Optimization of agricultural practices in winter crops Coriandrum sativum L.

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Abstract. The total volume of world production of essential oil products reaches 250 thousand tons per year, which use up to 300 species of cultivated plants and wild-growing volatile-oil-bearing plants. The soil and climatic conditions in the south of Russia are favorable for the successful development of the essential oil industry, which is important for our country. Sowing coriander (Coriandrum sativum L.) is the most common essential oil culture of the Russian Federation and countries of the Union of Independent States. Its crops occupy about 82.4% of all areas of volatile-oil-bearing plants. Coriander fruits contain from 1.5 to 1.8% essential oil. The main component of the essential oil, linalool, and serves as the initial product for the production of a number of fragrant substances with the smells of lemon, orange, rose, violet, etc., which are successfully used in the perfumery, food, and distillery industries. Coriander is also a honey plant. Due to the growth in demand and gross purchases of coriander seeds associated with its high purchase price, problems arose with increasing its productivity and improving the technology of cultivation. Due to the large volumes of sales of both coriander raw materials and finished products, the levels of profitability and net income of farms both in the Republic of Crimea and in the Russian Federation as a whole, as well as the development of the agro-industrial complex will significantly increase. The above analysis of domestic and foreign literature in this review article shows that winter coriander crops are most productive compared to spring crops. Introduction to the production of winter crops of coriander, with the implementation of all elements of the cultivation technology, is a promising direction of its cultivation in the Crimea, as it allows more efficient use of soil moisture, which accumulates during the autumn-winter period.

1. Introduction

Agriculture is a branch of the economy aimed at providing the population with food and obtaining raw materials for a number of industries, including essential oil. Out of 13.6 billion hectares of land on the globe, about 1 billion hectares (7.3%) are used for the cultivation of agricultural plants. Most of the acreage in world agriculture is occupied by grain crops. [12]. The total volume of world production of essential oil products reaches 250 thousand tons per year, which uses up to 300 species of cultivated plants and wild ether carriers [3, 4]. The soil and climatic conditions in the south of Russia are
favorable for the successful development of the essential oil industry, which is important for our country since it is possible to obtain high-quality products on an industrial scale. Essential oil raw materials grown in the Crimea, allows getting high-quality essential oil and a number of other products of its processing. Also there are available qualified personnel and appropriate technologies for growing and processing essential oil raw materials in this region [5].

Sowing coriander (Coriandrum sativum L.) is the most common essential oil culture of the Russian Federation and countries of the Union of Independent States. Its crops occupy about 82.4% of all areas of ether carriers [6]. Crops of Coriandrum sativum L. are located in almost all regions of Crimea, with the exception of the South Coast. The limiting factor in this case is only the availability of processing complexes. Coriander fruits contain from 1.5 to 1.8% essential oil.

Coriander essential oil contains over 20 components, including alcohols: linalool (40–80%), geraniol (3–5%), geranyl acetate (up to 50%), borneol (1–4%), their acetic esters and aldehydes terpenes. The main component of the essential oil, linalool, and serves as the initial product for the production of a number of fragrant substances with the smells of lemon, orange, rose, violet, etc., which are successfully used in the perfumery, food, and distillery industries. Coriander is also a honey plant [7–10].

Due to the growth in demand and gross purchases of coriander seeds associated with its high purchase price, problems arose with increasing its productivity and improving the technology of cultivation. Due to the large volumes of sales of both coriander raw materials and finished products, profitability levels and net incomes of farms will increase significantly both in the Republic of Crimea and in the Russian Federation, as well as the development of the agro-industrial complex [11]. When writing this review article, we used the domestic and foreign experience of scientists, and also used data from various agricultural enterprises in the south of Russia and Ukraine.

2. Results
The cultivation of coriander in winter crops is not a fully disclosed topic. The winter crops of coriander are a rather specific agricultural practice, which not all farmers use. Although there is a number of scientists who studied sowing dates, seeding rates, varieties, the effect of mineral fertilizers, herbicides, microelements on the productivity of winter coriander crops involved in this development [3, 6]. Optimization of agrotechnical methods for growing coriander in the dry conditions of Crimea is practically unstudied. The purpose of this review article was to optimize agrotechnical methods for cultivating seed coriander in the risky zone of southern Russia.

The average yield of sowing coriander in the steppe zone is 0.6–0.7 t / ha, and with the improvement of cultivation technology it can be increased to 2.0 t / ha with a high level of profitability. The coriander yield is low due to the lack of technology elements for growing this crop, taking into account the peculiarities of the soil and climatic conditions of the zone and the properties of new breeding varieties [12, 13].

One of the ways to increase the production of coriander seeds and essential oil in the south of Russia is to develop elements of the technology for its cultivation in winter crops. Coriander is of great agricultural importance as a good precursor for winter grain crops. It cleans the soil of root rot and other diseases of grain crops, early releases the soil, leaves after harvesting more by 15–20 mm of productive moisture compared to stubble predecessors. The seed coriander has a pivotal root system, penetrating deeper into the soil up to 1.5 meters, thereby transporting nutrients to higher horizons and also loosening the soil [14].

The root system of winter wheat or barley sown after coriander penetrates deeper into the soil (their roots go along the dead coriander roots, using nutrients after their decomposition). Plants develop better, do not require additional costs and form a higher grain yield. The introduction of coriander sowing in winter production is a promising direction of its cultivation in the Steppe zone, since it allows using moisture from the soil that accumulates during the winter period more efficiently and reducing stress in the spring on the machine-tractor fleet. At the same time, the coriander growing
season ends earlier, which is important in the region of risky farming. There is always a chance that the cultivated plant will not fall under the fuse, thereby ensuring a high yield [13].

As a result of studies conducted in the piedmont zone, it was revealed that for the period of sowing coriander in early spring, winter plants were in the phase of full germination. The full germination phase of early spring sowing plants was noted from April 14 to 22, depending on the conditions of the year when the winter plants were already in the rosette phase (3-4 pairs of true leaflets). Comparing the field germination of winter sowing plants with early spring, it should be noted that the field germination of winter sowing plants was 7-8% higher than early spring [12].

For coriander under the conditions of steppe, the optimal seeding rate is 2.0–2.5 million germinating seeds per 1 ha, which ensures yields of up to 1.2 t / ha. Sowing with a row spacing of 45 cm contributes to a higher yield (1.1–1.2 t / ha) and more than the usual ordinary method of sowing. The highest yield (1.4 t / ha) was obtained with a winter sowing period, with a row spacing of 45 cm and a sowing rate of 2.0–2.5 million / ha [13]. Also recently, coriander has been widely used in direct sowing agriculture. In this case, sowing rates should be reduced by 10–15%, since direct seeders differ in precise sowing and seeding at the desired seed depth is much higher than with traditional seeders.

When comparing the height of coriander plants depending on the sowing dates, it was noted that the plants of the winter sowing period were 30–35 cm higher than the plants of the early spring sowing period, and this trend was observed throughout the growing season [12]. This is due to the presence of a more developed root system, which was formed during the autumn-winter period and most effectively uses the reserves of food moisture.

With winter sowing periods, the height of attachment of the lower umbrella, the number of first-order branches, productive umbrellas and fruits from one plant had higher rates (24–48%) compared to coriander plants of the early spring sowing period [13]. Also, other studies have determined the effectiveness of growth regulators against a natural background and in combination with fertilizers on coriander productivity [15]. It should also be noted that growth regulators for agricultural plants, including coriander, are effective in the south of Russia only if there are sufficient reserves of productive moisture in the spring (about 100 mm). With smaller supplies, the available moisture will be a limiting factor and the preparations will not be effective.

Regarding weed control in winter coriander crops, research results and industrial practice indicate that to reduce a number of weed of coriander crops, only agrotechnical measures for weed control are not enough. When growing coriander, weeds have a great depressing effect on coriander plants. This primarily manifests itself in competition for light, water and nutrients. During the growing season, weeds can absorb up to a third of the available moisture and cause a decrease in yield up to 80% [16].

Weeds also significantly weaken photosynthesis [17]. Moreover, damage from weeds significantly exceeds damage from pests and diseases. Coriander requires extremely weed-free fields, especially in the early stages of organogenesis. This is due to the fact that the seed after sowing requires a long time for germination (more than 20 days), and it grows slowly at the beginning of the growing season, and therefore cannot compete with weeds during this period [18].

To control the number of weeds, chemical control agents (herbicides) should be used. Therefore, the issue of weed control is still relevant [19].

At the Kirovograd experimental station, studies were conducted on the use of herbicides to control weed in coriander crops. In the experiments, the Oxamite cultivar was used with a sowing rate of 2.5 million seeds / ha. It was found that with a winter sowing period, the use of a tank mixture of Gezagard herbicides (2 1 / ha) + Zenkor (0.5 kg / ha) provided the highest conditional net income and cost recovery. On average, in winter crops the yield of coriander was 1.14 t / ha, which is 25% more than with early spring (0.85 t / ha). In areas that were kept clean from weeds, the yield was 1.44 t / ha, while in the control - 0.14 t / ha, or shortage was 1.32 t / ha or 90% [20].

One of the important conditions for obtaining high coriander yields is the correct selection of varieties, which corresponds to zonal environmental conditions and optimal plant density per unit area, which ensures the formation of generative and vegetative organs [13]. The most suitable varieties for growing in winter crops are the following varieties of coriander. The Yantar variety belongs to the
middle and late ripening, the mass fraction of essential oil is 2.45–2.64%, it is characterized by increased resistance to lodging, relatively low grafting of fruits. Variety Nectar: mass fraction of essential oil - 2.40%, winter hardiness is high. Variety Medun: mass fraction of essential oil - 2.51%, winter hardiness is high. Grade Strongman: mass fraction of essential oil - 2.73%, winter hardiness is high [21].

As for the effect of fertilizers on coriander productivity, potash fertilizers on soils saturated with bases (almost all types of Crimean soils) have a weak effect on seed productivity. In the presence of K₂O above 20 mg / 100 g of soil, potash fertilizers are not applied [13, 22]. Also, a weak effect of potassium on coriander productivity was noted at the Alekseevskaya Experimental Station. In the crop rotation, winter wheat - coriander - oats - perennial grass fertilizers were introduced under the predecessor and directly under the studied crop. The yield of coriander fruits increased due to the introduction of nitrogen and phosphorus fertilizers. Potassium against the background of nitrogen and phosphorus did not have a positive effect on coriander productivity [12].

Also, experiments were conducted on the influence of mineral fertilizers at the Dnipropetrovsk Agricultural University. The doses of mineral fertilizers were N₄₅P₄₅K₄₅ and N₆₀P₆₀K₆₀. Coriander was sown in a wide-row way with a row spacing of 60 cm and a sowing rate of 2 million germinating seeds per 1 ha. As a result of the experiments, the following conclusions were made: 1. Introduction of mineral fertilizers helps to strengthen the development of coriander plants. In areas with the introduction of mineral fertilizers, the height of the plants increased markedly, they were better developed, formed a larger number of umbrellas and larger fruits; 2. The greatest effect of fertilizers is manifested in favorable years. The yield of coriander fruits rises to 20% depending on the dose of fertilizers, which significantly exceeds the smallest significant difference. In dry years, the yield increase is negligible; 3. The difference in the yield of coriander fruits between the backgrounds N₄₅P₄₅K₄₅ and N₆₀P₆₀K₆₀ is insignificant, on average over the years of research, it amounted to 0.35 c / ha. This indicates that it is more economically feasible to use von N₄₅P₄₅K₄₅ in this zone [14].

As for the experiments, most researchers who conducted experiments on the effect of mineral fertilizers on coriander came to the conclusion that the application of mineral fertilizers contributes to the enhanced development of coriander plants. In areas with the introduction of mineral fertilizers, the height of plants increases markedly, they are better developed, form a larger number of umbrellas and larger fruits [23, 24].

There is also an effect on the yield of winter coriander crops and micronutrients. The use of micronutrient fertilizers is an integral part of increasing the yield of coriander, as they play an important role in the development of the plant organism. The role of trace elements in plant nutrition is multifaceted. They help increase the activity of many enzymes and enzymatic systems and improve the use by plants of nutrients from the soil and fertilizers [25].

Growth regulators also play a significant role in increasing coriander productivity. Their use makes it possible to purposefully regulate the most important biological processes in the plant organism, to more fully realize the potential capabilities of the variety [26]. Growth regulators are natural phytohormones or their artificial analogues. They are important factors in increasing the resistance of plants to adverse conditions of natural or anthropogenic origin (temperature differences, moisture deficiency, toxic effects of pesticides, disease damage and pest damage), and ultimately contribute to higher yields and improved product quality [27].

It is known that mineral fertilizers play an important role in the formation of coriander productivity, but there remains an open question of the interaction of fertilizers with micronutrient fertilizers and growth regulators. At the Kirovograd Experimental Station, experiments were conducted to study the effectiveness of growth regulators, microelements and sowing fertilizers on coriander productivity. The experiments were carried out in a field crop rotation in primary and elite seed farming. As a result of the experiments, it was concluded that the efficiency of growing coriander increases due to sowing fertilizer application (N₁₀P₁₀K₁₀) in combination with pre-sowing seed treatment with micronutrient Reakom (4 l / t) and vegetative plants in the stem phase with Treptol growth regulator (15 ml / ha). The increase in seed yield was 0.49 t / ha, the additional collection of essential oil - 18.3 kg / ha [28].
In Crimea, to a greater extent, there is a lack of phosphorus in the soil, and coriander is very responsive to the introduction of phosphate fertilizers into the soil. With a high phosphorus content in the arable layer (2.6–3.0 mg / 100 g of soil according to Machigin), phosphorus fertilizers are not applied for coriander crops, with an increased (2.1–2.5 mg / 100 g of soil) should be applied simultaneously with sowing P₁₀, with an average content (1.6–2.0 mg / 100 g of soil) is recommended to be applied under the main soil cultivation P₄₀ and in rows simultaneously with sowing P₁₀. With low availability (1.1–1.5 mg / 100 g of soil), the dose of phosphorus is P₆₀ for the main tillage and P₁₀ in rows simultaneously with sowing [13].

Nitrogen fertilizers are also important in the mineral nutrition of coriander. With a lack of nitrogen, the development of coriander slows down, the biometric parameters of plants and the productivity of photosynthesis decrease. It is recommended to add N₃₀ to top dressing in the spring during autumn coriander sowing. A high payback has been established from fertilizing the planned crop, taking into account the availability of available forms in the soil, taking them out per unit of crop and the utilization rates of N, P and K from the soil and fertilizers applied [29–31].

It is rational to start introducing essential oil crops into the crop rotation of a functioning agricultural enterprise with the most profitable crop, which is now winter coriander. The culture is well prescribed in the crop rotation, can be cultivated after cereals and be their predecessor. The value of coriander is also determined by the fact that in the event of a possible fluctuation in demand and prices, unsold products (fruits) can be sold in subsequent years without losing their essential oil content and sowing qualities. Coriander has undoubted advantages over many cultivated crops, due to its high profitability, which reaches, on average, 55-60% for the sale of marketable grain and 100-120% for the production of essential oil and other products of its processing [3].

Thus, it should be emphasized once again that the realization of the potential for expanding the area under essential oil crops and the organization of processing of raw materials directly depends on the availability of agricultural land for agricultural enterprises, investments, as well as state support.

3. Conclusion
1. The above analysis of domestic and foreign literature shows that winter coriander crops are most productive compared to spring crops. Introduction to the production of winter crops of coriander, with the implementation of all elements of the cultivation technology, is a promising direction of its cultivation in the Crimea, as it allows to use soil moisture more efficiently, which accumulates during the autumn-winter period.

2. It is most rational to start the organization of a full-scale enterprise, growing and processing essential oil raw materials of a number of essential oil crops on the basis of the research farm of the Institute of Agricultural Production (Krymskaya Roza village, Belogorsky district). There are all the necessary prerequisites for this: the availability of qualified personnel, our own varietal, seed and planting materials, developed technologies for the cultivation and processing of essential oil raw materials. The institute has developed a business project for organizing this enterprise. The conditions for the beginning of its existence are land security and the solution of the issue of investments (public, private).

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