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The perspectives of *Nigella sativa L.* growing in the climatic conditions of the Precarpathian Region

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Abstract
We established that the climatic conditions of the Precarpathian region are favourable for *Nigella sativa L.* growing by seeds and seedlings. We used in our study the conventional methods of plants propagation by seeds and seedlings in both laboratory and field conditions. The research results indicate that the field germination of *Nigella sativa L.* seeds (18-21%) is less than germination in laboratory (38-42%) conditions. This is due to the low germination energy of these seeds (12-15%). We discovered that the temperature from 5 to 8 °C is the best one for *Nigella sativa L.* seeds early spring sowing. We observed the mass seed germination at a temperature of 12-18 °C and soil moisture of 60%. The plants grew well and resulted in a good yield. The seedlings of *Nigella sativa L.* planted in the mid-April showed the best rooting (75%), blossoming and forming of valuable seeds.

Keywords: *Nigella sativa L.*, seeds, sowing period, seed germination energy, seedlings growing.

1. Introduction
It is known that the plant materials quality depends on cultivation parameters. This is especially important for the industrial cultivation of medicinal plants. Today, one of the main objectives of pharmacognosy is the development of parameters for the cultivation of medicinal plants used in pharmaceutics. Therefore, the study of biological characteristics of *Nigella sativa L.* propagation and cultivation in soil-climatic conditions of the Precarpathian region plays a very important role for this medicinal plant's resource base development.
Nigella sativa L. species of the Ranunculaceae family are common for the Eurasian continent, particularly for the Mediterranean Europe and East Asia. Southern Europe is the birthplace of Nigella. The most investigated species of the family are: *Nigella arvensis L., Nigella carpatha Strid., Nigella damascena L., Nigella degenii Vierh., Nigella elata Boiss., Nigella fumariifola Kotschy, Nigella glandulifera Freyn & Sint., Nigella hispanica L., Nigella latisecta P.H. Davis, Nigella nigeellastrum (L.) Willk., Nigella orietalis L., Nigella oxypetala Boiss., Nigella segetalis M. Bieb., Nigella stricta Strid., Nigella ungicularis (Poir) Spenn., Nigella papilosa G. Lopez, Nigella sativa L.* [1 – 3]. Three species of the abovementioned grow in southern Ukraine. In 1985, *Nigella sativa L.* was cultivated in Ukraine for the first time as an ornamental, medicinal and ether-bearing plant [2].
Since ancient times the seeds of *Nigella sativa L.* were used for flavouring dishes, baking cookies and bread, cooking etc. Herbs were used as a seasoning for salads, soups and other dishes. Essential oil of *Nigella sativa L.* with a characteristic raspberry smell is used for making soap and perfumes. The leaves of *Nigella sativa L.* were used in folk medicine as a component added to the snuffing tobacco, which was recommended in case of rhinitis, headache, hypertension etc. The seeds of the plant are used in medicine as a diuretic, choleretic, galactopoietic, apocathartic and antihelminthic. Nigella seeds decoction has a vasodilatory action. Nigella herbs infusion improves cardiac function and strengthens the immune system [1 – 5]. Nigella seeds are used in homeopathy in case of gastrointestinal, gall-bladder or liver disease [3, 5].
Seeds and essential oil of *Nigella sativa L.* is widely used in pharmaceutics.
The objective of our study is to analyze the methods of *Nigella sativa L.* propagation by seeds and seedlings with further planting in the open ground under existing climatic conditions of the Precarpathian region.

2. Materials and Methods. The seeds and seedlings of *Nigella sativa L.* are the objects of our research. The seeds of *Nigella sativa L.* were harvested on medicinal plants test plots of the Dendrological Park named after Z. Y. Pavlyk of Vasyl Stefanyk Precarpathian National University in 2011 –2013 years during their germination period.

The seeds were standardized in accordance with the international seeds standardization rules [6 – 9]. The germinating ability of seeds was laboratory tested by means of Petri dishes [6, 7]. The technique involves the seeds of *Nigella sativa L.* warming process first inside the thermostat (germination chamber) for the period of seven days at a temperature of 45 ºC, and then put inside the Petri dish on a damped paper, thus providing the constant temperature of 24-26 °C. When the seeds sprout, their germinating ability is determined.

We carried out the experiments with *Nigella sativa L.* seedlings growing in accordance with the standard technique [8, 9]. The seedlings growing process starts with *Nigella sativa L.* sowing in seedling boxes filled with mixed soil [6, 8]. The optimum temperature after seeding and when first seeds sprout is 24-26 °C. After the cotyledons opening the temperature is lowered to 18-20 °C in the daytime and to 15-16 °C in the night time. The temperature is increased in 7-10 days to 20-22 °C in sunny weather, 18-19 °C in cloudy weather, and 17-18 °C in the night time. The seedlings are pricked off when the first true leaf appears. After the pricking off the distance between the plants should be enough to keep the latter from shading each other. When the seedlings are at the stage 8-11 true leaves, they are transplanted in a permanent place [8]. The transplanted *Nigella sativa L.* seedlings got watered with warm water and shaded for the period of 2 days.

You can grow the seedlings without pricking them off, but then the seeds should be sown in pots with the diameter of 8-10 cm. The terms of seedlings growing in pots are the same as of boxes (see the previous paragraph). When the first buds appear, the temperature is lowered to 18-20 °C in the daytime and to 16 °C in the night time. The soil optimum temperature is 18-20 °C. The watering of seedlings is dramatically reduced 10 days before transplanting as well as lowered the temperature. The seedlings age, which constitutes from 8 to 10 weeks, depends on the pot size, growing period, and growing conditions. When the seedlings are in phase 8-11 true leaves, they are transplanted in a permanent place [6 – 9].

3. Results and Discussion. The experimental study of methods of Nigella sativa L. propagation and cultivation on test plots of the National Dendrological Park "Druzhba" named after Z. Y. Pavlyk of Vasyl Stefanyk Precarpathian National University has been carried out. Due to the low humus content the soils of test plots are poor in nitrogen and nutrients, and the acidic reaction of the soil solution depresses the nitrification processes. Therefore, the accumulation of labile phosphorus compounds in soils is done slowly. The content of labile phosphorus compounds in these soils is 4,7-6,5 mg per 100 g of soils, labile potassium compounds – 4,3-6,3 mg per 100 g of soil. The soils were chalked and introduced with organic and mineral fertilizers to improve the fertility of the first. We propagated *Nigella sativa L.* by seeds and seedlings [6, 8].

***Nigella sativa L.* propagation by seeds**. We followed the process of seed germination in the laboratory environment. The results of our study indicate that the process of *Nigella sativa L.* seed germination is as follows:

- swelling, seeds absorb water actively;
- conversion, water absorption nearly stops and the process of seed's reserve constituents conversion in a readily available form starts;
- germination, when the stemlet starts to grow, water absorption processes restart, and the growing process begins.

Germinating ability and germination energy are the main indicators of seeds sowing qualities. The germinating ability of seeds was laboratory tested by putting them inside the Petri dish on a damped paper. The total weight of 1000 seeds was 0,40 g. The study results are presented in Table 1.

Table 1: *Nigella sativa L.* seeds germination and germination energy

Species	Seed germination, %	Seed germination energy, %		Weight of 1000 seeds, g
	Laboratory	Field		
Nigella sativa L.	38 – 42	18 – 21	12 – 15	0,40

The study results indicate that *Nigella sativa L.* seeds have a very low laboratory (38-42%) and field germination (18-21%). The seed germination energy is also low (12-15%), that is why it is necessary to sow the seeds on weed-free plots, otherwise the sprouts will be depressed and behind in development.

It is known that the seeds sown in the open ground face with another germination conditions. First of all, the rate of seeds germination in soil depends on water and temperature regime, which, after all, affects the field germination and seed friendliness [8].

According to the results of our studies we found out that the fastest sprouts of *Nigella sativa L.* appear upon condition that the soil moisture is 60%. The sprouts appeared in 7 – 11 days and field germination constituted 49%. Soil moisture reducing to suitable 40% of moisture capacity hampered the sprouts germination to 9 – 12 days, which influenced the field germination reaching 31%. This phenomenon was observed in the dry summer period of 2012 – 2013 years. Soil moisture increasing to 80%, if compared with 60% of moisture capacity, also negatively affected the sprouts germination. This was observed in 2011 and 2014, when the field germination of Nigella seeds decreased by 21%. The reason for this is that soil moisture increasing to 80% inhibits the oxygen supply to the seeds, and the germination process is delayed. We observed the partial destruction of sprouts due to rotting seeds.

Thus, soil moisture decreasing or increasing other than 60% will be unfavorable for *Nigella sativa L.* seeds germination.

We know that seeds during their germination demand not only correct soil moisture, but correct air temperature as well. We know that seeds germination starts under the temperature of 3 – 5 °C. Therefore, they can be sown early in the spring [7, 8]. Seeds sown in the early sowing period tend to temper in the soil, seedlings sprout earlier as compared with the late sowing period, and temperature fluctuations are better tolerated. To study this question we analyzed the influence of air temperature on the seeds germination intensity and field germination (Table 2).

Table 2: Influence of air temperature on the duration of *Nigella sativa* L. seeds germination and field germination (average value for the period of 2011-2014 years)

Rates	Temperature, °C					
	5	**8**	**12**	**18**	**25**	**30**
Seeds germination beginning (average value for the period of 2011-2014 years), days	18	14	11	8	13	15
Massive seeds germination (average value for the period of 2011-2014 years), days	24	19	16	12	18	22
Field germination (average value for the period of 2011-2014 years), days	38,7	42,0	41,85	48,75	51,5	36,6

We established that Nigella seeds can be attributed to the second group of plants due to their heat demand criteria. The results of our studies indicate that the seeds of *Nigella sativa L.* put in the climatic conditions of the Precarpathian region began to sprout at the air temperature of 5 – 8 °C. The early seed germination period was 14 days, whereas massive seeds germination appeared in 24 – 19 days respectively. With air temperature increasing to 10 – 12 °C and even 18 °C optimal early germination conditions were created and the germination period constituted 10 and 7 days respectively. Massive seeds germination appeared in 16 and 12 days respectively. We observed Nigella seeds field germination increasing. At the temperature of 12 °C the field germination was 41,7%, at a temperature of 18 °C – 48,6%. With air temperature increasing to 25 – 30 °C we observed the decreasing of seeds germination rates, massive seeds germination, and field germination.

Experimental data suggest that the early growth and development of seeds regardless of the variant was almost simultaneous with the difference in the phenological phase occurrence rate within the experimental accuracy of 1 – 3 days.

***Nigella sativa L.* seedlings growing.** The seedlings growing process starts with *Nigella sativa L.* sowing in seedling boxes filled with mixed soil. Prior to sowing the soil was fertilized and marked in separated from each other (5cm) rows with a depth of 1 cm, and the seeds sown in a row every other (1) centimeter. When the seeds were sown and at the time of their germination the temperature inside the greenhouse was maintained at the level of 24-26 °C with the soil moisture of 60%. When the first true leaf appeared, we pricked off the seedlings. 10 days before transplanting the seedlings we dramatically reduced the watering as well as lowered the temperature to 18-20 °C in the daytime and to 16 °C in the nighttime, which contributed to the tempering of plants. When the seedlings were at the stage 8-11 true leaves, they were transplanted in the field.

The seedlings of *Nigella sativa L.* planted the field in early spring resulted in 60% rooting. The plants showed good blossoming and blossoming and forming of valuable seeds. The seedlings of *Nigella sativa L.* planted in the middle of April resulted in 75% rooting if periodic watering was maintained. The intensive growth of plants started in the second half of summer. The plants showed bloom and form a full seed. The seedlings of *Nigella sativa L.* planted in May-June resulted in bad rooting. Their development was stagnated. The seedlings planted in early May resulted in bad rooting (33%) and slow growing, thus forming small and abortive seeds. The seedlings planted in June resulted only in 38% rooting, developed slowly, were weak and low-yield.

Thus, the Precarpathian region is recommended for planting *Nigella sativa L.* seedlings in the mid-April with further plants watering until fully rooted in dry years. In general, *Nigella sativa L.* can be propagated by seeds and seedlings.

4. Conclusions. We can make a conclusion that the climatic conditions of the Precarpathian region are favourable for *Nigella sativa L.* growing with the purpose of its resource base development.

1. From the laboratory results it is concluded that *Nigella sativa L.* seeds have low germination energy (12-15%), which leads to a poor laboratory (38-42%) and field (18-21%) germination of *Nigella sativa L.* seeds respectively.
2. The research results indicate that *Nigella sativa L.* can be propagated by seeds and seedlings. Sufficient watering and sprouts weeding are two necessary conditions.

It is suggested that *Nigella sativa L.* seeds should be sown in early spring. The temperature from 5 to 8 °C and 60% of soil moisture are the best conditions for seeds sowing. The field germination of seeds rises to 48,6% with the temperature increased to 18 ºC.

3 The research results suggest that the seeds germination rates (massive and field germination) worsen with the temperature increased 25-30 °C. Soil moisture decreased to 40% or increased to 80% doesn't help to improve the seeds germination rates.

4. The seedlings of *Nigella sativa L.* planted in middle of April resulted in the best rooting (75%). All plants showed good development, blossoming and forming of valuable seeds.

In our view it would be reasonable to carry out a phytochemical investigation of the plant and its seeds for the biologically active substances content to determine the quality of *Nigella sativa L.* seeds grown in the Precarpathian region.

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