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UDK: 633.88.631.5(575.1)

EFFECT OF AGROTECHNICAL FACTORS ON THE GROWTH, DEVELOPMENT AND PRODUCTIVITY OF BLACK CUMIN (NIGELLA SATIVA L.) (IN THE CONDITIONS OF NUKUS).

https://doi.org/10.5281/zenodo.17818546

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ABSTRACT: *Under the salinized soil conditions of the Republic of Karakalpakstan, research was carried out in Nukus during 2022–2024 to develop an improved cultivation technology for Black Cumin (Nigella sativa L.). The study investigated the effects of major agrotechnical factors - including sowing date, planting arrangement (row and plant spacing), and seed rate - on the plant's growth dynamics, developmental phases, and seed yield performance. Based on the results of the study, the optimal conditions for maximizing seed yield were determined to involve sowing during the second ten-day period of April (approximately April 12), adopting a planting configuration of 45 cm row spacing and 15 cm intra-row spacing, and applying a seed rate of 10 kg per hectare. This combination of agronomic parameters proved to be the most effective in ensuring the highest seed productivity. The findings generated in this study provide scientifically grounded and practically applicable recommendations that can significantly enhance the efficiency of Black Cumin (Nigella sativa L.) cultivation under the specific agro-environmental conditions of the Nukus region.*

KEY WORDS: *Nigella sativa L.; black cumin; sowing time; planting pattern; seed rate; yield.*

INTRODUCTION

The territory of the Republic of Karakalpakstan, situated in the northern zone of Uzbekistan, is distinguished by a pronounced continental climate, characteristic of extratropical desert regions. In summer, relative humidity is extremely low, whereas in winter it reaches high levels. The region's strongly seasonal and highly variable climate has a profound impact on plant growth and agricultural productivity. Under such conditions, the selection of optimal crops, the optimization of irrigation systems, and the implementation of appropriate agronomic practices are crucial for sustainable agricultural production. In this regard, the focus of our study, Black Cumin (Nigella sativa L.), as a medicinal plant, highlights that scientifically determined sowing dates are a critical agrotechnical measure for aligning its

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growth and developmental processes with the prevailing environmental and climatic conditions. For black cumin, the impact of different planting densities [1], combined with the fact that each stage of plant phenology is closely associated with specific environmental factors - temperature, moisture, light, and soil conditions - means that even slight inaccuracies in the sowing time can exert a substantial influence on the vegetation process. Specifically, delaying sowing decreases photosynthetic activity, slows the development of the root system, and results in a substantial reduction in seed yield. From an agrobiological standpoint, the sowing date is not only a criterion that determines plant growth and development within the agro-plantation, but also one of the principal factors that directly affects the components forming the primary raw-material yield, such as 1000-seed weight and oil content [3].

Moreover, the planting pattern for black cumin—including row spacing and intra-row plant distance - is a critical factor determining plant growth and yield performance [9], while also ensuring the rational and efficient use of land resources [7].

Objective: To assess the effects of sowing dates, planting patterns, and seeding rates on the growth, development, and seed yield of black cumin under the conditions of the Nukus district, and to formulate the most effective agronomic recommendations.

MATERIALS AND METHODS

The study was carried out from 2022 to 2024 on scientific–experimental plots located in the Nukus district of the Republic of Karakalpakstan. The study was conducted using an experimental approach and aimed to investigate three key agronomic factors affecting the yield of black cumin (Nigella sativa L.): sowing date, planting pattern, and seeding rate.

CULTIVATION PRACTICES

Fertilization: Nitrogen fertilizers should be applied in split doses during the vegetation period, with a recommended rate of 60 kg/ha [2]. The application of organic fertilizers at a rate of 10–15 tons per hectare prior to sowing is considered appropriate [9]. **Irrigation:** Soil moisture was maintained at 60–70% of the field capacity (FC) [6].

RESULTS

In the conditions of Nukus, planting operations typically commence in April. This is because air temperatures in February and March remain low, and the soil is not yet adequately prepared for planting. To assess the impact of sowing dates on the growth, development, and raw-material yield of black cumin, experiments were conducted in 2022 using three different sowing times: seeds were sown on April 2, April 12, and April 22. In the experiments, all factors except the sowing date were kept constant; that is, the principle of a single-factor design was strictly maintained. Observations on plant growth and development in the experimental variants were carried out from the seedling stage up to the full

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maturation of the seeds. "When examining the differences in plant growth and development, the height of the early-sown plants (27.33 cm) was 12% and 21% greater than that of the medium-sown (23.94 cm) and late-sown (21.5 cm) plants, respectively, up to the first ten-day period of June (Table 1). On June 25, the height of the medium-sown plants (51.2 cm) had increased more rapidly, surpassing the height of the early-sown (49.7 cm) and late-sown (45.4 cm) plants by 3% and 11.3%, respectively.

Table 1

The effect of sowing dates on the growth, development, and raw-material yield of black cumin.

№	Plant height (cm)		Leaf count		Bud count		Flower count		Fruit count		Capsule count
Date	08.06	25.06	08.06	1.07	16.06	25.06	16.06	25.06	30.06	02.07	30.07
2.04 early	7,3±1,5	49,7±0,9	16.6±0,7	21,1±0,4	13,2±0,8	,3±1,1	,5±0,4	8,78±0,9	2,0±0,5	12,7±1,2	21,4±1,4
12.04 medium	3,9±0,9	51,2±1,2	19,7±0,35	21,7±0,3	9,4±0,9	9,8±1,4	,1±0,7	7,83±0,8	2,11±0,5	9,0±1,02	26,9±3,6
22.04 late	1,5±1,8	45,4±1,9	16,9±1,0	22,2±0,5	13,1±1,6	5,2±0,7	,53±0,4	7,44±0,9	2,0±0,5	8,11±1,11	24,3±2,6

With respect to leaf number, the medium-sown plants exhibited a clear advantage during the first ten days of June, producing an average of 19.7 leaves. This figure was 15.7% higher than that of the early-sown plants (16.6 leaves) and 14.2% higher than that of the late-sown plants (16.9 leaves). These results were not consistent over time; in other words, the advantage in leaf number shifted, and during the early days of July, the highest leaf count was observed in the late-sown plants. They exhibited only a slight difference in leaf number compared with the medium- and early-sown plants, exceeding them by 0.5 and 1 leaf, respectively. By the end of the vegetation period, the medium-sown plants demonstrated a clear advantage in capsule number, averaging 26.9 ± 3.6 capsules

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per plant. This exceeded the capsule numbers of the early-sown and late-sown plants by 21.4% and 9.7%, respectively.

In 2023, experiments were conducted to assess the effects of row spacing and plant spacing on the growth, development, and yield of black cumin. The row-spacing trials included three variants: (1) 30 cm row spacing, (2) 45 cm row spacing, and (3) 60 cm row spacing (Table 2).

Table 2

Results on plant development and yield.

Variant	**Row spacing (cm)**	**Plant height (cm)**	**Number of primary branches (piece)**	**Number of secondary branches (piece)**	**Seed yield (t/ha)**
1	30 cm	48	6–7	2–3	0,95
2	45 cm	55	8–9	3–5	**1,20**
3	60 cm	58	9–10	4–6	1,05

The 45 cm row spacing was identified as the most effective planting pattern for black cumin cultivation. In this variant, the plants exhibited better growth and development, a higher degree of branching, and achieved the highest seed yield.

Plant-spacing experiments were carried out in three variants: (1) 10 cm between plants, (2) 15 cm between plants, and (3) 20 cm between plants. In all variants, the row spacing was fixed at 45 cm.

In the variant with a 10 cm plant spacing, the plants grew under highly dense conditions. This resulted in strong competition among the plants for water, nutrients, and light. As a result, plant growth slowed, branching decreased, and the average plant height reached 47 cm. The main stems produced 6–7 primary branches, while each primary branch developed only 2 secondary branches. The seed yield was recorded at approximately 0.90 t/ha (Table 3).

Table 3

Results obtained on the effects of plant spacing on the growth, development, and yield of black cumin.

Variant	**Plant spacing (cm)**	**Plant height (cm)**	**Number of branches on the main stem (piece)**	**Number of secondary branches (piece)**	**Seed yield (t/ha)**
1	10 cm	51	6–7	2	0,90

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2	15 cm	57	8–9	3–4	**1,18**
3	20 cm	60	9–10	4–6	1,00

In the variant where the plants were spaced 15 cm apart, sufficient distance was maintained between the plants. Under these conditions, they were able to access nutrients and water more effectively, and no light deficiency was observed. The plants developed actively, and the level of branching was high: the main stems produced 7–8 primary branches, while the primary branches formed 3–4 secondary branches. The average height of these plants was 54 cm, and the seed yield reached 1.18 t/ha, which was the highest result recorded during the experiment. This planting scheme was considered the most effective.

At the 20 cm plant spacing, the plants developed freely, and individual growth was strongTheir average height reached 57 cm, the main stems produced 9 primary branches, and each primary branch formed 4–5 secondary branches. However, due to the reduced number of plants per unit area, the total seed yield decreased to approximately 1.00 t/ha. Under the conditions of the Nukus district, the effects of different sowing rates of Nigella sativa L. (8, 10, 12, and 14 kg/ha) on plant growth, development, and seed productivity were investigated. During the research, it was determined that the sowing rate had a direct influence on plant density and their agromorphological characteristics (Table 4).

Table 4

Results obtained on the effect of different sowing rates on black cumin seed performance.

Seeding rate (kg/ha)	**Average plant height (cm)**	**Number of primary branches (piece)**	**Number of capsules (piece)**	**Seed yield (kg/ha)**
8	58,4	7,4	16,8	764
10	54,7	6,8	15,9	**828**
12	51,2	6,3	15,5	795
14	48,6	5,7	13,9	728

It was determined that in the conditions of Nukus, the highest yield of black cumin can be achieved by sowing at a rate of 10 kg/ha. This seeding rate was established as the optimal measure for providing adequate spacing, nutrients, and light, which ensures optimal plant growth, branching, and seed yield. [4] These data can serve as an important

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recommendation for local farmers and agronomists.

Discussion. Planting pattern and yield: The results showed that the variants with a 45 cm row spacing and a 15 cm plant spacing provided the highest yield. This result indicates that a 45 cm row spacing is recommended under the conditions of Uzbekistan. It is consistent with the conclusions reported in the studies of Saidov and To‘xtayev [10]. The optimal spacing creates a balanced environment for plants in terms of access to nutrients, water, and light. **Effect of dense planting:** Dense planting (30 cm row spacing / 10 cm plant spacing) led to strong competition among the plants, which resulted in reduced individual growth and branching, and consequently, lower yield [1]. **Sowing rate and yield:** The highest yield was recorded at the seeding rate of 10 kg/ha (828 kg/ha). This result is consistent with the findings of Tonçer and Kizil [11], who also reported that the highest seed yield was obtained when was sown at a rate of 10 kg/ha.

According to the overall results of the conducted studies, the following optimal agrotechnical package is recommended for cultivating Nigella sativa under the conditions of Nukus:

Sowing date: The second ten-day period of April (approximately around 12 April)

Planting pattern: Row spacing of 45 cm and plant spacing of 15 cm.

Seed rate: 10 kg/ha.

CONCLUSION

1. Experimental results scientifically substantiated that the optimal sowing period for Nigella sativa under Nukus conditions is the second ten-day period of April. The row spacing had a significant effect on the plant’s growth, branching, and seed productivity.

2. The highest seed yield (1.2 t/ha) was obtained in the 45-cm row-spacing treatment. In contrast, reducing the row spacing to 30 cm led to suppressed plant growth and a decrease in yield (0.95 t/ha). Although plants grown at a wider 60-cm spacing exhibited better individual morphological development, the overall stand density was lower, resulting in a total yield of 1.05 t/ha.

When Nigella sativa was planted at a 15-cm intra-row spacing, the plants developed vigorously and produced the highest seed yield (1.18 t/ha).At a 10-cm spacing, excessive plant density led to weaker growth and reduced productivity (0.90 t/ha).At a 20-cm spacing, individual plants exhibited stronger vegetative growth, but the reduced plant population per unit area resulted in a lower overall yield of 1.00 t/ha. 4. Under the conditions of Nukus, the most efficient seed rate for Nigella sativa L. was determined to be 10 kg/ha. At this rate, plant spacing and nutrient utilization were optimally balanced, resulting in the highest seed yield of 828 kg/ha. As the seeding rate increased, competition among plants intensified, leading to reductions in growth and developmental parameters. Therefore, a seeding rate of 10 kg/ha is

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considered optimal for achieving maximum yield and agromorphological efficiency.

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