Compacted crops of medicinal and essential oil crops

Maria Yurkevich[1*], *Tatiana* Popova[1], and *Ekaterina* Kholoptseva[1]

[1]Karelian Scientific Center of the Russian Academy of Sciences, Petrozavodsk, Russian Federation

Abstract. The characteristics of the growth and development of medicinal and essential oil plants in mono and compacted crops in open ground were studied. Compacted cropping involves the joint cultivation of two (binary) or more crops in one field. Compared to monospecies crops, this method effectively solves the problems of increasing productivity and plant resistance to stress. Purpose of the work: to establish the allelopathic effect of medicinal and essential oil plants in dense sowing. The experimental methodology included the joint cultivation in open ground of medicinal main crops - spearmint (*Menthaspicata* L.), lemon balm (*Melissaofficinalis* L.), garden strawberry (*Fragariachiloensis* L.), and calendula officinalis (*Calendulaofficinalis* L.) were chosen as complementary crops.), dill (*Anethumgraveolens* L.). Compacted crops significantly reduce the intensity of transpiration and stomatal conductivity of the main crops. The intensity of photosynthesis largely depends on the species characteristics of the plants, so strawberry plants in binary crops increased photosynthetic activity, while mint and lemon balm on the contrary, they increased the intensity of photosynthesis during monospecies cultivation. According to the results of the studies, the inhibitory effect of calendula officinalis plants in binary crops with lemon balm, spearmint, and garden strawberries was established. At the same time, the use of dill in binary crops increases the yield of spearmint and lemon balm.

1 Introduction

Currently, various methods and methods of growing crops are being actively introduced to reduce economic costs and maintain a favorable environmental situation [1]. One of the modern directions in the development of agricultural technologies is the introduction of compacted and joint crops [2]. The joint cultivation of diverse species, but correctly selected for biological and economic characteristics, ensures a more complete use of light, moisture, food and other environmental conditions by plants. Joint crops are less inhibited by weeds and better withstand unfavorable conditions. Properly formed crops can increase soil fertility and productivity of agrocenoses [3]. Compacted cropping involves the joint cultivation of two (binary) or more crops in one field. Compared to monospecies crops, this method effectively solves the problems of increasing productivity and plant resistance to stress. In compact sowing, plants interact with each other, using soil fertility more fully,

* Corresponding author: svirinka@mail.ru

since the root system of different crops develops in different soil horizons and the above-ground mass of plants generates solar energy in different tiers. However, the effectiveness of compacted crops is determined primarily by the allelopathic influence of the cultivated species. Since crops in compacted crops influence the chemical and physical factors around them, creating a self-sufficient phytocenosis [4].

We have studied the characteristics of the growth and development of medicinal and essential oil plants in compacted crops in open ground.

Medicinal and essential oil crops have been used in pharmaceuticals for a long time [5]. Despite the sufficient distribution of synthetic drugs, the share of plant raw materials remains high - more than 40% [6]. The value of medicinal plants only increases every year, so it is important to obtain a sufficient amount of high-level medicinal raw materials [7]. All this encourages the introduction of compacted sowing of medicinal plants.

The main factor when growing joint crops is the influence of neighboring crops on each other, identifying positive and negative properties [8]. Therefore, the purpose of our study was to establish the allelopathic effect of medicinal plants of the studied species in dense sowing.

2 Materials and methods

The main crops studied were spearmint (*Menthaspicata* L.), lemon balm (*Melissaofficinalis* L.) variety Freshness, garden strawberry (*Fragariachiloensis* (L.)) Mill), variety Solovushka.

Complementary crops — *Calendula officinalis* L., variety Apricot jam, dill (*Anethumgraveolens* L.), variety Alligator.

Mono crops of the main crops (3 options) were used as a control; binary crops consisted of the main and complementary crops (6 options). The age of perennial plants is the first year of life. Each crop was sown with a row spacing of 35 cm, the distance between plants in a row was 15 cm.

Complementary crops were sown two weeks after planting the main crop.

During the experiment, the dynamics of plant growth and phenophases were noted.

Plant productivity was taken into account. Mint, lemon balm and dill have a vegetative mass of plants, strawberries have a mass of fruits, calendula has a mass of flowers and seeds.

In a field experiment on the main crops of compacted crops, the physiological parameters of plant development were determined: the intensity of net photosynthesis, the intensity of transpiration, and stomatal conductance were studied using a portable system for studying CO_2 gas exchange and water vapor (HCM-1000, Germany). The maximum quantum yield of photochemical activity of PS II (Fv/Fm) was measured with a MINI-PAM fluorimeter (Walz, Germany) on dark-adapted leaves. Total chlorophyll concentration was determined using a SPAD 502 Plus chlorophyll meter (Konica Minolta, Japan).

3 Results

The soil of the experimental plot is a texturally differentiated typical deep-arable, medium-skeletal, medium-loamy agrozem on a loamy moraine. According to the degree of acidity in the salt extract, the soil reaction is strongly acidic ($pH_{sol.}$ - 4.10, $pH_{act.}$ - 6.06), according to Grishin and Orlova (1978) the soil is characterized by an average humus content (3.38%), according to the C:N ratio, the supply of humus with nitrogen is very low - 16.3, according to Kirsanov (Methodological instructions..., 2003) has a very high content of mobile phosphorus - 285 mg/kg and an average content of exchangeable potassium - 116 mg/kg.

The influence of mono and binary crops on the characteristics of phenological development of plants, linear growth, and biometric indicators of plants has been established.

Analysis of the dynamics of linear growth of medicinal plants showed the influence of species characteristics on this indicator in mint, lemon balm, and strawberry plants (Figure 1).

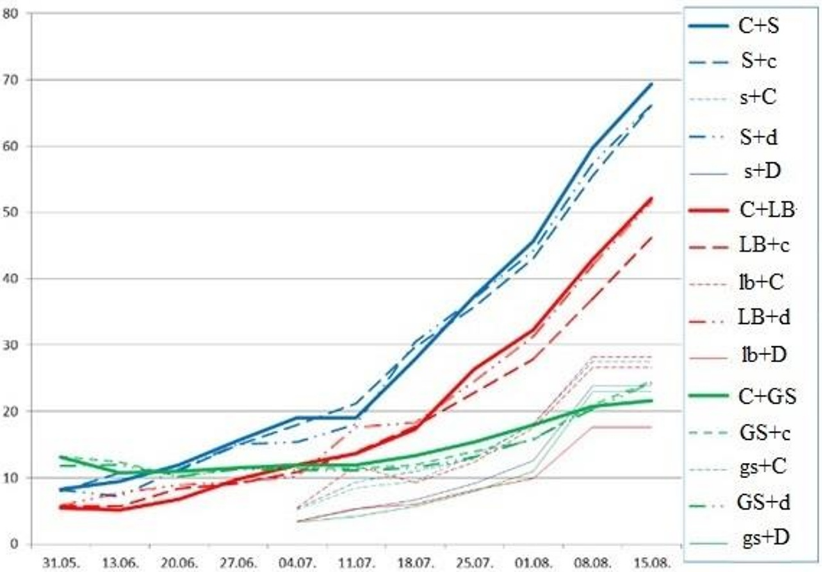

Fig. 1. Dynamics of linear growth of medicinal plants in compacted crops, where C is control, S is spearmint, LB is lemon balm, GS is garden strawberry, D is dill, C is calendula officinalis. In binary sowing, the capital letter is the species being measured..

The productivity of the species was determined. For spearmint plants in the control mono-sowing, the average yield was 600 g/m^2 (Figure 2). In compacted crops it varied from 545 to 750 g/μm. depending on the binary culture (Figures 2-3). When growing lemon balm, the average indicators were: in mono sowing - 380 g/m^2, in binary sowings - from 200 to 410 g/m^2. The yield of garden strawberries in the control variant (mono sowing) was 45 g/m^2, and in the variants with complementary crops it varied from 36 – 39 g/m^2.

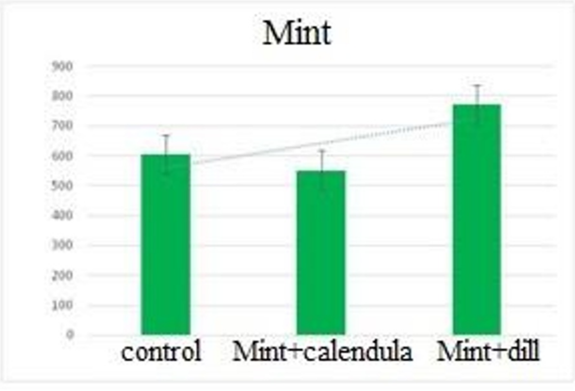

Fig. 2. Productivity of spearmint, g/m^2, where K is the control option.

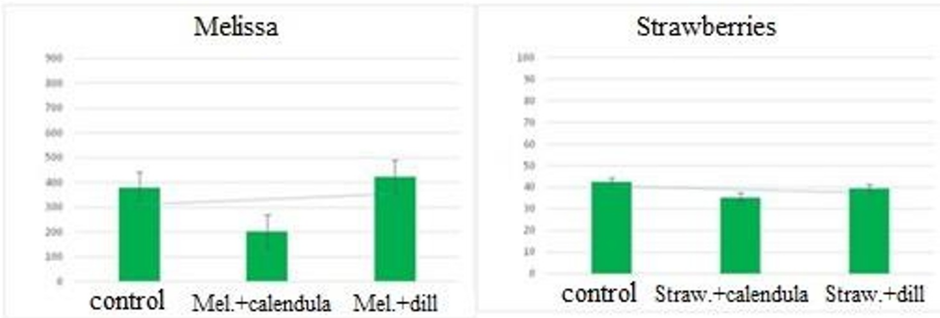

Fig. 3. Productivity of medicinal species in compacted crops, g/m^2, where K is the control variant of the studied species, chalk. – lemon balm, earth. -garden strawberries.

In a field experiment on the main crops of compacted crops, the physiological parameters of plant development were determined: the intensity of net photosynthesis, the intensity of transpiration, stomatal conductance, photosynthetic efficiency of water use (Figure 4).

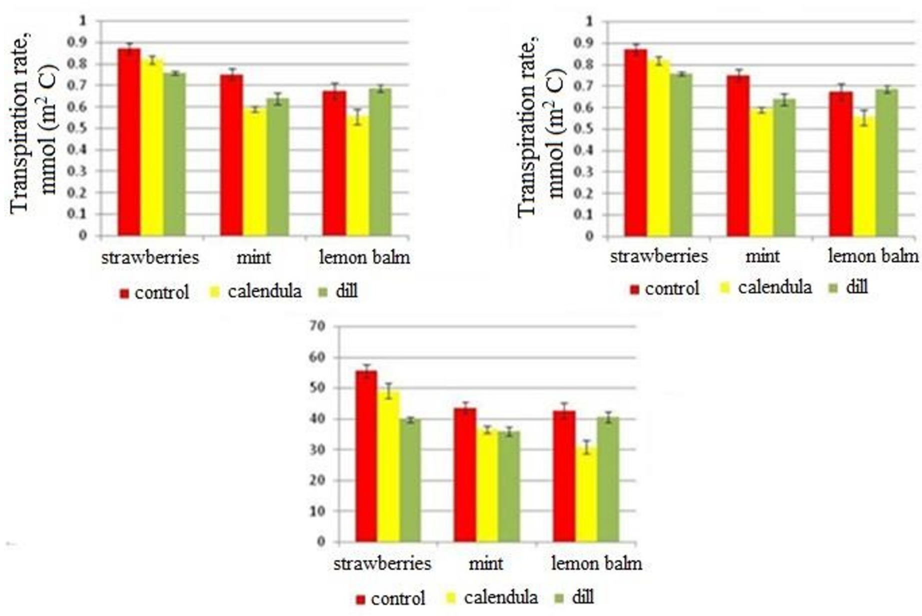

Fig. 4. Transpiration rate and stomatal conductance of plants, mmol (m^2 C).

4 Discussion

The plant species we studied belonged to different families and species, thereby possessing different morpho-biological properties and having different chemical compositions.

Thus, mint in the vegetative part of the plant contains up to 2–3% menthol, and in the inflorescences up to 6% essential oil, the main component of which (45–92%) is menthol [9]. Causes moderate sedative, antianginal, carminative, antihypoxic effects, choleretic, antiseptic, analgesic, antiemetic effects [10].

 https://doi.org/10.1051/e3sconf/202451003023

Calendula officinalis has antiseptic, wound healing, sedative, antispasmodic, mild hypotensive effects, normalizes cardiac activity and reduces swelling, accelerates tissue regeneration processes, and promotes faster epithelization [11]. The wide range of medicinal properties of calendula is explained by the presence of a large number of biologically active substances that are very different in chemical nature and pharmacological action [12].

With all the variety of vitamins found in garden strawberry fruits, it is valuable as a source of ascorbic acid, folic acid, polyphenolic compounds (anthocyanins, ellagic acid), and iron mineral elements [13].

Dill is widely used in medicine. The use of tincture from the fruits of dill increases the secretion of the digestive glands, has an antispasmodic, carminative, and expectorant effect due to the high content of essential oil [14].

We used the above plant species in compacted crops, in which the allelopathic influence of the species takes place. The influence of cultures on each other can change over time. According to Belyuchenko, the competitiveness of plants varies depending on three types of crop density: compacted in space, compacted in time, compacted in space and time [15].

The thickening of such crops has a direct impact on the physiological characteristics of plant growth and development. Our studies have established a significant decrease in the intensity of transpiration and stomatal conductance of the main crops in binary crops. The intensity of photosynthesis largely depended on the species characteristics of the plants, so strawberry plants in binary crops increased photosynthetic activity, while mint and lemon balm, on the contrary, increased the intensity of photosynthesis when grown in monospecies (Figure 3).

Growing calendula officinalis as a compacting crop significantly reduces the yield of lemon balm ($p=0.0484$) by 46.4%, with binary crops with spearmint by 10.6% ($p=0.729$) and strawberries - 4.9% ($p=0.897$)). Binary crops had no effect on calendula officinalis plants; plant height ($p=0.218$) and the yield of calendula inflorescences per plant did not differ significantly in these options ($p=0.861$).

At the same time, the use of dill in binary crops increases the yield of spearmint and lemon balm (Figure 2).

5 Conclusion

Based on the results of the studies, the inhibitory effect of calendula officinalis plants in binary crops with lemon balm, spearmint, and garden strawberries was established. At the same time, the use of dill in binary crops increases the yield of spearmint and lemon balm.

Acknowledgement

The study was supported by a grant from the Russian Science Foundation 23-26-10057

References

1. R. Priyatharshini, L. Pradheeban, K. Nishanthan, Suitability of Different Rooting Media and Length of Cuttings on Growth and Yield Performance of Mint (sp) Mentha p. (2020)
2. Ya.P. Lobachevsky, A cost-effective and environmentally sound method of compacted sowing of agricultural crops, Agricultural Machines and Technologies, **6**, 4 (2015)

3. V.I. Turusov, V.M. Garmashov, O.A. Abanina, Compacted and stubble crops as a method of increasing the efficiency of crop rotation, Combined cropping of field crops in crop rotation of the agricultural landscape, 44 (2016)
4. G.A. Dudenko, T.N. Kirtaeva, Plant compatibility as an element of creating symbiotic agriculture, Organic agriculture: from idea to implementation, Materials of the International Round Table, 88 (2023)
5. R.V. Razzhivin, Possibility of using specific markers of certain types of medicinal plant raw materials in the analysis of multicomponent herbal infusions and herbal teas, Bulletin of Moscow University, **2**, **50**, 129 (2009)
6. R.K. Abipov, Medicinal plants and their healing properties, World Science, **9**, 66 (2022)
7. E. V. Cherkashina, Problems of development of essential oil production in Russia, Scientific notes of Petrozavodsk State University, **2**, 139 (2014)
8. B.Kh. Akhalaya, A.P. Spirin, O.A. Sizov, Agroecological and energy efficiency of compacted crops, Proceedings of the international scientific and technical conference Energy supply and energy saving in agriculture, **2**, 78 (2012)
9. N.I. Bochkarev, S.V. Zelentsov, T.P. Shuvaeva, A.P. Borodkina, Taxonomy, morphology and selection of menthol mints (review), Oilseeds, **2**, 162 (2015)
10. Kh.N. Gyulbyakova, Phytochemical study of mint herb, Mnizh, **1-2**, 115 (2022)
11. A.V. Abramchuk, M.Yu. Karpukhin, Comparative assessment of varieties of calendula (calendula officinalis L.), AVU, 2, 144 (2016)
12. V. Filipović, Productivity and flower quality of different pot marigold (Calendula officinalis L.) varieties on the compost produced from medicinal plant waste, Industrial Crops and Products, **192**, 116 (2023)
13. M.Yu. Akimov, Garden strawberry fruits (Fragaria× ananassaDuch.) as a valuable source of nutritional and biologically active substances (review), Chemistry of plant raw materials, **1**, 5 (2020)
14. O.N. Jolimbetov, T.T. Davletov, Medicinal value of aromatic dill (Anethum Graviolens L.), Theory and practice of modern science, **6**, 100 (2021)
15. I.S. Belyuchenko, Competition of plant species in mixed crops, Ecological Bulletin of the Northern Caucasus, **3**, **10**, 85 (2014)