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UV-RAYS AND ELECTROMAGNETIC FIELD INFLUENCE ON THE SEED GERMINATION OF ESSENTIAL OIL PLANTS UNDER NATURAL HARSH CONDITIONS

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SUMMARY

The following study assessed the effects of UV rays and electromagnetic fields on the germination of promising medicinal and essential oil plants, sage (*Salvia officinalis* L.) and lavender (*Lavandula angustifolia* L.). The exposure of seeds of *S. officinalis* L. to ultraviolet rays (UV) and electromagnetic fields (EMF) individually and in combination (UV + EMF) showed the most efficient was UV + EMF (81%) and UV (77%) exposed at the experimental field, District Muynak, Republic of Karakalpakstan. By treating the *L. angustifolia* L. seeds with ultraviolet rays (UV) and electromagnetic fields (EMF) individually and in combination (UV + EMF), results revealed varied germination rates. However, in lavender, the highest seed germination was notable with UV + EMF (80%) and UV alone (78%).

Keywords: Sage (*S. officinalis* L.), lavender (*L. angustifolia* L.), essential oil, medicinal use, UV rays, electromagnetic field, seed germination

Key findings: The sage (*S. officinalis* L.) and lavender (*L. angustifolia* L.) seeds' exposure to UV rays and UV + EMF resulted in a significant increase in their seed germination, and both essential oil plants showed the same response.

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INTRODUCTION

In the present era of advanced technology, ultraviolet rays, electromagnetic waves, and ultrasonic waves are widely used tools in medicine, advanced biology, pharmaceuticals, drug production, and various agricultural industries. Ultrasonic waves' wide utilization in medicine is mainly for diagnostic and therapeutic purposes, which plays a key role through their effects on the enzyme system (Babakhanova *et al.,* 2024). Several ongoing studies apply ultraviolet and electromagnetic rays in medicine, as well as in agriculture, to enhance the plants' seed germination and improve their adaptability to adverse environmental conditions (Allaberdiev *et al.,* 2024). Relatedly, numerous urgent tasks include scientific study, analysis, and cultivation of essential oil plants under harsh natural conditions. However, the main attention should rely on obtaining medicinal products from plants used in the medical field and preserving their natural genetic resources (Eshonkulov *et al.,* 2022).

In various regions and worldwide, including the Republic of Uzbekistan, researchers have carried out consistent reforms to protect and process the essential oil plants, as well as develop their plantation under various environments (Ziyadov *et al.,* 2019; Ziyadov and Allaberdiev, 2020a, b). For growing medicinal plants in specialized farms, the technology has not achieved full development, and their application proceeds without a scientific basis in our country. Therefore, developing scientific recommendations for growing essential oil plants in various soil and ecological conditions, increasing their seed germination and rates by UV rays and electromagnetic field treatment of seeds, and selecting salt-tolerant plant species is highly crucial.

In Central Asia, the introduction, cultivation, and scientific studies on medicinal and essential oil plants became widespread at the end of the 19th century. Based on scientific acclimatization, more than 110 species of food, medicinal, and essential oil plants reached being planted in the Trans-Caspian regions. Among the introduced medicinal species, studying the growth and development of essential oil plants, such as *Salvia officinalis* L., *Lavandula angustifolia* L., *Foeniculum vulgare* Mill., *Matricaria recutita* L., and *Rhamnus cathartica* L., which have medicinal properties, has been progressing (Tokhtaev, 2009).

Scientists locally and abroad have conducted scientific research on planting crop plants with high medicinal properties with various aspects, especially increasing the germination index. For example, Kudryashov (1937), in his monograph 'Essential Oil Plants and Their Cultivation in Central Asia,' presented an analysis of the results about the introduction of 23 species of essential oil plants, considering their growth and characteristics under varied geographical conditions. He proved the introduction of perennial plants from the Mediterranean, Southern Europe, North Africa, Asia, Iran, Afghanistan, the Atlantic regions of North America, subtropical China, and Japan, as well as annual medicinal plants from India and Ceylon in various soils and climatic conditions of Uzbekistan, provided effective results and developed the recommendations for their cultivation.

Seed viability can attain increases under the influence of UV rays. According to results, the transmission of long-wave ultraviolet rays ranged from 4% to 10% based on the plant species and seed structure. The absorption of shortwave ultraviolet rays is almost complete in the seed coats of different crops. In this case, the seed transmittance is low, since the transmittance of short-wave ultraviolet rays is about 300 nm. According to past studies, the plant seeds exposed to ultraviolet rays had observed variations in the bark, causing water requirement in the endosperm tissues of irradiated seeds to increase, and when the irradiated seeds germinate, the need for water increases by 10% compared with non-irradiated seeds (Tertyshnaya *et al.,* 2017). In this regard, the study based on the influence of UV rays on the genetic basis of seeds and crops is an alarming task in electrobiological science (Totanov, 1962).

The effect of electromagnetic rays on biological processes has gained studies since the second half of the 20th century. For a long time, scientists believed electromagnetic fields had only a thermal effect on the body. However, the most research has shown electromagnetic rays affect the organisms at different levels (Kvashuk, 2021; Buronov and Xamroev, 2022; Buronov *et al*., 2023; Kholikova *et al.,* 2024). At present, the research scientifically substantiated the processes and the impact of very low-frequency electromagnetic pulses on different plant seeds. They focused their scientific work mainly on studying the bioeffect of the magnetic field on crop plants (Nazarov and Saidaliyev, 1982; Mukhammadiev *et al*., 1995). Ismailov (1997) reported various physical factors influenced the process of seed germination. The presented study aimed to assess the effects of UV rays and electromagnetic fields on the germination of promising medicinal and essential oil plants, sage (*S. officinalis* L.) and lavender (*L. angustifolia* L.).

MATERIALS AND METHODS

Experimental material and procedure

The experiments used the promising medicinal and essential oil plants: sage (*S. officinalis* L.) and lavender (*L. angustifolia* L.). In 2019, the seeds of selected essential oil plants sustained UV-ray irradiation (340 nm) and the treatment with electromagnetic field (at a low frequency of 4 Hz) at the laboratory managed by the Joint Stock Company BMKB-Agromash, Ministry of Agriculture, the Republic of Uzbekistan. Plant irradiation proceeded by following the methodology of Muhammadiev *et al.* (2005) and Solieva (2022). During the study, the different observations and their analysis served to scrutinize the plants' fertility under field conditions.

RESULTS AND DISCUSSION

The influence of electromagnetic rays on biological processes has received studies since the second half of the 20th century. For many years, scientists believed electromagnetic fields had only a thermal effect on the organism's body. However, currently, the research has shown electromagnetic rays affect the organisms at different levels (Gavrilenko, 2019; Kvashuk, 2021). At present, the experiment scientifically substantiates the processes observed in plant seeds due to the impact of very low-frequency electromagnetic pulses on plant seeds.

The potential studies continued on the medicinal and essential oil plants: sage (*S. officinalis* L.) and lavender (*L. angustifolia* L.). The treatment of selected seeds of the essential oil plants with UV and electromagnetic field (EMF) comprised three stages (Table 1). In the first stage, the seeds incurred treatment with UV; at the second stage, with EMF; and at the third stage, with UV + EMF. Collecting 300 seeds came from each plant species (using 100 seeds at each stage), with 100 seeds selected for the control. The sorting of seeds used the method of determining the quality of plant seeds. The treated seeds succeeded in sowing on the same day, with intervals of 3–5 hours in the field. However, if the planting of treated seeds happened later, the fertility productivity indicators will decrease and, eventually, reducing the processes affecting the seeds. Given the efficiency of using UV radiation largely depends on the uniformity of seed irradiation and the amount of energy absorbed by them. For each type of seed, an optimal amount of absorbed UV energy is necessary that produces the maximum effect (Braginets *et al*., 2024).

Table 1. Type and time of seed treatment of *S. officinalis* L. using different methods.

Processing methods	UV	EMP	UV + EMP
Time required for irradiation. (min.)	15	15	15
	20	20	20
	25	25	25

Table 2. Germination of *S. officinalis* L. seeds treated with UV rays and untreated seeds.

Processing methods	Time required for irradiation (min.)	Number of seeds	Seed germination period (days)	Seed germination (%)
UV rays	15	100	9-10	74
UV rays	20	100	8-10	77
UV rays	25	100	9-11	73
Control	Unprocessed	100	16-18	62

Table 3. Germination of *S. officinalis* L. seeds treated with EMF and untreated seeds.

Processing methods	Time required for irradiation (min.)	Number of seeds	Seed germination period (days)	Seed germination (%)
EMP	15	100	10-11	70
EMP	20	100	9-10	76
EMP	25	100	9-10	74
Control	Unprocessed	100	16-18	62

The traditional planting method was applicable for sowing the seeds of both essential plants. The row spacing, as calculated earlier, had the planting carried out according to the plan. In the first stage, the *S. officinalis* L. seeds' irradiation with ultraviolet rays ensued, with the germination rates analyzed after (Table 2). The results showed the germination rate of *S. officinalis* L. seeds irradiated with three different levels of UV rays was different. However, the best results were evident in seeds treated for 20 minutes. Seeds treated with UV radiation had a high germination rate (77%) compared with the control seeds (as 15% higher). The results obtained in this research confirm findings of other scientists in this field. When using ultraviolet radiation in pre-sowing seed preparation, the germination process gets activated and the germination energy and rate increase, which have a positive effect on the yield and quality of the product (Nelyubina and Kasatkina, 2021). These results proved a good indicator for the territory with moderate soil salinity and severe climatic conditions.

At the next stage of the research, the *S. officinalis* L. seeds' treatment with an electromagnetic field (EMF) occurred. At this stage, the selected 100 seeds received EMF treatment for 15, 20, and 25 minutes (Table 3). Seeds treated with EMF showed better results for germination than the untreated seed samples. The germination rate of seeds treated for 20 and 25 minutes was the same. Seeds treated with EMF indicated a 14% higher germination than the control seeds, and on average, the 76 treatments of seeds with electromagnetic waves allow accelerating the process of seed germination and reduce losses of seed material to a minimum. Moreover, they increased the growth energy of seeds by three times, prevention from pathogenic microflora infection, and the viability of plants in unstable climate conditions due to intensive growth of the root system. Similar results surfaced in the works of Pozhiritskaya (Pozhiritskaya, 2024), which studied the germination of grain crop seeds.

At present, to ensure the rapid fertilization of plant seeds sown in the field at a high rate, significant work progressed to stimulate the plant cells and increase their energy capacity by exposing their cells to ultraviolet rays and electromagnetic pulses. According to Muhamedov *et al.* (2005), by treating the crop seeds with UV rays, the acceleration of seed germination occurred, improving physiological indicators, and as a result, the plants grown from irradiated seeds grow quickly.

The EMF-treated seeds were slightly different from the UV-irradiated sage seeds. These results provided a good indicator for the area with severe soil and environmental conditions. At the next stage of the research, the seeds of the *S. officinalis* L. gained simultaneous treatments with ultraviolet rays and electromagnetic pulses (UV + EMP) (Table 4). Various indices prevailed for the germination indices of seeds treated with simultaneous exposure to ultraviolet rays and electromagnetic fields (UV + EMF). Overall, the UV-treated seeds had significantly better germination than control seeds, with an average germination of 81%. Compared to control-treatment seeds, the germination was 19% higher. The use of ultraviolet radiation and electromagnetic fields on seeds are more advanced methods of preparing seeds for sowing, allowing not only to bring seeds out of dormancy but also to activate the work of various biological catalysts: enzymes that ensure rapid growth and development of seeds (Zankevich, 2023). The obtained results allow us to assume that the treatment with UV+EMF leads to stimulation of processes in seeds, which causes the increase in their germination and growth strength.

For the study, the other selected plant was lavender (*L. angustifolia* L.), and the seeds of this plant received a similar procedure as the seeds of the sage plant. In three stages, out of 100 seeds, the sorted seeds underwent processing for 15, 20, and 25 minutes (Table 5). The seeds of *L. angustifolia* L. bore sowing in the usual manner, at the depth of 2–3 cm, with 20–25 cm and 50–60 cm plant and row spacing, respectively. The germination rate of lavender seeds irradiated with UV at three different levels showed different results, and the seeds treated for 25 minutes gave relatively better results (Table 6). This is due to the energetic action of photons: the permeability of biological cell membranes changes, as well as the level of lipid oxidation, pH, and adenosine triphosphate (ATP), leading to an increase in bioenergetic and biosynthetic processes, causing an escalation in the energy potential of seeds (Levina *et al.,* 2019). In seeds, ultraviolet light mobilizes genetically embedded growth reserves, which are hidden resources used to enhance the growth and development of plants.

The data presented on the influence of electromagnetic fields on plant seeds, and by treating seeds with electromagnetic fields, an acceleration of metabolism, enzyme activity, and various biochemical processes were evident (Ismoilov, 1997). As a result of the these process effects, despite the low temperature, the seeds germinated 2–3 days earlier than the control, with their resistance to soil diseases also determined.

Compared with the control seeds, the seeds treated with UV radiation had an average germination rate of 78% and were 18% higher than the control seeds. These results were a good indicator for the territory with severe soil and environmental conditions (Table 6). At the next stage of the research, the seeds of *L. angustifolia* L. sustained application with an electromagnetic field (EMF). At this stage, the selected 100 seeds treated with EMF had three periods: for 15, 20, and 25 minutes (Table 7). The effect of EMF on seeds causes a change in ionic strength and pH in the membrane layer, with their subsequent effect on the release of proteins from the membrane-bound state. This activates esterase enzymes and changes pH, which, in turn, have a beneficial effect on the growth of roots and sprouts from wheat seeds (Kornaukhov, 2014). The transition of seeds from a state of dormancy to germination in the first stages occurs in one direction—to the release of various structures from a bound state, with a certain sequence of processes. These are, first, the formation of roots occurs, followed only by the formation of sprouts.

The germination rate of seeds treated with electromagnetic pulse compared with untreated control seeds of *L. angustifolia* L. showed better results. By treating the seeds with an electromagnetic field for 25 minutes, the germination rate was 70%. Compared with the control-treatment seeds, the germination rate was 12% higher (Table 7). According to past studies, the plants emerged highly sensitive to electromagnetic impulses at various stages of development (Mirzoakhmedov, 1995). Considering the above, the said research was successful at improving the technology for growing the essential oil plants in the Moinak Region, Karakalpakstan.

In the next stage of the experiment, the seeds of *L. angustifolia* L. acquired simultaneous treatment with UV rays and

Table 4. Germination of *S. officinalis* L. seeds treated with UV rays and electromagnetic field (UV+EMF) and untreated seeds.

Processing methods	Time required for irradiation (min.)	Number of seeds	Seed germination period (days)	Seed germination (%)
UV + EMF	15	100	9-10	74
UV + EMF	20	100	8-10	81
UV + EMF	25	100	9-11	78
Control	Unprocessed	100	16-18	62

Table 5. Type and time of processing of *L. angustifolia* L. seeds using different methods.

Processing methods	UV	EMP	UV+EMP
Time required for irradiation. (min.)	15	15	15
	20	20	20
	25	25	25

Table 6. Germination of *L. angustifolia* L. seeds treated with UV-rays and untreated seeds.

Processing methods	Time required for irradiation (min.)	Number of seeds	Seed germination period (days)	Seed germination (%)
UV rays	15	100	8-9	72
UV rays	20	100	7-8	76
UV rays	25	100	7-8	78
Control	Unprocessed	100	13-14	60

Table 7. Germination of *L. angustifolia* L seeds treated with EMF and untreated seeds.

Processing methods	Time required for irradiation (min.)	Number of seeds	Seed germination period (days)	Seed germination (%)
EMF	15	100	10-11	64
EMF	20	100	9-10	68
EMF	25	100	9-10	70
Control	Unprocessed	100	13-15	58

electromagnetic pulse. Various indices obtained for the seed germination treated with the simultaneous action of ultraviolet rays and electromagnetic pulse appeared; however, the seeds treated for 25 minutes showed the best germination (Table 8). The germination rate of *L. angustifolia* L. seeds treated with UV + EMF was, on average, 80% compared with the control-treatment seeds. This means that its germination rate was 19% higher than the control seeds. The obtained results showed the germination of both essential oil plants, lavender (*L. angustifolia* L.) and sage (*S. officinalis* L.), as higher in the seeds treated with UV + EMF. The attained results from exposure to the UV + EMF of the *L. angustifolia* L. were similar to the data of the authors who conducted research on cucumbers (Zankevich*, 2023*). UV and EMF have a special effect on living cells, which scientists have repeatedly discovered in their studies (Starukhin, 2009). They cause changes in morphological, cultural, and biochemical properties, which ultimately leads to an increase in enzymatic and synthetic activity, the content of reserve substances, the yield of biomass, and resistance to stress factors.

Table 8. Germination of *L. angustifolia* L. seeds treated with UV rays and electromagnetic field (UV+EMF) and untreated seeds.

Processing methods	Time required for irradiation (min.)	Number of seeds	Seed germination period (days)	Seed germination (%)
UV + EMF	15	100	9-10	75
UV + EMF	20	100	8-9	78
UV + EMF	25	100	8-9	80
Control	Unprocessed	100	15-16	61

CONCLUSIONS

By treating the seeds of essential oil plants (*S. officinalis* L. and *L. angustifolia* L.) with ultraviolet rays and electromagnetic field (UV + EMF) showed the highest germination and efficiency in the experimental field at the District Muynak, Republic of Karakalpakstan.

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