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Development of Some Medicinal Plants Under the Agroecological Conditions of the Ganja–Gazakh Region

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Abstract. *The article provides information on innovative methods for cultivating medicinal plants in the Ganja–Gazakh region, which has favorable climatic conditions for agriculture, as well as their potential application within the region's agroecological environment. As is known, medicinal plants are widely used in traditional medicine, the pharmaceutical industry, cosmetology, and other fields. The cultivation of these plants in the Ganja–Gazakh region plays an important role, particularly in providing income for the rural population. The use of innovative technologies in the cultivation of medicinal plants is important not only for increasing productivity but also for ensuring ecological safety. Soil sample analysis shows that the soils are insufficiently supplied with available forms of nitrogen, phosphorus, and potassium. These soils are generally poorly provided with nutrients. Therefore, the application of organic and mineral fertilizers is essential to ensure the growth, development, and high yield of agricultural crops, as well as to maintain soil fertility. Observations conducted on Achillea filipendulina demonstrated that the duration and percentage of germination vary depending on soil moisture and temperature conditions. In the case of Taraxacum officinalis, seeds sown under certain agrotechnical conditions show higher productivity in the third year. Experimental results have established that the application of different rates of mineral fertilizers in combination with manure significantly increases the number of vegetative and generative shoots per plant.*

Keywords: *medicinal plants, agroecology, innovative methods, organic fertilizers, mineral fertilizers*

Introduction

The Ganja–Gazakh region is one of the most productive and actively cultivated regions of Azerbaijan. It possesses favorable climatic conditions for agriculture. This region has unique soil and water resources, which make it ideal for cultivating medicinal plants. Due to their pharmaceutical value, medicinal plants have played an important role in the development of agriculture in recent years (Krommelin et al., 2019; Behera et al., 2017; Dhakad et al., 2017).

The use of innovative technologies makes it possible to increase efficiency in the cultivation of medicinal plants, improve quality, and enable harvesting without harming the ecosystem. This article examines innovative methods for cultivating medicinal plants in the Ganja–Gazakh region and their potential application under the region's agroecological conditions.

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Medicinal plants are widely used in traditional medicine, the pharmaceutical industry, cosmetology, and other fields. The cultivation of these plants in the Ganja–Gazakh region plays an important role in providing income, especially for the rural population. This region is one of the most favorable agricultural areas of Azerbaijan. Its agroecological conditions, including climate, soil, and water resources, are suitable for growing medicinal plants.

The use of innovative technologies in the cultivation of medicinal plants is important not only for increasing productivity but also for ensuring ecological safety. Therefore, considerable attention is paid to studying the effectiveness of innovative technologies in agriculture. In his work "Agroecological Technologies and Innovative Approaches" (2021), Kuyukov examines the application of innovative methods in agriculture. He argues that modern technologies such as hydroponics, aeroponics, and smart irrigation systems play a significant role in preserving soil fertility and ensuring the efficient use of water resources (Labashchi, 2017; Muhammadjonova et al., 2022; Šarćević Todosijević et al., 2019; Sen & Samanta, 2014). The application of these technologies in the cultivation of medicinal plants in the Ganja–Gazakh region can significantly increase productivity.

The Ganja–Gazakh region is located in the western part of the republic and is characterized by a dry and semi-dry climate with a moderately warm steppe type. Summers are hot, while winters are dry and mild, with unstable snow cover. The average annual temperature is 11.8–13.1 °C. In the lowland semi-zone, at an altitude of 69–450 meters above sea level, the sum of active temperatures reaches 4000–5000 °C, and annual precipitation ranges from 252 to 294 mm. In the foothill and mid-mountain semi-zones, at altitudes of 600–1200 meters above sea level, the average annual temperature is 10.3–11.8 °C, the sum of active temperatures is 3200–3700 °C, and precipitation ranges from 346 to 525 mm. The cold period of the year lasts from November to March. The coldest month is January, while the average summer temperature is 23–25 °C.

In the Ganja–Gazakh region, groundwater lies deep and does not participate in soil formation processes. In the mountainous, central, and western parts of the region, natural soil drainage, combined with intensive irrigation, leads to the mineralization of groundwater, which gradually increases from the mountainous areas toward the Kura River. In the eastern part of the region, sulfate-sodium and chloride-sulfate mineralization dominates in groundwater. According to Professor M. E. Salayev, dry, dark gray-brown (chestnut) soils are widespread in the Ganja–Gazakh plain.

Water resources in the Ganja–Gazakh region are extremely important for agriculture. However, their efficient management and economic use have become a pressing issue. Smart irrigation systems, such as automated irrigation, help reduce water loss and allow for more precise forecasting of crop moisture requirements.

Materials and Methods

The systematic position of the species was determined according to generally accepted principles, including APG IV (World Flora Online Consortium, 2012), World Flora Online **(**Angiosperm Phylogeny Group, 2016), and The Euro+Med PlantBase through which the taxonomy and nomenclature of the species were clarified. In studying the bioecological characteristics of the species, the following sources were used: Flora of Azerbaijan (Grossheim, 1945; Flora of Azerbaijan, 1952), Plant World by A. M. Asgarov (2016), Volume III of Conspectus of the Flora of the Caucasus (2012), as well as works by other researchers (Bayramova et al., 2025).

The experiments were conducted in dry soil conditions in the Ganja–Gazakh region. Field experiments were established as a three-factor design (3 × 3 × 5) according to the following scheme:
Factor A – Sowing time: 1) April 1–5; 2) April 10–15; 3) April 20–25

Factor B – Planting scheme: 1) 45 × 5 cm spacing, plant density 440,000 plants/ha; 2) 45 × 10 cm spacing, plant density 220,000 plants/ha; 3) 45 × 15 cm spacing, plant density 148,000 plants/ha
Factor C – Fertilizer rates: 1) Control (no fertilizer); 2) Manure 10 t/ha (basal application); 3) Basal + N30P60K30; 4) Basal + N60P90K60; 5) Basal + N90P120K90

Table 1
Agrochemical Properties of Soils in the Experimental Area

			Azot			Fosfor		Kalium	
Depth, cm	pH water	Total humus, %	Total, %	Absorbed ammonia, N/NH_3 mq/kq	Nitrate nitrogen, N/NO_3 mq/kq	Total, %	Mobile, mq/kq	Total, %	Exchangeable, mq/kq
0-30	7,8	2,15	0,15	18,0	9,7	0,13	16,8	2,39	263,5
30-60	8,2	1,17	0,09	15,3	6,4	0,09	13,8	1,85	201,0
60-100	8,4	0,85	0,06	6,5	2,6	0,07	4,5	1,51	105,3

Results and Discussion

The analysis of soil samples showed that the soils are poorly supplied with available forms of nitrogen, phosphorus, and potassium. These soils are characterized by a low level of nutrient availability. Therefore, the application of both organic and mineral fertilizers is essential for ensuring the growth and development of agricultural crops, achieving high yields, and maintaining soil fertility.

Achillea filipendulina Lam. is characterized by a wide range of biologically active compounds, which determine its diverse pharmacological effects. The plant primarily possesses hemostatic properties. The herb exhibits anti-inflammatory, antiallergic, bactericidal, and wound-healing effects, which are associated with the presence of azulenes, tannins, and flavonoids.

The plant is used to relieve spasms of the stomach, intestines, bile ducts, and urinary tract. It is included in appetite-stimulating and anti-hemorrhoidal preparations. In cases of gastric and duodenal ulcers, ulcerative colitis, acute and chronic dysentery, hepatitis, cholecystitis, and angiocholitis, an infusion of yarrow (20:200) is used—1 tablespoon 3–4 times daily after meals.

Between 2022 and 2025, studies were conducted on the germination, propagation, and cultivation of *Achillea filipendulina* (Fig. 1). The ontogenesis of the plant was observed. Seeds of this species were collected from natural habitats.

The seeds are brown in color, and the weight of 1000 seeds is 0.53 g.
During the experiments: Seeds were sown in open field conditions from February to June; sowing was repeated every 15 days; soil temperature and moisture levels were monitored until germination. The observations showed that germination time and percentage vary depending on soil moisture and temperature.

Optimal Conditions for germination – soil moisture: ≤ 35%; temperature: 10–20 °C
Effect of Temperature on germination – at 15 °C → germination occurs in 19–20 days; at 20 °C → germination occurs in 10–12 days.

Germination Rate Depending on Temperature at 10 °C → 20–25%; at 15 °C → 50–60%; at 20 °C → 80–82%.
Effect of sowing depth on germination – 3 mm → 75–80%; 5 mm → 60–65%; 7 mm → 40%; 10 mm → 10–12%
Germination time by depth 3 mm → ~20 days; 5 mm → ~17 days; 7 mm → ~5 days (≈40% germination); 10 mm → ~7 days (≈25% germination).

- Germination is strongly dependent on temperature and moisture, indicating sensitivity to environmental conditions
- Optimal germination occurs at moderate temperature (≈20 °C) and controlled moisture.
- Shallow sowing (≈3 mm) provides the highest germination rate.
- Increasing depth significantly reduces germination percentage due to: oxygen limitation; mechanical resistance of soil

Figure 1
Achillea filipendulina Lam.

In the Ganja–Gazakh region, optimal conditions for normal germination of *Achillea filipendulina* seeds require soil moisture of 35% and a temperature of 20 °C. Seeds should be sown at a depth of 3 mm and within a 10-day period, no later than March 14.The cotyledon leaves emerging from the seeds are elongated in shape; under open field conditions, their length is 2.76 mm and width is 1.62 mm. The petiole length is 1.89 mm, and its color is dark purple. The virginal stage lasts until the end of April.The first true leaves are segmented, pinnate, and elongated lanceolate in shape, with a purple-violet color. The petiole length is 2.09 mm. The next two leaves are pinnately lobed, with a length of 2–12 mm and a width of 1–8 mm.The stem is usually single, straight, and erect; it is woolly-hairy in the lower part and branched, while the upper part is glabrous. Mature leaves have a length of 6–17 mm and a width of 2–6 mm. The involucre is lanceolate and pointed, with a length of 3 mm. The receptacle length is 4.5–5 mm, and its width is 2–3 mm. Observations show that the first flowering period begins in the second decade of May and continues until the end of August. Seeds ripen in August and September.

Taraxacum officinale leaves are rich in vitamins A, C, and K, as well as minerals such as potassium and iron. This plant can be used to support liver function and promote the elimination of toxins from the body. Due to its mild diuretic effect and its ability to stimulate appetite, it helps alleviate problems such as constipation and bloating. It also contains antioxidant compounds that help combat stress and reduce the risk of chronic diseases. *Taraxacum officinale* propagates by seeds (Figure 2). The seeds were collected together with their pappus.

Figure 2
Taraxacum officinale

The seeds are light brown in color, and the weight of 1000 seeds ranges from 0.25 to 0.96 g.The conducted experiments showed that when seeds of medicinal dandelion (*Taraxacum officinale*) are sown at a depth of 10 mm and at a temperature of 15–20 °C, they achieve up to 80% germination within 7 days. Seeds sown at a temperature of 10–12 °C show 65–70% germination after 9 days. Thus, for normal germination of dandelion seeds, the optimal soil temperature should be in the range of 8–10 °C. For transplanting seedlings, the row spacing should be 25 cm, and the distance between plants should be 15 cm. Seeds sown in autumn flower and produce seeds in the spring of the following year. Seeds sown in spring produce flowers and seeds in the autumn of the following year. Plants grown from sown seeds reach their highest productivity in the third year.

Conclusion

The conducted experiments demonstrated that the application of different rates of mineral fertilizers in combination with manure significantly increased the number of vegetative and generative shoots per plant. In the treatment basal + N30P60K30 under the planting scheme of 45×5 cm, the seed yield per plant was 15.5–16.2 g and 140.3–142.7 g (note: clarify units/interpretation in final manuscript if needed). The highest values were observed in the treatment basal + N60P90K60 under the same planting scheme (45 × 5 cm).

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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