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UDC 595.796:591.524.12(575.1)
DOI: https://doi.org/10.17721/1728.2748.2026.105.5-8

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STORAGE DURATION AND SEED GERMINATION OF SMALL-FLOWERED OREGANO (*ORIGANUM TYTTANTHUM*) IN THE KARSHI REGION

B a c k g r o u n d *. The development of Uzbekistan's pharmaceutical industry based on local natural raw materials, reduction of import dependence, and enhancement of export potential require the scientifically justified introduction of promising essential oil-bearing species into cultivation. The small-flowered oregano (Origanum tyttanthum Gontsch., Lamiaceae), endemic to Central Asia, is a valuable essential oil plant. Its essential oil is characterized by high contents of carvacrol, thymol, and other terpene components, which determine its antiseptic and technologically important properties. At the same time, natural populations of the species are subject to significant anthropogenic pressure, while the effective establishment of industrial plantations requires the development of a reliable seed production base. Key indicators of seed quality include storage duration and germination dynamics, which may vary substantially under the arid continental climate conditions of the Karshi region. This study aimed to determine the optimal age of O. tyttanthum seeds for sowing under the conditions of the Karshi region, to assess the effects of different storage regimes on laboratory and field germination, and to characterize the early growth dynamics of embryonic organs after spring sowing.*

M e t h o d s *. Seeds of small-flowered oregano (O. tyttanthum), collected in 2020–2024 in the mountainous areas of the Kashkadarya region, were stored at room temperature (+18+22 °C) and under refrigerated conditions (+4 °C). Germination was determined under laboratory conditions (in Petri dishes) and in field experiments by counting seedlings emerging from the experimental plot. The growth dynamics of the embryo, cotyledons, and the hypocotyl–root complex were recorded over 30 days in sowings established on 25 March 2024. The obtained data were processed using descriptive statistical methods and presented as ranges of values.*

R e s u l t s *. When stored at room temperature, the laboratory germination of freshly harvested seeds of small-flowered oregano was 7-9%, increased to 32-38% by the third month, and reached a maximum of 78-82% by the twelfth month; field germination during this period was 74-80%. After 18 months of storage, a gradual decline in germination was observed (laboratory: 70-78%; field: 62-70%), while after 36 months, a sharp decrease in seed viability occurred (30-40% and 22-34%, respectively). Under refrigerated storage (+4 °C), seeds retained high viability even after 36 months of storage (86-89%). The most intensive growth of embryonic organs was observed between 22 and 30 days and showed a clear correlation with an increase in temperature to 24-28 °C and with higher soil moisture following irrigation.*

C o n c l u s i o n s *. The optimal seed age of small-flowered oregano (O. tyttanthum) for sowing under the conditions of the Karshi region is 6-15 months after harvest. For long-term storage of seed material, a cold storage regime (+4°C) is recommended, as it significantly slows down aging processes. The obtained results are of practical importance for the development of a seed production base and the introduction of small-flowered oregano into cultivation.*

K e y w o r d s *: small-flowered oregano (Origanum tyttanthum), seeds, germination, storage, Karshi region, arid climate, early growth.*

Background

Scientific literature emphasizes that essential oil plants of the family Lamiaceae possess considerable potential for use in medicine and the food industry; however, their reproductive biology, particularly aspects of seed reproduction, remains insufficiently studied (Baskin, & Baskin, 2014). Studies on endemic Lamiaceae species of Central Asia indicate a combination of high adaptability to extreme environmental conditions and, at the same time, increased sensitivity of reproductive structures to temperature stress (Skoula et al., 2022). Recent studies on germination optimization in Lamiaceae species, including *Origanum onites*, *Lavandula stoechas*, and *Ocimum basilicum*, have demonstrated that seed priming and pre-sowing treatments can significantly enhance germination uniformity in this family (Ekren et al., 2024). The effects of seed moisture content and storage duration on germination have also been studied in the *Lallemantia* species (Lamiaceae), confirming that increased moisture during storage markedly reduces viability (Paravar et al., 2024). Nadarajan et al. (2023) provide a comprehensive conceptual framework for seed longevity, underscoring that lower temperatures and reduced moisture content are the primary factors extending seed viability across a wide range of species.

Studies on the chemical composition of *O. tyttanthum* indicate the dominance of phenolic components in the essential oil, primarily carvacrol and thymol, which determines the sustained demand for raw materials of this species (Baser et al., 1997; Sharopov et al., 2011). The biological activity of *O. tyttanthum* essential oil, including its strong antioxidant and antimicrobial properties, has been further confirmed by Sharopov et al. (2015), reinforcing its pharmaceutical and industrial importance. At the same time, instability of natural population regeneration is recognized as one of the main limiting factors for the widespread use of the species, highlighting the relevance of research on seed material (Khodzhimatov et al., 2021). The response of seeds to abiotic stresses under arid conditions has been demonstrated in closely related xerophytic taxa, where

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temperature and salinity are key determinants of germination success (Chen et al., 2022), and understanding these germination ecology patterns is crucial for the effective cultivation of medicinal and aromatic plants in water-scarce environments (Tiwari et al., 2022).

At the present stage of development of the pharmaceutical industry of the Republic of Uzbekistan, ensuring the supply of local plant raw materials, reducing import dependence, and increasing export potential are among the priority strategic objectives. Among promising resources, essential oil-bearing plants occupy a special place, as they are rich in biologically active compounds with antiseptic, antispasmodic, and sedative properties. One such species is *Origanum tyttanthum* Gontsch. (Lamiaceae), endemic to Central Asia, a valuable essential oil plant characterized by a high content of carvacrol, thymol, and other terpene components in its essential oil, which determines its wide application in medicine, perfumery, and the food industry (Arabova, & Makhmarazhabov, 2025; Baser et al., 1997; Sharopov et al., 2011).

O. tyttanthum is naturally distributed in the southern and southwestern regions of Uzbekistan, particularly in the mountainous and foothill zones of the Kashkadarya region. In recent years, natural populations of the species have been declining due to excessive harvesting, expansion of grazing areas, and increasing anthropogenic pressure, which necessitate its introduction into cultivation and the development of seed production systems (Arabova, 2024). The Karshi region (the vicinity of the city of Karshi) features a sharply continental climate with hot, dry summers, relatively cold winters, and carbonate-calcareous soils that are favorable to this xerophytic species. At the same time, climate change, as evidenced by rising mean annual temperatures and decreasing precipitation, negatively impacts natural populations and seed productivity. Under arid climatic conditions, high temperatures and low air humidity can accelerate the loss of seed viability. In this context, the study of seed storage duration and germination of *O. tyttanthum* is a relevant scientific and practical task, as these parameters largely determine the success of establishing cultivated plantations.

Aim of the Study. This study aimed to determine the optimal seed age of *Origanum tyttanthum* Gontsch. for sowing under the conditions of the Karshi region, to assess the effects of different storage regimes on laboratory and field germination, and to characterize the early dynamics of embryonic organ growth after spring sowing. For this purpose, the study determined the dynamics of laboratory and field germination of *O. tyttanthum* seeds depending on the storage duration and regime, and described the early growth dynamics of embryonic organs in field conditions after spring sowing.

Methods

The studies were conducted in the Kashkadarya region (Republic of Uzbekistan) during 2020-2024. Seeds of *O. tyttanthum* were collected from natural populations in mountainous and foothill areas of the region. After collection, the samples were stored under two temperature regimes: room temperature (+18+22 °C) and refrigerated conditions (+4 °C).

Laboratory germination was determined in Petri dishes in accordance with standard methods, while field germination was assessed by counting seedling emergence on experimental plots. The early growth dynamics of the embryo, cotyledons, and the hypocotyl-root complex were studied during the first 30 days after spring sowing. The obtained results were processed using descriptive statistical methods, analysis of relative indicators (percentages), and graphical visualization of data.

Results

1. Germination Dynamics Depending on Storage Duration (Room Temperature Regime). The obtained data demonstrate a pronounced nonlinear pattern of germination dynamics, characterized by low initial values in freshly harvested seeds, an increase during the first 6-12 months of storage, and a subsequent decline during prolonged storage at room temperature. This pattern is consistent with the concept of physiological dormancy and post-harvest seed maturation, during which a portion of the germination inhibitors is gradually inactivated.

Table 1

Germination of *O. tyttanthum* seeds under room temperature storage (+18+22 °C; seed moisture content 6–8 %)

Storage period (months)	Laboratory germination (%)	Field germination (%)	Brief explanation of dominant factors
0	7-9	-	Probable physiological dormancy, presence of germination inhibitors
1	18-20	-	Partial post-harvest maturation; possible drying effects
3	32-38	42-48	Adaptation to germination; in the field, more favorable microbiota/substrate
6	75-80	72-78	Optimization of the physiological state of seeds
12	78-82	74-80	Maximum viability under room temperature storage
18	70-78	62-70	Onset of ageing processes; effect of summer heat
36	30-40	22-34	Accelerated ageing, loss of viability

Importantly, during the 6–12-month interval, seeds stored at room temperature exhibited the highest germination rates both under laboratory and field conditions. From a practical perspective, this indicates that when planning sowing for plantation establishment or nursery production, it is advisable to use not freshly harvested seeds but seeds that have undergone a certain storage period sufficient to complete post-harvest maturation.

2. Germination under Cold Storage (+4 °C). The comparative analysis showed that cold storage significantly stabilizes seed viability: even after 36 months of storage, germination remained high (86-89%). This result is consistent with widely accepted concepts that lower temperatures slow oxidative and hydrolytic processes, reduce membrane damage, and preserve the enzymatic potential of seeds. From a practical standpoint, room-temperature storage is acceptable only for relatively short-term storage (12-15 months) followed by sowing in the planned season, whereas cold storage is optimal for forming a reserve seed stock and for use in seed production systems.

Table 2

Dynamics of embryonic organ growth (sowing date: 25 March 2024; Karshi)

Day	Embryo (cm)	Cotyledons (cm)	Hypocotyl-root (cm)	Conditions / influence
10	0.4-0.5	0.5-0.6	0.6-0.7	Cold wind, 8–12 °C, growth retardation
15	1.2-1.4	0.6-0.7	0.8-0.9	Temperature still low, gradual growth
18	2.0-2.2	0.8-0.9	1.1-1.3	16–19 °C, activation of root growth
22	2.2-2.4	2.0-2.2	1.6-1.8	Dry wind, possible dehydration stress
25	3.2-3.5	2.6-2.8	2.3-2.5	Irrigation, humidity 48–52 %-growth acceleration
30	3.9-4.1	2.7-3.0	3.0-3.1	24–28 °C-optimization of growth processes

3. Early Growth of Embryonic Organs after Spring Sowing. The growth dynamics of seedlings over 30 days clearly reflect the dependence of early ontogenesis on temperature conditions, wind regime, and water availability, which is typical for xerophytic species during the initial stages of development.

During the first 10–15 days, an adaptation phase" predominated, during which organ growth was relatively slow. After day 18, with an increase in temperature to 16–19 °C, a pronounced acceleration in root development was observed, which is biologically consistent, as the formation of the root system enhances the plant's ability to supply itself with water and mineral nutrients under xerophytic conditions. The most intensive growth occurred between days 22 and 30, especially after irrigation, when soil moisture increased to 48–52 %, and conditions approached optimal levels for growth.

Discussion and Conclusions

1. Interpretation of Germination Dynamics. The low germination rate observed in freshly harvested seeds (7–9 %) is indicative of physiological dormancy. Many species and populations possess internal regulatory mechanisms that prevent premature germination under unfavorable conditions. Ecological studies of seeds emphasize the role of hormonal balance, particularly abscisic acid, and the process of post-harvest seed maturation (Bewley et al., 2013). The gradual increase in germination, reaching a maximum at 6–12 months, aligns with the post-harvest maturation model: germination inhibitors are gradually inactivated, seed coat permeability improves, and the activity of enzymatic systems stabilizes. The sharp decline in germination after 18-36 months at room temperature conditions is attributable to seed aging. In hot and arid climates, thermo-oxidative damage to membrane lipids and protein degradation can accelerate. Studies on medicinal plants in various regions confirm that storage duration and temperature are critical factors, and that optimal conditions, particularly cold storage, can significantly extend seed viability (Nadarajan et al., 2023). A practical implication of these findings is that room-temperature storage is suitable only as a short-term strategy when sowing is planned within the next one to two seasons. For the accumulation of seed reserves, necessary for plantation scaling, breeding programs, or emergency stock-controlled cold storage.

2. Why Field Germination Sometimes Exceeds Laboratory Germination. As shown in Table 1, the field germination of 3-month-old seeds (42–48 %) even exceeded laboratory germination (32–38 %). Several factors may explain this phenomenon: the soil microclimate, including improved gas exchange and more stable moisture in the seed microsite; natural "soft stratification" during spring temperature fluctuations; and the influence of soil microorganisms and physical conditions that facilitate seed coat rupture. These hypotheses require further verification (e.g., comparing substrates, sterile vs. non-sterile conditions, and controlled moisture levels), yet they are consistent with general ecological observations regarding differences between laboratory and field germination.

3. Early Seedling Growth in Relation to Climatic Risks. The growth dynamics reported in Table 2 highlight the critical role of temperature and moisture during the first month after sowing. Under cold wind and temperatures of 8–12 °C (day 10), seedling growth was markedly slowed. With increasing temperatures up to 24–28 °C (day 30), conditions approached the physiological optimum for xerophytic species, and organ growth became most intensive.

From an applied perspective, these findings indicate that for plantation establishment in the Karshi region:

- Sowing dates should be selected to avoid the most sensitive stage (first 2–3 weeks) coinciding with periods of sharp cold spells or dry winds;
- Irrigation or maintenance of minimal soil moisture during peak growth activation (days 22–30) can significantly accelerate seedling development;
- Agronomic practices should minimize topsoil desiccation (e.g., light mulching, fine soil structure, appropriate sowing depth).

4. Scientific and Practical Significance. The essential oil of *O. tyttanthum* is rich in carvacrol and thymol compounds, widely used in food, perfumery, and pharmaceutical industries. Ensuring stable seed production is therefore not merely an agronomic task but a foundational step in creating a value chain: from seeds → plantations → processing → final product. Given current climate trends that indicate increasing heat and drought stress, controlled seed storage assumes a strategic significance for the sustainable cultivation and utilization of this species.

Authors' contribution: Nodira Arabova – conceptualization, formulation of the research problem, methodology, organization of field experiments, interpretation of results, drafting of the initial manuscript, reviewing and editing; Doston Maxmarajabov – collection of field materials, species identification, statistical data analysis, preparation of tables and figures, data visualization.

Sources of funding. This study was carried out within the framework of the primary activities of the Taras Shevchenko National University of Kyiv, with no external funding involved.

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Отримано редакцією журналу / Received: 23.02.26
Прорецензовано / Revised: 15.04.26
Схвалено до друку / Accepted: 12.05.26
Опубліковано / Published: 31.05.26

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ТРИВАЛІСТЬ ЗБЕРІГАННЯ ТА ПРОРОСТАННЯ НАСІННЯ ДРІБНОКВІТКОВОГО ОРЕГАНО (*ORIGANUM TYTTANTHUM*) У КАРШИНСЬКОМУ РЕГІОНІ

Вступ. ***Розвиток фармацевтичної промисловості Узбекистану на основі місцевої природної сировини, зменшення імпортної залежності та підвищення експортного потенціалу потребує науково обґрунтованого впровадження у культуру перспективних ефіроолійних видів рослин. Дрібноквіткова орегано ("тог'райхон", Origanum tyttanthum Gontsch., Lamiaceae), ендемік Центральної Азії, є цінним ефіроолійним видом рослини. Її ефірна олія характеризується високим вмістом карвакролу, тимолу та інших терпенових компонентів, що визначає антисептичні й технологічно важливі властивості. Водночас природні популяції виду піддаються значному антропогенному навантаженню, а ефективне створення промислових плантацій потребує розвитку надійної насіннєвої бази. Ключовими показниками якості насіння є тривалість зберігання та динаміка схожості, які можуть істотно змінюватися за умов аридного континентального клімату Каршинського регіону. Метою цього дослідження було визначити оптимальний вік насіння O. tyttanthum для посіву в умовах Каршинського регіону, оцінити вплив різних режимів зберігання на лабораторну та польову всхожість, а також охарактеризувати ранню динаміку росту зародкових органів після весняного посіву.***

Методи. ***Насіння O. tyttanthum, зібране протягом 2020–2024 рр. у гірських районах Кашкадар'їнської області, зберігали за кімнатної температури (+18...+22 °C) і в умовах охолодження (+4 °C). Всхожість визначали в лабораторних умовах (чашки Петрі) і в польових дослідах шляхом обліку сходів на експериментальній ділянці. Динаміку росту зародка, сім'ядоль і гіпокотиль-кореня контролювали протягом 30 діб у посівах, закладених 25 березня 2024 року. Отримані дані обробляли методами описової статистики та зображували у вигляді діапазонів значень.***

Результати. ***За умов кімнатного зберігання лабораторна всхожість свіжозібраного насіння становила 7–9 %, зростала до 32–38 % на третьому місяці й досягла максимуму 78–82 % на дванадцятому місяці; польова всхожість у цей період коливалася в межах 74–80 %. Після 18 місяців зберігання спостерігалося поступове зниження всхожості (лабораторна: 70–78 %; польова: 62–70 %), а після 36 місяців відбулося різке падіння життєздатності (30–40 % та 22–34 %, відповідно). За умов охолодженого зберігання (+4 °C) насіння зберігало високу життєздатність навіть після 36 місяців (86–89 %). Найінтенсивніший ріст зародкових органів спостерігався в інтервалі 22–30 днів і чітко корелював із підвищенням температури до 24–28 °C і збільшенням вологості після поливу.***

Висновки. ***Оптимальний вік насіння O. tyttanthum для посіву в умовах Каршинського регіону становить 6–15 місяців після збирання. Для тривалого зберігання насіннєвого матеріалу рекомендується холодовий режим (+4 °C), який суттєво сповільнює процеси старіння. Отримані результати мають практичне значення для формування насіннєвої бази та введення O. tyttanthum у культуру.***

Ключові слова: *дрібноквіткова орегано, Origanum tyttanthum, насіння, всхожість, зберігання, Каршинський регіон, аридний клімат, ранній ріст.*

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; in the decision to publish the results.