L. and its preservation were started in 1997.

Investigations *ex situ* are carried out in the monopopulation agrofitocoenosis under the same agrotechnical conditions. In 1998, seeds were sown (first sowing) of samples that grew in *in situ* coenopopulations (1997), for investigation of the stability of valuable species indices (stem height, beginning of stem branching from the caulicle, inflorescence number, weight of 1000 fruits, content and composition of essential oil). The harvest was obtained in 1999. The seeds of this harvest were resown (second sowing) in 2000, the harvest was obtained in 2001.

The weight of 1000 fruits was the most stable parameter. Other parameters showed a characteristic lower or higher lability depending on ecological conditions.

The number of inflorescence became the most varying parameter. It was 8.6 times higher under more favourable moisture conditions in 2001 as in the drier 1999. The weather conditions of 1999 were more favourable for the synthesis of essential oil. The content of essential oil in caraway fruits was 7.05% in 1999, and 4.35% in 2001. The strong inverse correlation ($r = -0.9464$) between the content of essential oil in fruits and the summer hydrothermal coefficient (HTC) was established.

Plasticity of the morphological and biochemical parameters studied is characteristic of *Carum carvi* L. and it closely related to ecological conditions.

Key words: common caraway, height of stems, height of branching start, number of inflorescence, essential oil

INTRODUCTION

Global thawing causes an increasing number of problems related to the preservation of biological diversity of plant species in our planet. The years 2001–2002 have been announced to be the international year of biodiversity evaluation. International integrated attitude to biodiversity preservation will be strengthened (Wall et al., 2000). Man depends on 350,000 species of photosynthesising organisms. Global and local preservation of biodiversity is of vital importance for the world as 2/3 of all organisms will disappear at the end of the 21st century (Raven, 2000). Protection of plant species biodiversity is possible only if their spreading and ecological peculiarities as well as adaptation possibilities are known. In Lithuania, areas of natural meadows are decreasing (Balevičienė et al., 1998) and coenopopulations of species growing there are disappearing. This process has involved also such a valuable species of medicinal and aromatic plants as common caraway (*Carum carvie* L.).

Common caraway (*Carum carvi* L.) is a luciphile medicinal and aromatic plant of the upper storey of natural meadow phytocoenoses. Caraway belongs to staurigamic plants characterized by a rich diversity of coenopopulations. Preservation of common caraway biodiversity *ex situ* (in collection plot) has not been investigated in Lithuania.

The aim of this work was to investigate adaptation possibilities *ex situ* of different coenopopulations of common caraway.

MATERIALS AND METHODS

Seven coenopopulations of *in situ* growing caraways from different ecological conditions in South–South-east Lithuania were selected for the investigations. Two habitats (Meteliai in Lazdijai distr. and Puodžiai in Varėna distr.) were in fertile mesophytic meadows. Caraways grew in shade among tall meadow grasses. Two habitats (Babtai in Kaunas distr. and Taučionys in Trakai distr.) were in fertile mesophy-

tic meadows of shortish grasses where caraway as a luciphilous plant had very favourable light conditions. Three habitats (Vaickūniškiai in Trakai distr., Švenčionys in Švenčionių distr. and Juodiškės in Kaišiadorys distr.) were in poor xeromesophytic meadow phytocoenoses of shortish grasses.

Ex-situ investigations were carried out in the period 1998–2001 in monopopulation agrophytocoenoses under similar agrotechnical conditions. For the analysis of morphobiochemical characteristics and stability of the species adaptation properties, seed samples of *in situ* growing coenopopulations were taken during expeditions in 1997 and sown (first time) in 1998. The obtained harvest was sown in 2000 (second time).

When growing *ex situ* (in a collection plot), all the analyzed coenopopulations were exposed to the same edaphic conditions. The climatic ecological conditions were different in 1997, 1999 and 2001. The ratio of precipitation and air temperature (expressed by the hydrothermal coefficient, HTC (Kudakas, Urbonas, 1983) differed significantly. In the phase of stem growing (HTC_{sp} – spring), blossom and fruit ripening (HTC_{sm} – summer) the amount of precipitation was very little, the weather was dry and warm (HTC_{sp} 0.9; HTC_{sm} 0.9); in 2001 the growing conditions in the same phase were favourable (HTC_{sp} 1.3, HTC_{sm} 2.2) – sufficient moisture and temperature were similar to the average conditions *in situ* in 1997 (HTC_{sp} 2.0, HTC_{sm} 1.3).

Adaptation possibilities of the coenopopulations were evaluated according to the morphobiochemical parameters: plant height, height of branching start, number of inflorescence, mass of 1000 fruits, plant habitat form and essential oil content in fruits.

The content of essential oil was established by the method of water steam distillation and calculated for absolutely dry mass. The data were processed by methods of mathematical statistics using the Anova Minitab package.

RESULTS AND DISCUSSION

The parameters of individual plants from *in-situ* caraway coenopopulations (1997) varied (Figure). Plants of the Meteliai, Puodžiai, Babtai coenopopulations had the tallest and of the Juodiškės, Vaickū-

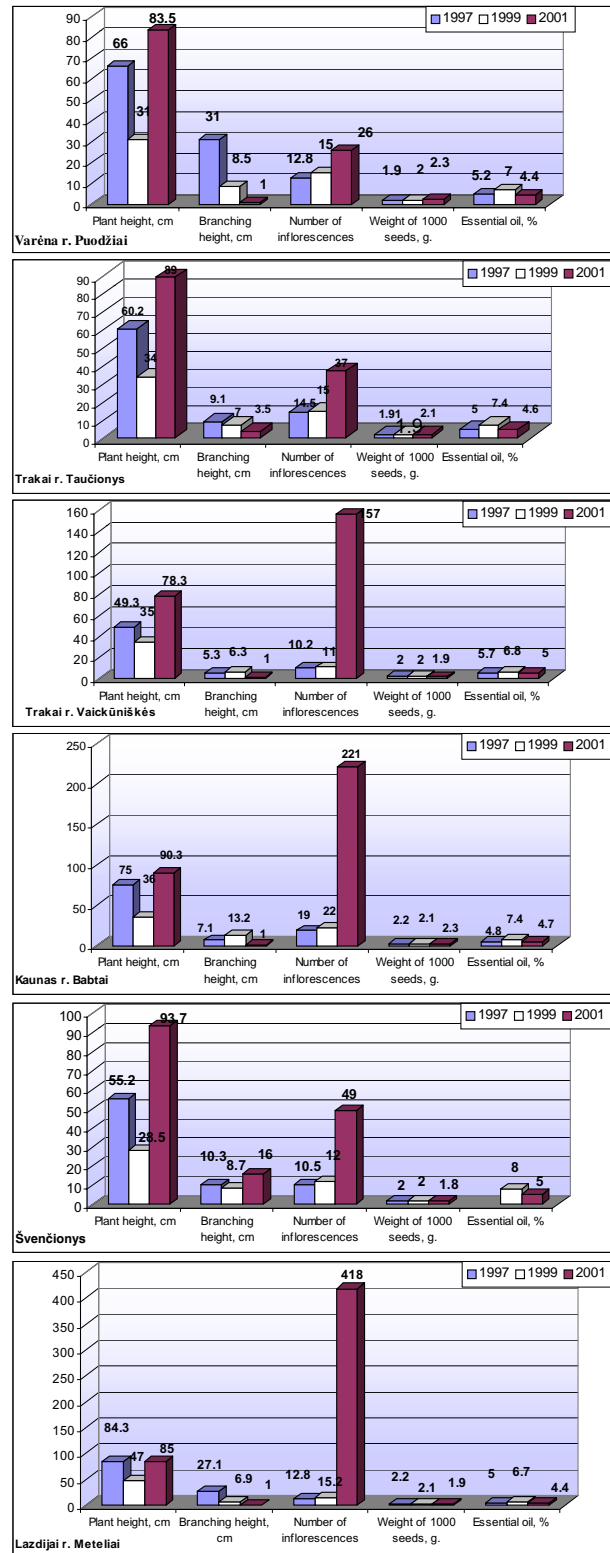


Figure. Morphobiochemical indices of *Carum carvi* L. in different habitats (1997 *in situ*; 1999 *ex situ*; 2001 *ex situ*)

niškės, Švenčionys coenopopulations the shortest stems. The branching start was highest in the caraway plants growing in the Meteliai and Puodžiai coenopopulations. The height of the meadow grass cover influenced the height of stems and branching.

Caraway plants growing among high grasses had higher stems and branching. Caraway plants of the Babtai coenopopulation had the highest number of inflorescence and mass of 1000 fruits, but the content of essential oil in their fruits was lowest.

The Babtai and Meteliai coenopopulations exceeded the other populations in height and the Meteliai and Puodžiai coenopopulations in branching height. Coenopopulations did not differ in the number of inflorescences. The Babtai and Meteliai coenopopulations had the highest mass of 1000 fruits. Caraway of Vaickūniškės coenopopulation significantly exceeded the general group of coenopopulations by the content of essential oil in their fruits.

Summarized data on *in situ* coenopopulations allowed conclude that in spite of some variations there were no essential differences among the coenopopulations.

In 1998–1999, *ex situ* caraway of the first generation (Figure) suffered a strong stress because of the absence of competitors characteristic of phyto-coenoses, lack of moisture, high temperature in the phase of stem formation – fruit ripening (HTCsp, sm – 0.9). As a response to stress, the height of the plants was decreased. The greatest difference in stem height among *in-situ* and *ex-situ* plants was observed in *in situ* in productive mesophytic meadows – Meteliai, Babtai, Puodžiai coenopopulations (height difference was 37.3; 39.0 and 35.0 cm, respectively). Plants grown from the seeds picked in poor xeromesophytic meadows suffered a weaker stress, which was expressed by a smaller difference in stem height (Vaickūniškės 14.3 cm, Juodiškės 14.9 cm). Branching height in all coenopopulations decreased, however, no reliable difference was observed. The difference in inflorescence number among the coenopopulations and between *in situ* and *ex situ* was insignificant. Changes of edaphic and climatic conditions had no essential influence on 1000 fruits mass.

The content of essential oil in fruits increased significantly. Coenopopulations from productive and poor habitats did not differ significantly in this respect. In the Meteliai coenopopulation caraway fruits contained 6.7% of essential oil and in Vaickūniškės 6.8%. In 1999 the ecological conditions were favourable for the synthesis of essential oils in the phase of fruit formation and ripeness. However, despite similar conditions, differences among the coenopopulations remained, and the content of essential oil in different coenopopulations varied from 6.2% to 8%. The most stable volatile oil content in caraway fruits was observed in the Juodiškės coenopopulation. Here the difference between *in situ* and *ex situ* was 1.6%.

Discussing the data on the first generation of *ex situ* caraway plants, it should be noted that the stress

caused by the change of conditions most strongly influenced the growth of stems and accumulation of essential oil in fruits. Some authors indicate that stressors decrease the growth parameters (Stanton et al., 2000). Literature sources (Bouwmeester et al., 1993) state that abiotic stresses (draught, high temperature, etc.) decrease fruit mass, however, no such influence was observed in the investigated caraway plots of the same coenopopulations were higher than those of the first generation (Figure). The difference in height varied greatly and did not depend on the growing conditions of maternal coenopopulations. Caraway plants of the Meteliai coenopopulation were an exception. In 2001 they were higher than the first generation plants as much as the latter were lower than those growing *in situ*. Thus, caraway plants of this coenopopulation reached the height of those growing *in situ* (difference 0.7 cm). Caraway seeds of all other coenopopulations produced higher plants than caraway plants of both the first generation and grown *in situ*.

Branching height increased only in the Švenčionys coenopopulation, while in others it decreased significantly. The decrease of branching height by 1 cm from ground level shows an increase of edaphic space and change of the plant habit (architecture) (Батыгин, 1986). In the improved light conditions branchy, spreading plants adapted to a better use of photosynthetically active radiation (Czereďnik et al., 2000; Жукова, 2001). These plants produced by 2.4 (Taucionys coenopopulation) to 27.5 (Meteliai coenopopulation) times more inflorescences than did caraway plants of the first generation. The Babtai coenopopulation exhibited a stable high mass of 1000 fruits. In the plants of the second generation essential oil content in caraway fruits was lower than in the fruits of the first generation plants, the difference varying from 1.6 to 3%. Such a significant decrease of essential oil level can be explained by unfavourable conditions – in 2001 both warmth and light were insufficient. Comparison with caraway plants of *in situ* coenopopulations showed that essential oil content in the second generation plants was slightly lower (by 0.4–0.8%) and only in one coenopopulation it was the same (difference 0.1%). Literature sources indicate (Bouwmeester et al., 1993) a negative correlation between essential oil content in fruits and the number of inflorescence, *i.e.* the fewer inflorescence the more essential oil in fruits. Data of the present investigations corroborate this statement.

The morphological parameters and essential oil content in fruits of the first and second generations *ex situ* caraway plants were different. The differences were determined by ecological conditions. In 1999 they were favourable for the synthesis of es-

sential oil. In 2001 the conditions were more favourable for the growth of morphological parts, but unfavourable for the synthesis of essential oil. Earlier investigations (Sliesaravičius et al., 2001) established a mean ($r = 0.534$) inverse correlation between the summer hydrothermal coefficient (HTCs) and the content of essential oil in caraway fruits grown *in situ* in natural meadows. Our investigations established a strong ($r = -0.946$) correlation between essential oil content in fruits and HTCsm in plants growing *ex situ* in monopopulation agrophtocoenoses in 1998–2001.

CONCLUSIONS

1. In the course of a changing ecological situation, changes in plant appearance and size of different parts due to phenotypical plasticity were observed. All the coenopopulations were labile, easily adapted to new *ex situ* conditions and maintained the stability of some features. The parameters that were most variable and depending on ecological conditions were as follows: plant height, branching height, form of habit, inflorescence number; the most stable parameter was the mass of 1000 fruits.

2. The same tendency in the changes of the morphobiochemical features (at a decreasing hydrothermal coefficient (HTCsp.sm) all morphological parameters decreased and the content of essential oil increased) was characteristic of all coenopopulations growing *ex situ*.

3. The coenopopulation that *in situ* grew in open plots with a weak competition for light and warmth and absence of tall edificators of other species demonstrated more stable parameters in *ex situ* conditions.

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PAPRASTOJO KMYNO (*CARUM CARVI* L.) MORFOBIOCHEMINIŲ POŽYMIŲ STABILUMO TYRIMAI *EX-SITU*

S a n t r a u k a

1997 m. septyniose skirtingose *ex-situ* augusio paprastojo kmyno cenopopuliacijose buvo surinkti sėklų pavyzdžiai. *Ex situ* sąlygomis iš jų išauginti dviejų (1998–1999 ir 2000–2001 m.) kartų augalai. Tyrimų tikslas – ištirti cenopopuliacijų prisitaikymo galimybes *ex-situ* sąlygomis. Aplinkos sąlygos stiebų formavimosi – vaisių brandos tarpsnyje 1999 ir 2001 m. buvo skirtingos. Dėl fenocenotinės konkurencijos, streso, edafinės erdvės padidėjimo, kontrastingų ekologinių sąlygų pirmos ir antros kartos augalus veikė nevienodai. Labiausiai parametrai, jautriausiai reaguojantys į pakitusias sąlygas, – augalų aukštis, šakojimosi aukštis, žiedynų skaičius, vaisių eteringumas. Stabiliausias parametras – 1000 vaisių masė.

Cenopopuliacijos plastiškos, jų fenotipinė išvaizda lengvai kinta keičiantis aplinkos sąlygoms.

Raktažodžiai: paprastasis kmynas, augalų aukštis, šakojimosi aukštis, žiedynų skaičius, 1000 vaisių masė, eterinis aliejus