Effect of short-term seed priming on germination of wild-growing plant Scorzonera tau-saghyz

Zarina Abzhami1, Svetlana Turasheva2*, Dayana Tleubayeva3, Kenzhe-Karim Boguspaev 4

1 National Higher School of Agronomy and Food Industries, Vandoeuvre-Lès-Nancy, 54505, France
2 Al-Farabi Kazakh National University, Almaty, 050040, Kazakhstan
3 King Abdullah University of Science and Technology, Thuwal, 23955, Saudi Arabia
4 Scientific Research Institute of Biology and Biotechnology Problems, Almaty, 050040, Kazakhstan

Abstract. This study examines the efficiency of vermicompost tea, an organic fertilizer, in improving the process of seed germination in rubber-producing plants of the species Scorzonera tau-saghyz. Seeds collected from three-year-old plants within the Karatau State Nature Reserve in Kazakhstan were treated with 5% and 10% vermicompost tea for 2 hours and 4 hours’ exposure. Germination progress was closely monitored over a four-week period, revealing a significant correlation between higher concentrations and exposure times with increased rates of seed germination. In particular, tau-saghyz’ seeds treated with a 10% solution of vermicompost for 4 hours showed 1.3 times higher percentage of germination compared to seed pre-treatment by 5% solution and 1.9 times greater than that of the control. These results provide valuable information on optimizing seed treatment protocols to improve the germination and growth of Scorzonera tau-saghyz seedlings, offering potential approaches for biodiversity conservation and sustainable agricultural practices.

1 Introduction

Scorzonera tau-saghyz Lipshec et Bosse, a perennial semi-shrub belonging to the Asteraceae family, stands at a height of 25-40 cm and boasts a lengthy taproot. Its singularly arranged yellow baskets and rosette-forming cereal-like leaves characterize its appearance. Notably, when its root or stem is damaged, such as other rubber-bearing species T.kok-saghyz, Scorzonera Uzbekistan growing in Central Asia, S. tau-saghyz plants exhibit elastic rubber threads [1, 2]. However, human activities have significantly reduced the population of tau-saghyz, resulting in its classification in the Red Book of various regions since the 1980s [3]. Despite efforts to restore their numbers, the process is slow due to factors such as low seed production and high mortality rates among seedlings. Additionally, the species faces challenges from stronger competitors in its environment.

* Corresponding author: svetlana.turasheva@kaznu.kz

Protecting and restoring populations are essential not only for biodiversity preservation, also for maintaining ecosystem resilience and supporting local livelihoods dependent on...
these resources. Utilization of both synthetic and natural fertilizers can improve seed germination, enhance agricultural productivity and sustainability by promoting plant health, increasing yields, and nutrient content.

Vermicompost, characterized as an organic nutrient fertilizer, is rich in essential plant nutrients and various trace elements. Vermicompost has a very high content of Nitrate Nitrogen (NO₃⁻) relative to the content of Ammonium Nitrogen (NH₄⁺). Despite findings showing higher yields with mineral fertilizers compared to pure compost, compost still positively influences soil structure by reducing bulk density, thereby increasing soil porosity as compost concentration rises. Vermicompost includes enzymes such as amylase, lipase, cellulase, and chitinase, which persistently decompose organic materials in the soil, releasing nutrients and facilitating their absorption by plant roots. Vermicompost tea, a product of vermicomposting, significantly boosts soil fertility by supplying vital nutrients, thus enhancing plant growth and fostering beneficial microbial communities [4, 5]. Vermicompost tea contains both water-soluble components (humic acids, sulfonic acids, organic acids, amino acids, regulatory peptides, vitamins, hormones) and living soil (rhizosphere) microflora. Humic substances in vermicompost are important chelating agents for trace elements that help improve their availability to plants. Because of the existence of nitrogen-fixing bacteria, phosphate- and potassium-dissolving microorganisms, rhizobacteria, antagonistic fungi of the genus *Trichoderma*, mycorrhizal arbuscular fungi in the vermicompost, its fungicidal and growth-stimulating effect is manifested. Vermicomposting, a cost-effective technology, involves earthworm activity, converting organic materials into stable compounds like humic substances, which are environmentally safe and can serve as organic supplements in agriculture [6].

By employing strategies such as the adoption of bioorganic fertilizers and harnessing biotechnological progress, there is optimism for rejuvenating declining populations and securing the enduring existence of species like *S. tau-saghyz* amid the challenges posed by human activity, environmental degradation and safeguarding the biodiversity of Central Asia's flora. Recognizing the urgency of preservation, the study endeavors to enhance the growth rate of *Scorzonera tau-saghyz* seedlings. This involves investigating the optimal concentration and duration of pretreatment by vermicompost tea to improve the germination rate of the species' seeds.

## 2 Materials and methods

### 2.1. Plant material

Seeds were collected in the Karatau Mountains within the Republic of Kazakhstan, situated at approximately 43°33′13″N latitude and 68°53′52″E longitude, 816 m above sea level. The initial plant material was collected by hand, cutting off the anthodia at the point of attachment to the peduncle at the last stage of development, when the anthodium is fully open (Figure 1 A, B). The investigation into seed germination followed conventional laboratory protocols under controlled conditions, maintaining a temperature of 23 ± 2°C.

### 2.2. Method of vermicompost tea preparation

Earthworms belonging to the *Eisenia fetida* species were obtained from untouched mountainous areas within the Almaty region of Kazakhstan. To bolster their numbers, they were first reared in transparent plexiglass containers featuring funnel-shaped bases.
Manure was added to these containers in the laboratory before transferring the earthworms to vermireactors, ensuring an ample quantity for their growth. To maintain the ideal humidity range of 60-70% necessary for earthworms, the culture units were regularly watered, and drainage and aeration were facilitated through holes made on the sides [7]. The incorporation of manure serves to expedite the vermicomposting process due to its high moisture content and low C/N ratio. In this investigation, manure sourced from cattle farms was utilized as a blending material. Additionally, P2O5, K2O, Ca, and Mg inorganic elements were introduced to the mixture. The pH was measured at 7.9 [8].

2.3. Seed priming

Prior to the first seed treatment, tau-saghyz seeds were sterilized for 45 minutes in a diluted potassium permanganate solution. After sterilization, the treated seeds were placed in Petri dishes for exposure to vermicompost tea for 2 hours and 4 hours. For seed priming, a fresh vermicompost tea solution at concentrations of 5% and 10% was used. Untreated seeds, grown in water without any treatment, served as the control group. Investigations were carried out in three replicates with 100 seeds in each variant. Germination screening was conducted every 3 days to assess the germination percentage of the seeds. Distilled water acted as a source of moisture, and the seeds were regularly moistened every 2-3 days as required. Germination progress was monitored continuously from the beginning until the conclusion of the process, with seeds considered germinated once a root emerged, matching the size of the seed.

An average value with a standard deviation was calculated to assess the parametric data in each experiment. The criterion for independent samples from Student was employed for the statistical analysis of experimental data on the influence of vermicompost tea on seed germination.

3 Results and Discussion

Germination is the result of a complex series of events, beginning with the absorption of water by the cells of the seed coat and active division of the stemlet cells, ending with the development and functioning of the plant organ system. This series of physiological phenomena are regulated by various factors, which are observed in our experiments to
examine the impact of vermicompost tea on the germination of tau-saghyz seeds. This study delves into the intricate relationship between the utilization of vermicompost tea as organic fertilizers, and its influence on the germination of tau-saghyz seeds. Seeds obtained from plants aged three years were subjected to 5% and 10% concentrations of freshly prepared vermicompost tea for short-term 2 and 4 hours seed pre-treatment. Screening intervals were set at every three days throughout a four-week observation period to meticulously track germination progress.

The findings underscore a notable trend: higher concentrations and short-time exposure times to vermicompost tea correspond to elevated seed germination rates. For instance, seeds treated for 2 hours with a 5% liquid vermicompost demonstrated the highest germination percentage (16.3%±3.71) compared to those subjected to the 10% concentration (13.66%±3.45). However, even the 10% concentration exhibited a substantially improved germination rate over untreated (6.33%±2.44) control seeds (Figure 2).

It's evident that when exposed to a 4 hours’ treatment with a 10% concentration of vermicompost tea, the germination percentage is notably higher (15.33%±3.62) compared to a similar treatment with a 5% concentration (Figure 3). Conversely, the application of 5% liquid vermicompost treatment did not result in any notable impact on seed germination (11.66%±3.22), as evidenced by a comparison with the germination percentage (8.0%±2.72) of untreated seeds (control). Additionally, for both 2 h and 4 h short-term exposures, treatment by a 10% vermicompost tea resulted in nearly double the germination percentage (13.66%±3.45 and 15.33%±3.62 respectively) compared to control (6.33%±2.44 and 8.0%±2.72 respectively). This enhanced germination can be credited to the presence of vital elements such as potassium, calcium, magnesium in vermicompost tea, which play a crucial role in plant growth. In particular, humic acids and hormone-like substances that are part of vermicompost tea cause acidification of the cellular barrier in cells of the seed coat, promoting cell growth by stretching, and also stimulating the processes of division.

![Germination percentage of tau-saghyz seeds treated with varying levels of vermicompost tea concentration for 2 h](image)

Fig. 2. Germination percentage of tau-saghyz seeds treated with varying levels of vermicompost tea concentration for 2 h

The seed coat of tau-saghyz seeds plays a protective and on another hand nourishing role. Functionally, the outer layer of the tau-saghyz seed coat is a protective layer, and the inner layer plays the role of a water-absorbing layer. A 5% vermicompost tea penetrates the seed and membrane by diffusion through the cells of the tissue filling the hillocks and ribs of the pericarp, as well as through vascular bundles that come close to the lower end of the
seed pod and end freely in it. Vermicompost has a water-holding capacity, which has a positive effect on the swelling of the solid seed coat. However, the treatment of the seed for 2 h with various concentration of vermicompost tea is insufficient for complete penetration through the hard seed coat and absorption of the vermicompost solution containing dissolved organic and mineral elements. It is noteworthy that with 4-hour seed priming the sprouting rate also increases since the solution is absorbed in the base of the seed, where the tip of the stemlet root is located, which induces intensive division of the stemlet cells. Mainly, humic acids and growth-regulating substances such as cytokinins, and auxins in the vermicompost composition start the cell cycle and a series of sequential divisions of meristem cells.

It is recognized that humic acids activate enzymes involved in the cell cycle and DNA replication (cyclin-dependent kinases) [9], induce root growth, enhance the functional activity of H-ATPase, stimulate plant growth by improving the availability of iron and zinc ions, polyamines [10, 11]. Cytokinins and gibberellic acid regulate the formation and development of tau-saghyz shoots. This is evidenced by our earlier experiments on clonal reproduction of tau-saghyz in vitro cell culture [12]. Calcium, when applied to the soil in different forms such as oxides, hydroxides, or carbonates, enhances nutrient accessibility for plants. Meanwhile, magnesium influences the activity of numerous enzymes involved in CO₂ assimilation [8]. Furthermore, the species Eisenia fetida, commonly used in vermicomposting, possess the capability to consume a wide array of organic materials and exhibit greater resistance to environmental stresses [7].

Thus, 10% vermicompost tea induces the germination of hard tau-saghyz seeds and accelerates the growth of seedlings, thereby stimulating an increase in the raw biomass of shoots and roots, which ultimately affects the high productivity and yield of rubber plants S. tau-saghyz. Moreover, the role of processing time emerges as pivotal in the germination process. Extended treatment exposure for 4 hours are essential for breaking seed dormancy, particularly considering the dense covering of tau-saghyz seeds. The intricate interplay between processing time and concentration highlights the complexity of seed germination dynamics and underscores the necessity of tailored treatment protocols for optimal results.

4 Conclusion
Vermicomposting emerges as a farmer-friendly method, offering the convenience of on-site application near fields, thus minimizing transportation expenses. It requires minimal labor and boasts high cost-effectiveness, rendering it a financially prudent choice. Notably, the method generates negligible waste and pollution, positioning it as one of the most environmentally-conscious methods for handling organic waste. Hence, organic fertilizers, notably vermicompost tea, offer a preferable option for improving the germination and growth of \textit{S. tau-saghyz} seedlings. The content of vermicompost tea, enhanced by the vital activities of earthworms like \textit{E. fetida} and microorganisms, along with essential nutrients such as calcium, magnesium, potassium, and phosphorus, exerts a stimulatory effect on breaking seed dormancy and promoting robust germination of tau-saghyz seeds. In essence, this research offers comprehensive insights into the nuanced impacts of vermicompost tea on the germination process of \textit{S. tau-saghyz} seeds. By elucidating the intricate relationships between concentration, treatment duration, and germination outcomes, the study provides invaluable guidance for optimizing seed treatment protocols to maximize germination rates and foster optimal plant growth.

In summary, the utilization of vermicompost tea as an organic fertilizer represents a practical and effective approach for enhancing the germination and growth of \textit{S. tau-saghyz} seeds, offering benefits in terms of cost-effectiveness, environmental sustainability, and agricultural productivity.

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**Authors’ contribution**

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