

Little-known medicinal plants with a widespectrum of pharmacological action under the conditions of introduction in the Middle Urals

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Abstract. Under conditions of introduction into the subzone of the southern taiga of the Middle Urals, species that are little known as medicinal plants in European countries and in Russia have been studied. These species have a wide spectrum of pharmacological action and are promising for use. Success of introduction was the most for *Agastache foeniculum* (Pursh) Kuntze, *A. scrophulariifolia* (Willd.) Kuntze, *A. urticifolia* (Benth.) Kuntze, *Echinacea pallida* (Nutt.) Nutt., *Campanula rapunculoides* L., *C. latifolia* L. These species are characterized by high winter hardiness, stable fruiting, give self-seeding, accumulate a sufficiently large biomass, are not damaged by diseases and pests.

1 Introduction

Medicinal plants play a large role in modern medicine. All over the world there is a tendency to increase the number of medicines based on plants. At the pharmaceutical market in Russia, at present, about 40% of the preparations are of plant origin. Relevant is the search for promising new species with different types of pharmacological action: immunomodulating, antitumor, antiseptic, etc. An important point is the creation of a sustainable raw material base for medicinal plant materials. One of the ways of its formation is the cultivation of medicinal plants under controlled conditions. For the Ural region, with a high level of anthropogenic environmental impact, the expansion of the number of cultivated medicinal plants to obtain medicinal raw materials with various types of pharmacological action is very relevant. The introduction of plants represents the initial stage of the transition to wide cultivation, allowing us to study the peculiarities of plant development and the accumulation of biologically active substances. The study of new promising species is of great importance. The purpose of this article was to analyze the

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perspectivity of introducing a number of little-known species of medicinal plants into the conditions of the Middle Urals.

Promising sources of raw materials for obtaining medicines are species of the genus *Agastache* J. Clayton ex Gronov, common in North America and Southeast Asia. The aerial part of these plants contains phenolic compounds (flavonoids, free phenolic acids, lignans), as well as terpenoids contained in volatile fractions - essential oils and represented by non-volatile substances (oleanolic and ursolic acids, α - and β -amyrin, carotenoids, etc. [1]). The main component of *Agastache* essential oils is usually methylchavicol (from 18.6% to 98%) which gives anise flavor to plants. Other components of essential oils (myrcene, linalool, limonene, menthol, pulegon, spatulenol, camphor, β -caryophyllene, thymol) are found in various ratios. Species of *Agastache* possess antimicrobial, antiviral, antifungal, anti-inflammatory, anti-atherogenic, anti-tumor, antioxidant activity [1-2].

Echinacea pallida (Nutt.) Nutt. - a perennial herb common in the southern states of the USA. This species is widely used in US medicine, along with two other species of this genus - *E. purpurea* (L.) Moench and *E. angustifolia* DC. In European countries and Russia, mainly *E. purpurea* is used. *E. pallida* is much less known here, is rarely used and is not sufficiently investigated [3]. Rhizomes and roots of *E. pallida* are used to prevent and treat infections of the upper respiratory tract and as means that enhance innate (non-specific) immunity and modulate adaptive (specific) cellular immunity [3-4]. The biologically active substances of this species cause a pronounced anti-inflammatory action [5]. The underground organs of *E. pallida*, unlike *E. purpurea*, contain echinacoside - a caffeic acid glycoside [4, 6 et al.]. Derivatives of caffeic acid are known to be active antioxidants and have anti-inflammatory and anti-hyaluronidase activity, which leads to their wound healing effect. Echinacoside has antibacterial and antiviral activity, in particular against herpes simplex virus types 1 (HSV-1) and 2 (HSV-2).

A. Chicca et al. [7] showed the cytotoxic activity of acetylene compounds from the roots of *E. pallida* on several lines of human cancer cells, including leukemia, breast carcinoma and melanoma cells. Lipophilic extracts of *E. pallida*, due to the presence of high concentrations of polyacetylenes and polyenes, which are absent in *E. purpurea* and *E. angustifolia*, showed the highest efficiency compared to the last two species.

Important pharmacological properties of medicinal plants, in particular, immunomodulatory, antitumor, and antiviral effects, are associated with the presence of a number of biologically active compounds, including fructose-containing polysaccharides (fructans) [8]. These compounds are present in large quantities at species of the family Campanulaceae, in particular *Campanula rapunculoides* L., *C. latifolia* L., *Codonopsis clematidea* (Schrenk) C. B. Clarke. These species are known as decorative, but are also used as medicinal plants in traditional medicine in several countries. In Turkey, flowering aerial shoots of *C. rapunculoides* are used for colic, flatulence, and abdominal pain [9]. A mixture of fresh leaves and flowers of *C. latifolia*, as well as *Codonopsis clematidea* used to treat herpes [10]. *Codonopsis clematidea* is also used in Chinese traditional medicine. It was shown that polysaccharides of this species have a pronounced positive action in cancer-induced cachexia in mice (which may be associated with inhibition of tumor growth), and flavonoids have antioxidant properties [11].

2 Materials and methods

Study on the introduction of medicinal plants was carried out in the Botanical Garden of the Ural Branch of the Russian Academy of Sciences (Ekaterinburg), in the climatic conditions of the southern taiga subzone. The growth and development features of the following

species were studied: *Agastache foeniculum* (Pursh) Kuntze, *A. mexicana* (Kunth) Lint & Epling, *A. pringlei* (Briq.) Lint & Epling, *A. rugosa* (Fisch. & C.A.Mey.) Kuntze, *A. scrophulariifolia* (Willd.) Kuntze, *A. urticifolia* (Benth.) Kuntze; *Echinacea pallida* (Nutt.) Nutt.; *Campanula rapunculoides* L., *C. latifolia* L.; *Codonopsis clematidea* (Schrenk) C. B. Clarke. The introduction prospectivity of the species was determined using the following six indicators: seed reproduction (presence, regularity, fruiting intensity and self-seeding); natural vegetative propagation in the conditions of culture; the degree of plant development (height of individuals, size of shoots) compared with the natural habitat; resistance to damage by pests and diseases; resistance to adverse environmental factors (was estimated by the magnitude of the winter loss of plants); the duration of the existence of the species under conditions of introduction. Each indicator was evaluated on a three-point scale. As a result of the summation of scores for all indicators, an integrated assessment of the prospectivity of introduction was obtained.

3 Results and discussion

Our comprehensive study of species of the genus *Agastache* showed the possibility of their successful cultivation in the Middle Urals. As a medicinal raw material, the aerial part of plants collected during the mass flowering period should be used, since during this period the plants are characterized by the highest biomass and a high content of biologically active substances. The maximum content of essential oils under growing conditions in the Middle Urals is typical for *A. scrophulariifolia* (2.4%) and *A. mexicana* (1.2%). In other species, the amount of essential oils is less. Employees of the Central Siberian Botanical Garden (CSBG, Novosibirsk) identified 29 compounds in essential oils of *Agastache* [12]. In the conditions of the Middle Urals, a change in the relative content of the main components was observed: menton (up to 42.2%) and isomenton (up to 18.8%) prevailed in all samples, and the content of methylchavicol (the main component in other regions) may decrease in our conditions to 1% (*A. urticifolia*). A significant share in the essential oil of all studied species was pulegon (up to 9.1%). The phytochemical analysis carried out by the employees of the CSBG showed the presence of a number of biologically active substances in the aerial part of *Agastache* plants: saponins (up to 20.75%), carotenoids (up to 330 mg%), tannins (up to 17.45%), as well as flavonols, catechins, pectins, etc. Antioxidant activity was highest in leaves [12].

During the first year of life, plants were mainly in the pregenerative period. However, with early spring sowing in April or cultivation through seedlings, plants of these species may flower in the first year of life in early to mid-August; in this case, seed ripening occurred in late September - October. In the second year of life, the beginning of the growing season was observed in the first decade of May. Plants formed from 2 to 5 generative shoots, with a height of 50-180 cm, shoots branched up to III order. Mass flowering was observed in late July - early August, the duration of flowering was 40-60 days. The seed ripening period lasted from late August to October. By the end of the growing season, 10-13 renewal buds were formed in the plants of the second year of life in the basal part of the shoot, but only *A. foeniculum*, *A. rugosa*, and *A. urticifolia* grew new monocarpic shoots in May of the following year. In *A. scrophulariifolia*, *A. pringlei*, and *A. mexicana*, the renewal buds were freezing. All studied species go through a full developmental cycle, produce mature seeds, renewal by self-seeding and winter without covering (Table 1). In nature, *Agastache* species are perennial herbaceous plants, but in culture, the species we studied can be attributed to biennials (*A. scrophulariifolia*, *A. pringlei*, *A. mexicana*) or plants with a short duration of life (*A. foeniculum*, *A. rugosa*, *A. urticifolia*).

E. pallida in the conditions of the Middle Urals is also promising for cultivation (Table 1). This species is characterized by a large, vertically thickened, slightly branching rhizome, with a small number of adventitious roots. Unlike the underground organs of *E. purpurea*, it is easily dugged out when grown on different soils and is quickly washed off the ground. In our conditions, the maximum mass of the underground part of individuals was reached at 3-4 years of life (60-72 g in the wet state).

Table 1. The results of the introduction of the studied species of medicinal plants (in scores).

Species	Seed reproduction	Vegetative propagation	Degree of plant development	Resistance to damage by pests and diseases	Winter loss	Duration of the existence of the species	Prospectivity of introduction
<i>Agastache foeniculum</i>	3	1	3	3	3	2	15
<i>A. mexicana</i>	3	1	2	3	2	1	12
<i>A. pringlei</i>	3	1	2	3	3	1	13
<i>A. rugosa</i>	3	1	2	3	3	1	13
<i>A. scrophulariifolia</i>	3	1	3	3	3	1	14
<i>A. urticifolia</i>	3	1	3	3	3	1	14
<i>Echinacea pallida</i>	2	2	2	3	2	3	14
<i>Campanula latifolia</i>	2	1	2	3	3	3	14
<i>Campanula rapunculoides</i>	3	3	3	3	3	3	18
<i>Codonopsis clematidea</i>	2	1	2	3	2	3	13

Winter hardiness of the species, in general, was good. The loss of individuals was quite large in the first winter, when the plants were at the pregenerative period of development, - from 10 to 25%. In subsequent years the loss was insignificant. From 42 to 75% of plants were entering to the generative period in the second year of life, 53-94% - in the third year, in the fourth year all individuals were flowered. Plants reached their greatest development at the 3-4 years of life. From the fifth year of life a transition to the old-generative state began. The life span of individuals was 5-7 years under the conditions of introduction.

Regrowth was usually observed in late April - the first half of May. Flowering was beginning in mid-July, ending in the second half of September. Seeds were ripening in the middle - the end of September. Fruiting was regular and plentiful. Plants were giving self-seeding. Only once, in 2002, during an extremely unfavorable growing season, most seeds did not ripened. Plants were capable of natural vegetative propagation. The height

of plants, the size of shoots and leaves corresponded to those observed in natural habitats. High resistance of plants to damage by diseases and pests was noted.

According to our data, the underground organs of *E. pallida* in the Middle Urals contain a large amount of fructose-containing carbohydrates (fructans) that have a variety of pharmacological effects: immunomodulating, antitumor, hypoglycemic, hypolipidemic, antioxidant etc. The fructans content was 20.5-67.5% (for an air-dry mass) at 3-4 year of life [13]. It should be noticed, in plants of *E. pallida* it was noticeably larger than in plants of *E. purpurea* of the same age.

We also found a high content of fructans in the underground organs of the species of the family Campanulaceae introduced into our conditions: *Campanula rapunculoides* L., *C. latifolia* L., *Codonopsis clematidea* (Schrenk) C.B. Clarke: respectively 28.1, 13.0, 23.4% (for an air-dry mass) [13]. All these species flowered profusely and stably fruiting (in August - early September). *C. rapunculoides* was giving abundant self-seeding and intensively propagated vegetatively (Table 1), actively spreading over the collectional plot. The biomass of underground organs and aboveground parts of plants of all three species was quite high. *C. rapunculoides* was characterized by high winter hardiness. In *Codonopsis clematidea*, in the first years of life, a loss of part of individuals was observed in winter. These species are not damaged by pests and diseases (Table 1). *Campanula rapunculoides* has the highest potential for cultivation in local conditions. However, it must be borne in mind that under certain conditions this species may behave like a weed.

4 Conclusion

Under the conditions of introduction into the subzone of the southern taiga of the Middle Urals, species of medicinal plants, little known in European countries and in Russia, were studied. These species have a wide spectrum of pharmacological action and are promising for use. The success of introduction is the most for *Agastache foeniculum* (Pursh) Kuntze, *A. scrophulariifolia* (Willd.) Kuntze, *A. urticifolia* (Benth.) Kuntze, *Echinacea pallida* (Nutt.) Nutt., *Campanula rapunculoides* L., *C. latifolia* L. These species are characterized by high winter hardiness, stable fruiting, give self-seeding, accumulate a sufficiently large biomass, are not damaged by diseases and pests. Some of them can reproduce vegetatively.

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References

1. S. Zielińska, A. Matkowski, *Phytochem. Rev.*, **13**, 391-416 (2014)
2. R. Fuentes-Granados, M.P., Widrlechner, L.A. Wilson, *J. Herbs Spices Med. Plants*, **6**, 69-972 (1998)
3. E. Skopińska-Rózewska, A. Wasiutyński, E. Sommer, P. Skopiński, K. Pastewka, R. Zdanowski, *J. Bany, Centr. Eur. J. Immunol.*, **36**, 18-23 (2011)
4. Zhai Z., Liu Y., Wu L., Senchina D.S., Wurtele E.S., Murphy P.A., Kohut M.L., Cunnick J.E., *J. Med. Food.*, **10**, 423-434 (2007)
5. C.A. LaLone, L. Rizshsky, K.D. Hammer, L. Wu, A.K.S. Solco, M. Yum, B.J. Nikolau, E.S. Wurtele, P.A. Murphy, M. Kim, D.F. Birt, *J. Agric. Food. Chem.*, **57**, 8820-8830 (2009)
6. J. Barnes, L.A. Anderson, S. Gibbons, J.D. Phillipson, *J. Pharm. Pharmacol.*, **57**, 929-954 (2005)

7. A. Chicca, B. Adinolfi, F. Pellati, G. Orlandini, S. Benvenuti, P. Nieri, *Planta Med.*, **76**, 444-446 (2010)
8. E. Dobrange, D. Peshev, B. Loedolff, W. Van den Ende, *Biomolecules*, **9**, 615 (2019)
9. Ç. Kizilarlan, N. Özhataywild, *Turk J. Pharm. Sci.*, **9**, 199-218 (2012)
10. T. Chakraborty, S. Saha, N.S. Bisht, *Plants*, **6**, 13 (2017)
11. J.Y. He, N. Ma, S. Zhu, K.Komatsu, Z.Y. Li, W.M. Fu, *J. Nat. Med.*, **69**, 1-21 (2015)
12. M.A. Myadelets, Kukushkina T.A., Vorobjeva T.A., Shaldaeva T.M., *Khimija Rastitel'nogo Syr'ja*, **4**, 147-152 (2014) (In Russian)
13. E.S.Vasfilova, R.I. Bagautdinova, T.F. Okoneshnikova, *Vestnik Tomskogo Gosudarstvennogo Universiteta. Biologiya*, **30**, 96-112 (2015) (In Russian)