THE STUDY OF THE VOLATILE OILS CONTENT IN THE ESSENTIAL OIL CROPS IN THE NON-CHERNOZEM ZONE IN RUSSIA

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Abstract: the composition of essential oils and its changes in ontogeny and under the exogenous effect of retarding substances on fh'e plant varieties Mentha piperita L., Monarda didvma L., Monarda citriadora Cerv, Dracocephalum molda\'ica L., Agastache Clavt., Lophanthus Adans., Elsholtzia ciliata Thunb in pre-han>esting period has been studies by GLC-MS methods. The introduction of oil-bearing crops from the southern areas to the northern regions practically does not cause changes in the component structure of essential oils (EO). Only slight deviations in the content of some terpenoid oils are obsen'ed. Exogenous pre-han>esting treatment of crops with growth regulators allows, in some cases, to influence purposefully the biosynthesis of particular terpenoids increasing the content of more valuable volatile oil components.

Keywords: GLC, MS, essential oil, terpenoides, retordantes, mentha (peppermint), monarda, agastache, lophantus, dracocephalum.

Within the framework of the program "The cultivation technology of essential oil crops possessing the given and controlled composition in the target product (essential oil)'' the GLC-MS method [24] for the oil analysis using such a hardware-software complex as the gas liquid chromatograph with the mass-spectral detector "Clarus 600 C/D/S/T MS" (producer Perkin Elmer Lift and Analytical Sciences, USA) has been developed [12].

Introduction

The aim of the research is to study the component structure of the essential oil crops introduced in the Non-chemozen zone in Russia, to compare it with the oil obtained from crops grown under conventional conditions, to develop a new approach to the purposeful changing of the component structure in order to increase the content of more valuable components by treating with synthetic phytoregulators as well as to study the wild taxons to be recommended for cultivation.

In introducing and selecting oil-bearing and drug crops, not only yields and the output of the target product are considered to be important indicators, but the quality of the essential oil (EO) determined by its composition is of great value. Thus, the EO content in various crop biotypes and varieties recommended for cultivation in the Non-chemozen zone in Russia has been studied thoroughly. The obtained data were compared with the oil contents for crops grown in the southern regions (mainly, in the Nikitskij Botanical Garden).

The increase in productivity and quality of oil-bearing crops, as a rule, is achieved by applying the conventional method, that is, by developing new genotypes using selection methods (endogenous productivity regulation). It is known to be an effective, but a time and labour-consuming method. It is rather difficult to use modification (ontogenous) plant variability for these purposes as it is greatly affected by climatic conditions during the growing period.

As a result of data processing the system of purposeful exogenous regulation of the modification variability of raw material quality (oil content and composition) in some oil-bearing crops using the method of pre-harvest treatment with synthetic phytoregulators has been proposed [15].

Materials and methods

To study the above mentioned problems the small plot field and pot experiments on the collection materials growing in the Al-RRIMAP Botanical Garden were carried out. The experiments inviolved five breeding mint varieties *Mentha piperita* L. (Moskvichka, Lekarstvennaj-4, Medichka, Cubanskaj-6 and Prilukskaj-6), *Monarda didyma* L., *Dracocephalum moldavica L., Agastache* Clayt., *Lophanthns* Adans., *Elsholtzia ciliata* Thunb. The mixture of sod-podzol soil with peat (1:1) was used as the substrate in the pot experiments. As the mineral fertilizer background calcium carbonate was applied at a rate to neutralize total hydrolytic acidity as well as nitrogen, phosphorus and potassium were added as salts at the rate of 0.15g active substance per 1 kg soil mixture. Four mint plants were grown in each vegetative pot with the capacity of 12 kg. There was a five-fold experiment replication.

The field experiment was carried out on the plots of 1.7 sq.m. with a four-fold replication. The experiments were done at the experimental station in the Al-RIMAP.

The growth regulators were commercially produced: domestic gibberellin A_3 (GA); chlorcholine chloride (CCC); chlormethyl chorid; camposane-M extra (Bitterfeld, Germany). The concentration of water solutions of phytoregulators was calculated on the basis of the substance. The plants were treated with growth regulators in the early phase of budding - the beginning of blossoming when the oil content is maximum. The control plants were sprayed with water. The above ground plant potion was cut down and analyzed 7-15 days later after the treatment. Taking in to account species and variety crop response to phytoregulators, the optimum concentration of retards ensuring the better combination of crop yield, EO composition and EO yield was chosen for each crop, camposane was applied in concentrations 0,03; 0,05; 0,1 и 0,15%, but CCC was used in concentrations: 0,05; 0,075 and 0,1%.

Essential oil was obtained using the Ginsberg hydrodistillation method. The EO composition was determined by the GLC-MS method mentioned above. The content of oil components was calculated as the square of the chromatograph peaks produced by the fiame-ionization detector (FID). The identification of the EO components was done relying on the "NIST-05 ” library of mass-spectral data and the library of terpenoid retention indexes by the method of ellipsoid n-alkanes distribution under random temperature programming.

Discussion

The EO content and composition are greatly affected by such factors as plant and leaves age as well as by various climatic, soil and agrochemical conditions [18,20,21]. The plant treatment with different phytoregulators influences the oil content and composition as well [3, 7-9, 13, 16-19, 22, 23]."

The biosynthesis of terpenoids occurs in the polyenzyme centers, which activity is primarily determined by plant genetic features. Besides, the activity of enzymes in these centers is controlled by the hormone balance and changes in ontogenous as well as under the influence of exogenous factors.

As a consequence, firstly, the oil content of various species, types and varieties of oil-bearing crops which are of special interest was determined (taking in to account a wide range of literature data) using our method of EO analysis (e.g. table 1)

The hormonal status of plants varies in the course of development (change in phases) and, according to the given stage, the character of biosynthesis of secondary metabolites varies as well. In case of essential oil cultures, the components ratio of EO varies.

Therefore, for several examples the change in hormonal balance and character of biosynthesis of the EO in ontogeny was investigated.

In tabl. 2 the change in the oil structure of Mentha *piperita* L. low-menthol grade - Krasnodar 2 is submitted depending on the growth phase. It is obvious, that at the transition

Table 1

The composition of essential oils various grades peppermint. From a collection VILAV

Component Name	Moskvichka	Medichka	Lekarst-vennay-4	Kuban-skaj-6	Priluk-skaj-6
a-Pinene	0.06	0.13	0.17	0.03	0.20
P-Pinene	0.10	0.20	0.28	0.11	0.43
Sabinene	0.03	0.08	0.11	0.06	0.28
Myrcene	0.07	0.13	0.08	0.13	0.23
Limonene	0.20	2.11	1.72	0.97	3.86
1,8-Cyneol	0.09	0.27	0.15	0.12	4.91
c/s-p-Ocimene	0.02	0.07	0.04	0.00	0.57
frans-p-Ocimene	0.06	0.01	0.00	0.00	0.14
p-Cymol	0.01	0.03	0.00	0.00	0.00
a-Terpinene	0.15	0.04	0.04	0.00	0.06
Octenol-2	0.06	0.02	0.16	0.07	0.16
Menthone	7.82	14.82	17.43	11.55	25.37
Menthofurane	0.13	0.16	0.06	0.02	0.20
/so-Menthone	2.88	1.35	1.57	18.26	2.25
/so-Pulegone	0.00	0.00	0.00	0.12	0.24
Camphore	0.00	0.00	0.00	0.00	0.00
Linalool	0.02	0.10	0.10	0.00	0.35
Menthyl acetate	5.19	1.57	2.34	14.57	1.74
P-Caryophillene	1.10	2.28	1.38	0.55	0.00
neo-Menthol	1.74	2.30	1.74	1.16	3.98
Terpinen-4-ol	0.07	0.07	0.04	0.00	0.29
/-Menthol	79.17	71.58	70.88	47.02	47.61
/so-Menthol	0.05	0.10	0.00	0.69	0.00
Puligone	1.14	1.13	0.58	0.82	2.81
y-Cadinene	0.36	0.22	0.31	0.21	1.40
Piperitone	1.14	1.01	0.68	1.28	1.94
The contents EO, g/100 g dru mass	4.44	3.48	5.08	4.93	2.53

T a b l e 2

Change of essential oil structure of peppermint depending on a phase of development
(Grade "Krasnodarskaj-2", GBG, Moscow), %

Component Name	Tillering	Budding	Flowering
	19-20.06	7.08	23.08
a-Pinene	0.12	0.09	0.21
Camphene	0.03	0.04	0.08
P-Pinene	0.31	0.24	0.40
Sabinene	0.15	0.14	0.17
Myrcene	0.05	0.04	0.02
Limonene	0.89	0.54	0.88
1,8-Cineol	2.17	2.44	2.63
c/s-p-Ocimene	0.04	0.04	0.07
frans-p-Ocimene	0.04	0.03	0.03
p-Cymol	0.20	0.28	0.28
a-Terpinjlene	0.02	0.04	0.03
Octanol-3	0.10	0.11	0.12
Octenol-3	0.21	0.47	0.49
Menthon	**55.21**	**25.08**	**32.34**
Menthofurane	0.68	1.27	0.10
/so-Mebthone	5.77	8.30	4.77
Linalool	0.23	0.16	0.07
Menthylacetate	0.47	1.44	1.26
/so-Carvone	0.19	0.36	0.29
neo-Menthol	1.72	2.96	2.62
P-Caryophyllene	1.13	0.91	0.37
Sabinenhydrate	0.53	0.66	0.38
Terpinen-4-ol	0.20	1.09	0.40
/-Menthol	**24.71**	**45.35**	**41.45**
/so-Menthol	1.32	5.11	8.07
Pulegone	0.11	0.2	0.07
a-Caryophyllene	0.39	0.26	0.40
y-Cadinene	0.48	0.21	0.01
Piperitone	1.61	1.3	1.22
The contents EO, g/100 g dru mass	0.45-0.55	0.75-0.80	1.20

phase from tillering to budding the sharp increase in the menthol content in oil happens, then, at the phase of flowering its content is practically stabilized and even reduces a little. Naturally, the menthone content at the budding phase decreases by more than twice in comparison with the tillering phase, but at the flowering phase it increases it at the expense of other components.

In fig. 1 the dynamics of EO accumulation and the increase in menthol and menthone in EO is more evident and is traced in accordance with transition from the tillering phase to the flowering phase. However, the tangent derivative the declination angle in the curve

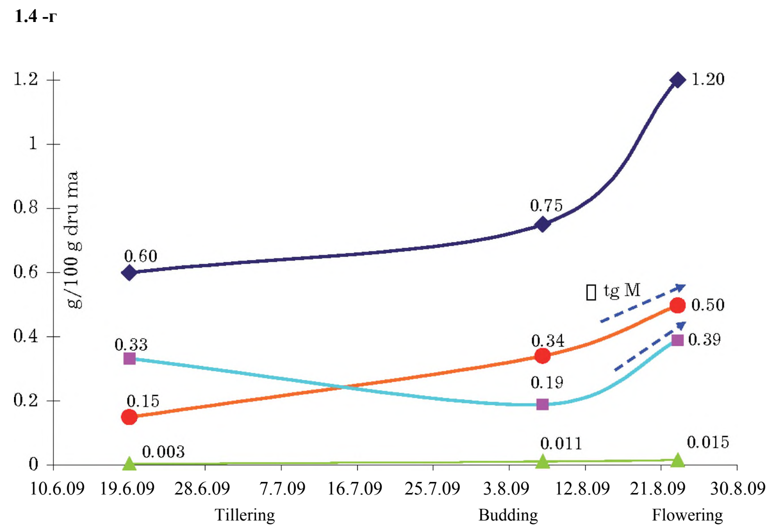

Fig. 1. *Mentha piperita* **L.** Grade "Krasnodarskaj-2" Change of the contents EO and it basic componentes of relation to a phase of development

(tg M) menthone contents change at the transition phase from budding to flowering phase has been found to be higher, than the corresponding derivative for menthol. The menthone biosynthesis at the given stage of ontogenesis is higher than for menthol, the contents of both components in a plant being increased at this stage ratio of three variables, that is the total oil content, and menthol and menthone content is optimum. The similar outcomes are observed and for highly-menthol mint varieties (fig. 2), and for other essential oil cultures.

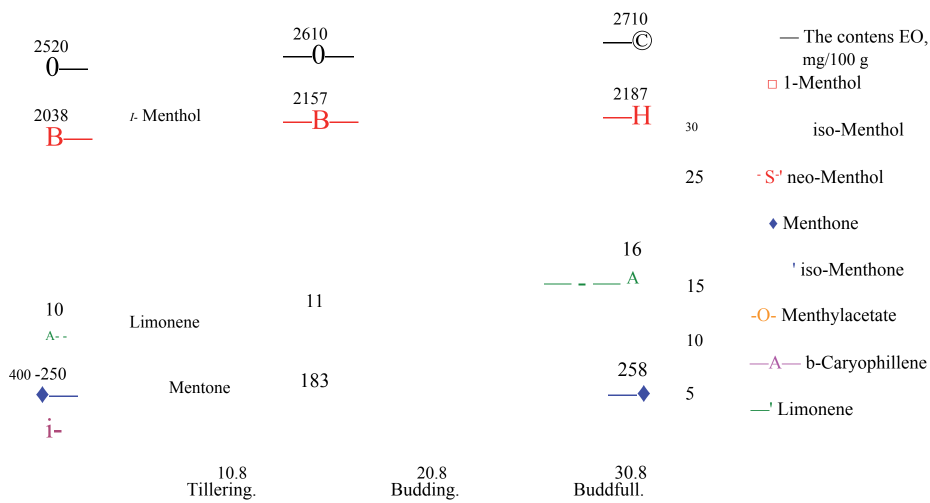

Fig. 2. Dynamics of change of the contents and structure EO in ontogenesis. Grade peppermint Moskvichka

It was possible to assume, that the retarding in plant development at the ontogenesis stage by treatment with retardants, can result in the increase in EO and menthol content.

The first pot experiments with mint of Moskvichka variety have shown that the preharvesting treatment of plants with CCC resulted in changes of the oil contents and biosynthesis character of its components. The output of oil, seven day after plants treatment retardants, was increased by 40% in comparison with the control sample. In the preharvesting treatment plants, with several tested concentrations of CCC, the menthol content in EO gradually increased by 5-11%. The further research has confirmed the trend, while the menthol content in the oil was increasing, the amount of menthone was decreasing.

The treatment of plants with such retardants as CCC reduces the activity of ent-kaurensynthetase, thus inhibiting cyclesation of ent-kaurene in to geranylgeranylpirophosphate, suppressing biosynthesis of gibberellins, "2-CEFC" (camposan) also suppresses gibberellins biosynthesis.

In EO mint (tabl. 3) varieties (Moskvichka, Lekastvennaj-4, Medichka) the content of menthone and other ketones decreased by 1,2-1,4 times (from 15-18% to 9-12% depending on the variety). The content of monoterpene hydrocarbons were reduced as well. Thus the level of /-menthol, /'so-menthol, menthylacetate and sesguiterpene hydrocarbons (on the p-caryophillen in 1,2-1,4 times) increased. Evdent changes in the EO structure were revealed in the high yielding genetically flexible plasticity, but low-menthol content variety of mint Prilukskaj-6 (fig. 3). In this case the menthone contents reduced from 42 to 26%, and total quantity of monoterpene hydrocarbons - 1,5 times. Decreased by at the same time quantity of /-menthol (from 34 to 48%) and menthylacetate (with 2,7 up to 5,8%) practically increased correspondenty.

The ways of biosynthesis EO components, gibberellins and abscisic acid (ABA) are closely interrelated, as these compounds have common predecessors for their formation. The

Table 3

Influence of synthetic phytoregulators on the contents and structure of essential oil. Grade peppermint Moskvichka

Component Name	The control	CCC	Campo-zame
a-Pinene	0.06	0.07	0.08
P-Pinene	0.10	0.12	0.11
Sabinene	0.03	0.00	0.00
Myrcene	0.07	0.07	0.08
Limonene	0.20	0.22	0.21
1,8-Cyneol	0.09	0.12	0.09
c/s-p-Ocimene	0.02	0.00	0.00
frans-p-Ocimene	0.06	0.00	0.00
p-Cymol	0.01	0.00	0.00
a-Terpinene	0.15	0.14	0.09
Octanol-2	0.00	0.00	0.00
Octenol-2	0.06	0.00	0.00
Menthone	7.82	6.95	6.83
Menthofurane	0.13	0.07	0.09
/so-Menthone	2.88	3.04	2.79
neo-Menthone	0.00	0.00	0.00
Camphore	0.00	0.00	0.00
Linalool	0.02	0.00	0.00
Menthyl acetate	5.19	5.72	4.83
P-Caryophillene	1.10	1.26	1.10
/so-Menthol	1.74	1.77	1.70
Terpinen-4-ol	0.07	0.00	0.00
/-Menthol	79.17	77.69	79.44
neo-Menthol	0.05	0.00	0.00
Puligone	1.14	1.10	1.12
a-Caryophillene	0.00	0.00	0.00
y-Cadinene	0.36	0.38	0.31
Piperitone	1.14	0.96	0.88
/-Carvone	0.00	0.00	0.00
The contents EO, g/100 g dru mass	4.44	4.42	5.22

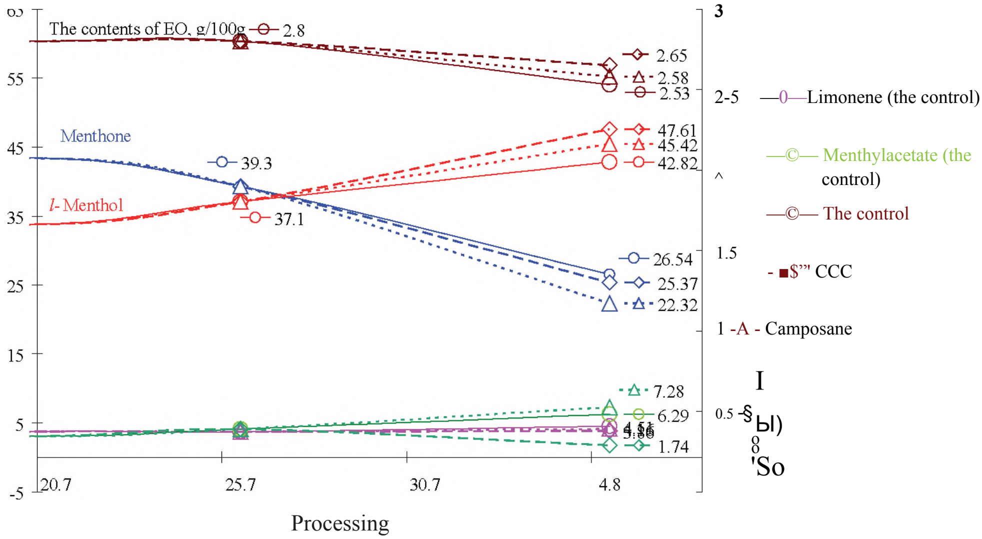

Fig. 3. Influence of the retardantes on the contents and the structure of EO. Grade peppermint Prilukskaj-6

analysis of hormonal balance has shown, that the influence of retardants on plants suppresses biosynthesis of exogenous gibberellins and shifts the balance between geranylpirophosphate - geranylgeranylpirophosphate in biochemical reactions geranylpirophosphate and its further transformation in to monoterpenoides: menthol and (or) ABA and indolylacetic acid. Thus, for the high-menthol containing mint varieties, where the genetically determined EO biosynthesis is maximum, the treatment with phytoregulators increased the ABA level considerably, and for the low-menthol varietis the ABA level was close to the control group, but the significant increase in the menthol content in oil was observed [11].

The interesting outcomes were obtained in the dynamics accumulation essential oil components during the development *Monctrda citrictdora* Cerv. (fig. 4) [4-5]. At the transition stage from budding to foil flowering the decrease in the contents of carvacrol, aromatic and other hydrocarbon in plants is observed. Parallelly there is an intensive biosynthesis of thymol. At the budding phase, the thymol content calculated for 100 g aerated dry plants mad weight accounted for the 480 mg, and at full flowering stage has increased up to 904 mg. While of flowering and shifting was coming to the end ripening phase, the thymol biosynthesis sharply decelerated and its content in oil dropped to 440-460 mg. Thus, the ammount of cavacrol reduced from 500 mg at the budding phase to 100 mg at the flowering phase, and began increase steadily. The mass ratio of p-cymol during the ontogeny tended decrease steadily gradually.

The contents of terpene and sesguiterpene hydrocarbons in plants reaches the maximum during the flowering stage, and then the intensity of their biosynthesis gradually decreases. The biosynthesis of y-terpinene is an exception, its maximum is reached at the ending of flowering. The similar trend is observed for its oxyderivative such as terpinen-4-ol (fig. 4).

The treatment of plants with retardants at the phase of transition full flowering sharply stimulates the accumulation of the most valuable essential oil component such as thymol

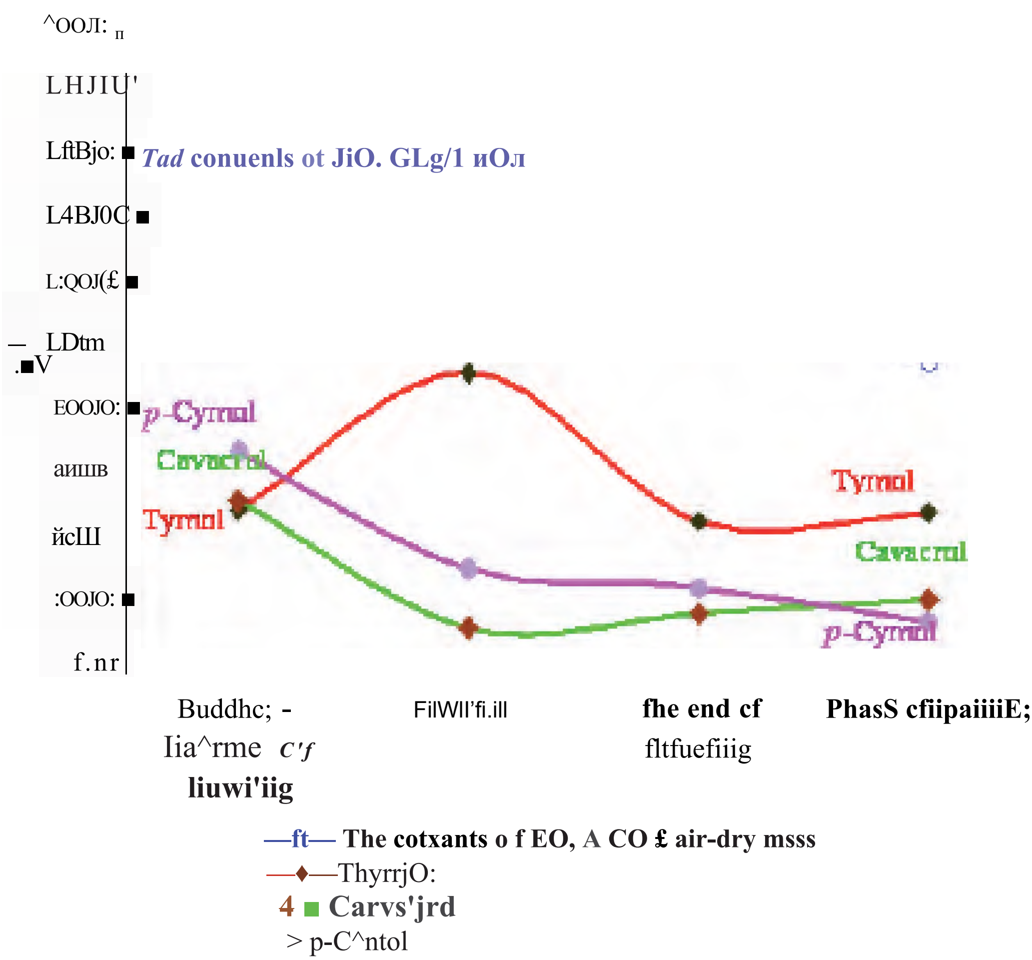

Fig. 4. *Monarda citriodora* Cerv. Dynamics of change of structure EO in ontogenesis

[4-5, 11]. It was shown, that if the ratio of thymol to carvacrol in the tested plants was 1:2.3, after preharvesting treatment with CCC, thymol became a dominant oil component and its contents, in relation to cavacrol, increased up to the ratio 2:1. Even greater effect was observed in preharvesting treatment of plants with camposan, in this case, the thymol contents was 14 times higher, than carvacrol contents (tabl. 4).

The *Drctcocephctlum moldcmcct* L. oil [6, 14, 15], consists of hydrocarbon - a-Copaene (0,05-0,2%), P-burbonene (0,05-0,2%), y-elemene (1,7-3,5%); of alcohols - octanol-3 (0,05-0,25%), linalool (0,06-1,10%), /ram-sabincnchydratc (0,04-0,17%), nerol (0,19-0,46%), geraniol (3,15-7,90%); ketones - menthone (0,08-0,26%), verbenone (0,05-0,16%); aldehydes - neral (12-20%), geranial (25-45%); ethers - bomylacetate (0,20-0,90%), geranylacetate (15—43%).

The biosynthesis ofEO components of *D. moldcmcct* L. follawsthe shorter route, than, for example, menthol biosynthesis of mint oil. The transformation of geranylpirophosphate is mainly limited, by its transition into geraniol and its *cis*-isomer - nerol and products of

Table 4

Influence of regulators of growth of plants to a structure of Essential oil *Monarda citriodora* Cerv.

Component Name	The control	GA	ccc	Camposan	GA + CCC	GA + Camposan
a-Tujene	0.47	0.56	0.48	0.36	0.31	0.37
a-Pinene	1.57	1.61	1.40	1.10	1.05	1.04
Camphene	0.18	0.13	0.09	0.18	0.14	0.20
P-Pinene	0.21	0.10	0.10	0.17	0.14	0.21
Sabinene	0.11	0.14	0.14	0.11	0.14	0.11
A^3-Carene	0.12	0.16	0.14	0.12	0.10	0.10
Myrcene	0.12	0.08	0.06	0.09	0.09	0.09
a-Terpinene	2.60	2.71	2.34	2.17	1.85	1.51
Limonene	0.18	0.08	0.05	0.09	0.08	0.10
P-Phellandrene	1.18	0.67	0.59	0.52	0.48	0.41
1,8-Cyneol	0.31	0.30	0.27	0.23	0.43	0.19
^uc-p-Ocimene	0.08	0.06	0.04	0.07	0.05	0.10
y-Terpinene	0.38	0.54	0.49	0.42	0.16	0.29
p-Cymol	**27.64**	**29.49**	**21.03**	**19.16**	**17.96**	**22.55**
Octenol-3	1.60	0.00	0.67	0.48	0.00	0.08
Citronellal	4.47	5.36	5.41	5.34	6.34	4.31
Linalool	1.10	1.08	1.07	1.19	1.65	1.28
Thymol	**14.19**	**14.62**	**38.12**	**58.31**	**18.63**	**10.22**
Carvacrol	**32.05**	**35.53**	**20.44**	**4.30**	**35.95**	**50.27**

their oxidation and acetification. The total content of these compounds in EO is 90%, and concentration of components in the alternative biosynthesis (linalool and its derivatives) does not exceed 0,5%. Such high geraniol content is due to the genetic factors, and it does not allow exogenous phytoregulators to cause the essential shift in equilibrium of metabolic reactions to the formation of other biosynthetically products. It was found out revealing the increase in menthol mint oil by 5-20% and due to the adequate reduction in menthone concentration (see above).

The exogenous regulation of the oil contents in *D. moldctvicct* L. depends on the growing conditions and accumulation of above-ground mass in the period preceding the treatment with phytoregulators. Under favorable water and thermal conditions for plant cultivation the treatment with retardants and exogenous GA caused the increase in the content of EO up to 0,90-1,25% (0,70% - in the control trial). Under the water stress conditions, plants produced the maximum amount of EO (1-1,12%) according to the genetic type. The treatment with phytoregulators in such conditions resulted in the decrease the oil content in plants up to 1,00-0,70% and simultaneous formation in plants of high amounts of an ABA (1000-10 000 ng/g of crude weight) [14, 15]. (Usually, by the content of an acid in plants varies within the limits of Ю-lOOng/g). Therefore, under the conditions of water deficit *D. moldctvicct* L. produces maximum quantity of EO and the excess of such redundant a geranylpirophosphate is transformed in to ABA.Under favorable growing conditions and accumulation of biomass the treatment plants with phytoregulators results in transformation of the predecessor in to EO biosynthesis.

The EO component structure of *D. moldctvica* L. is poorly subjected to the influence of the external factors, however, under the stress conditions, the change in oil components ratio is observed for the other essential oil crops as coll. Under the water deficit and because of phytoregulators the aldehydes content (geranial, neral) in the oil of *D. moldctvica* increases but ethers concentration (geranylacetate) reduces correspondingly. Under optimum growing conditions and biomass accumulation, and by treatment retardants, the biotransformation EO components has the irrevers able relation, that is ether content increases and the aldehydes concentration reduces (tabl. 5).

Table 5

Influence of regulators of growth of plants to a structure of Essential oil *Dracocephalum moldavica* L., %

Component Name	The control	GA	Camposan	CCC	GA + Camposan	GA + CCC
Octanol-3	0.15	0.21	0.20	0.12	0.17	0.13
Octenol-3	0.09	0.14	0.13	0.13	0.11	0.09
a-Copaene	0.09	0.06	0.07	0.08	0.09	0.05
P-Burbonene	0.83	0.36	0.21	0.14	0.38	0.30
Linalool	0.58	0.46	0.43	0.45	0.38	0.47
Bornylacetate	0.34	0.76	0.66	0.89	0.81	0.71
frans-Sabinenehydrate	0.13	0.12	0.10	0.23	0.18	0.14
Is not identified	3.28	1.40	0.74	0.59	0.93	0.77
Neral	19.57	20.68	19.57	21.41	22.55	19.41
/so-Borneol	0.11	0.12	0.09	0.07	0.09	0.06
Verbenone	0.15	0.05	0.07	0.06	0.06	0.05
y-Elemene	2.11	2.18	2.26	2.05	1.95	1.98
Geranial	29.60	29.78	30.20	32.11	33.84	28.66
Geranylacetate	39.14	39.59	39.97	37.65	34.50	43.47
Nerol	0.19	0.17	0.19	0.32	0.19	0.16
Geraniol	3.61	3.86	5.10	3.63	3.70	3.56

Many wood cultures have a rather permanent component structure under cultivation in different soil-climatic zones [15], such cultures as *Dracocephalum moldavica* L., some species of genus *Monarda* L., genus *Agastache* Clayt. and *Lophantus* L. (on condition in case of the correct specification) and others.

So, the comparison of the results of the GLC-MS analysis for plant oil genus *Elsholtzia* growing under the conditions of the Moscow area with the available sample of *El. ciliata* obtained from Leipzig grown the conditions of the Nikitskij Botanical Garden and or the sample of *El. patrini* from the Sukhumi experimental station has shown stability of this species in the EO components and has allowed to refer it to *El. ciliata* Thunb. [1, 6]. The ratio of main oil components in the studied sample (elsholtziaketone (11,9%) and naginatoketone (74,3%)) has the shift to the formation of naginatoketone and serves as an indication of *El. ciliata*. The remaining EO components contained in small quantities, also are characteristic for the given species. The derivatives of furane are seldom found in EO and are considered to be characteristic for these genus *Elsholtzia* and *Perilla*.

All forms of this type of the family of lamiacea as *Agastache* Clayt. and *Lophanthus* Adans contain in the overgrown part of the plants a significant quantity of essential oils. The introduction experiment showed that the plants under the conditions of Moscow region pass the complete cycle of development and they possess productivity not lower than in the regions of industrial cultivation.

The models EO of these forms differ in essence in the content EO components [2]. In *A. foeniculum* oil prevail three basic component: isomenthone (30%), methylchavikol (25%) and methyleugenol (18%); the sufficiently high content ofthe terpene hydrocarbon of limonene (5,5%); aldehydes and ketones - citronellal (4,5%), pulegone (8,0%), piperitone (0,2%), /-carvone (0,3%); alcohols and their ethers - oktenol-3 (1,3%), geranyl acetate (0,4%), geraniol (0,2%), eugenol (1,0%).

A. nigosa oil consists practically of the same components, but in oil of this form prevails one basic of components - isomenthone (70%). The presence of comparatively small quantities of citral (10%), pulegone (5,5%), /-carvone (1,6%), methyleugenola (1,8%), eugenol (0,6%), limonene (0,5%) determines the specific smell of oil.

The presence in the essential oil of the model of the plants of those introduced in the Moscow region, of pulegone (47%), isomenthone (29%) and limonene (9,5%) as basic components, practical absence of methyleugenola (0,3%) and a small quantity of estragol (0,4%), they made it possible to carry it to the form of *Lophantus of chinensis*.

The wide collection of connections makes it possible to assume the possibility of the biotransformation of the components of essential oil under the effect of the growth regulators actions.

The preharvesting treatment of plants by the preparation of 2-CEPC caused changes in the nature of the biosynthesis of components, what was reflected in their numerical ratio (pulegone - 26%, isomenthone - 40%, limonene - 0,4% and methyleugenol - 2,5%).

Under the action of 2-CEPC in the biosynthesis of essential oil, as a result change in the hormonal balance, appears the intensive process of phosphorylase activation of those transforming geranylpirophosphate into geraniol and geranyl acetate. The basic pool of limonene practically completely is expended on the formation of pulegone and isomenthone. As a result increase in the activity the cytochrome P-450 systems, /-limonene practically completely are hydroxylated with the subsequent oxidation by operator ferments to ketone (isopiperitone) of that restoring with the participation NADH into the cv.v-isopulcgonc. which, in turn, will be isomerized with the passage of homoallyl connection into the allyl with the formation of pulegone. The high activity of ferments at these stages explains the absence in oil of intermediate products. Treatment retardant activates the reductases of allyl restoration according to the double bonds with the participation NADH. As a result a significant quantity of pulegone is restored into isomenthone.

Conclusions

The conducted research has shown that the introduction of essential oil crops from the southern regions into the northern areas practically does not cause any changes in their EO component structure. Only slight deviations are observed in the content of some terpenoids oils.

In order to achieve the maximum bio-productivity in ontogeny of essential oil crops it is recommended to apply a two-stage technology for crop cultivation. For the plants producing terpenoids volatile oils it is necessary to ensure the conditions for obtaining the maximum yield of the above ground plant part at the first ’’growing” vegetative stage, synthetic growth regulators being of practical value. At the second “biosynthetic” stage, as a rule, at the generative stage before crops harvesting one should inhibit the plant growth by application of phytoregulators of the retard type in order to stimulate the accumulation of the secondary metabolites in the above ground plant portion. The growth inhibition of essential oil crops in the pre-harvest period influences the management strategy of the production process and bio-productivity as the integral function of high terpenoids yield and concentration in raw materials.

Exogenous pre-harvesting treatment of crops with growth regulators allows, in some cases, to influence purposefully the biosynthesis activity of some terpenoids increasing the content of more valuable EO components.

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ИССЛЕДОВАНИЕ ЛЕТУЧИХ МАСЕЛ НЕКОТОРЫХ ЭФИРОМАСЛИЧНЫХ КУЛЬТУР В НЕЧЕРНОЗЕМНОЙ ЗОНЕ РОССИИ

Аннотация: с помощью метода ГЖХ-МС исследован состав эфирных масел и его изменение в онтогенезе и под экзогенным воздействием на растения препаратами ретардантного типа в предуборочный период пяти сортов Mentha piperita L., Monarda didyma L., Monarda citriadora Cerv, Dracocephalum moldavica L., Agastache Clavt., Lophanthus Adans., Elsholtzia ciliata Thunb. При интродукции эфиромасличных культур из южных районов в более северные регионы компонентный состав их ЭМ практически не претерпевает изменений. Наблюдаются лишь незначительные отклонения в содержании некоторых терпеноидов масел. Экзогенная предуборочная обработка растений регуляторами роста позволяет в некоторых случаях целенаправленно влиять на активность биосинтеза тех или иных терпеноидов, повышая содержание наиболее ценных компонентов ЭМ.

Ключевые слова: КЖХ, МС, эфирное масло, терпеноиды, ретарданты, эфиромасличные культуры, мята, монарда, многоколосник, лофант, эльшольция, змееголовник.

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