

QUINOA (CHENOPODIUM QUINOA WILLD.) AN ALTERNATIVE CEREAL CROP RESISTANT TO ECOLOGICAL PROBLEMS

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Abstract. *In laboratory conditions, it was found that the percentage of quinoa (Chenopodium quinoa Willd) seed germination changes positively with increasing temperature. For example, at a temperature of 15°C, the germination rate was 14.8%, and the first seeds began to germinate 3-4 days after sowing. On the 15th day, 22.7% of the sown seeds germinated, on the 20th day, 28.6% germinated, and in total, at a temperature of 15°C, 28.6% of the sown seeds germinated. This figure is 71.4% at 20°C, which is 42.8% higher than at 15°C. At 25°C, 93.8% of the planted seeds germinated. This temperature was found to be optimal for laboratory germination of quinoa (Chenopodium quinoa Willd) seeds, and maximum seed germination was achieved after 20–25 days.*

Keywords: *global desertification, soil degradation, alternative culture, soil degradation, alternative, pseudopodium, halophyte, agrocenosis, agroecosystem.*

The world's population today considers healthy nutrition to be the foundation of the nation and the most important factor influencing human life expectancy. Therefore, the search for and use of new food sources is one of the pressing issues of our time. One of these sources is the ancient plant quinoa (Chenopodium quinoa).

It is imperative to highlight that in recent years, a network of suppliers of environmentally friendly natural products has been actively developing, offering the world flour, jelly, tea and balms from rare medicinal plants, natural drinks from unique cereals. One of these plants is a forgotten and ancient crop - the cereal plant Chenopodium quinoa, which is currently widely cultivated in the world.

Quinoa (Chenopodium quinoa Willd.) is an annual plant with high nutritional value, which is becoming increasingly important in Europe and other continents as an alternative grain that is resistant to environmental problems. This article discusses the agronomic characteristics of quinoa, the technology of its cultivation and its role in ensuring food security.[2]

In a similar context, quinoa was historically a staple food in South America, especially in the Andes, before the Spanish conquest. In recent decades, it has gained renewed attention worldwide due to its high protein content and adaptability to stable agro-climatic conditions. The Food and Agriculture Organization of the United Nations (FAO) declared 2013 the “Year of Quinoa” to further promote the strategic importance of this plant.[3]

Quinoa is a source of protein with high biological value, containing all essential amino acids. This includes lysine (6.1%), as well as rare amino acids such as methionine, threonine, and histidine.[4]

Quinoa is also gluten-free, making it a suitable food for people with gluten sensitivity. Its PER (protein efficiency ratio) is at a desirable level - equal to or higher than casein when cooked. Quinoa contains:

- Protein: 14.6% (by weight)
- Fat: 5.6% (55–63% linoleic and α -linolenic acids)
- Starch: 52–60% (low amylose content — 11–12%)
- Vitamins: A, E, B6, folate, riboflavin
- Minerals: Ca (1487 mg/kg), Fe (132 mg/kg), Mg, K, Cu, Mn, etc.

Additionally to the foregoing, quinoa is resistant to salinity, drought, and low-fertility soils. These properties confirm its importance as an alternative grain in the CIS and Central Asia. Quinoa has a high tolerance to various abiotic factors. This characteristic gives it the ability to adapt to different agro-ecological zones in agro-ecosystems, allowing it to grow from -8 °C in hot dry deserts and tropical regions with relative humidity up to 88%. Its adaptation to 40 °C and mountainous areas at an altitude of 4000 m above sea level, to alkaline and hydroxide soils, has unique adaptive properties that allow it to be grown in soils with a pH of 4.5 to pH 9.06.[6]



Figure 1. Morphology and color of seeds (panicles) of quinoa genotypic groups (*Chenopodium quinoa* Willd)

Taking these features into account, we set ourselves the goal of studying the bioecology of this plant, the influence of various soil and climatic conditions and environmental factors of our country on the yield of quinoa in our research work and substantiate it.

We conducted field experiments of our research work on irrigated gray soils of the Golib state farm, which is part of Boston Forest Innovative Technologies LLC in the Andijan region.

It is imperative to highlight that quinoa is a species of the genus (lat. *Chenopodium*) of the Amaranth family (lat. *Amaranthaceae*), subfamily (lat. *Chenopodium*) of the *Chenopodium* subfamily.

It must be unequivocally stated that our field experiments were laid in one layer in a 4-row arrangement. As is known, soil is an important edaphic factor affecting the growth and development of introduced plants. Introduced plants also affect the physicochemical properties of the soil and all biotic components present in the agrocenosis. For this purpose, before sowing quinoa seeds, in order to study the chemical and physical properties of this soil, samples were taken from the 0-25-240 cm soil layer and laboratory tests were carried out. According to the

results of the analyses, the soil of the experimental plot was recognized as slightly saline, medium loamy of the 2nd degree. Quinoa is a plant that can grow in sandy, low-fertility soils with a pH of 4.5 = 4.8 to pH = 9.6, so the plan was to sow the seeds in this soil.[1]



Figure 2. Laboratory and field germination of quinoa seeds (*Chenopodium quinoa* Willd)

Field and laboratory germination of quinoa seeds from 9 different genotypic groups was studied in the experimental plot of our study.



Measuring Soil Temperature and Collecting Phenological Data for Sowing Quinoa (*Chenopodium quinoa* Willd) Seeds

As a result of studying the ontogenesis of medicinal quinoa (*Chenopodium quinoa* Willd), it was found that its seeds have high germination properties and do not require scarification or stratification before sowing. To determine the optimal option for germination of medicinal quinoa (*Chenopodium quinoa* Willd) seeds in the laboratory, observations were carried out by placing them in a thermostat at the following temperatures: +10°C, +15°C, +20°C, +25°C, +30°C, +35°C.

With critical emphasis on the fact that our experiments show that the seeds began to germinate in the laboratory on the 4th–5th day. On days 12–16, the cotyledons turned yellow and stuck together

In laboratory tests of our study, it was found that the optimum temperature for quinoa (*Chenopodium quinoa* Willd) seed germination was 25°C. After sowing, 6.5 seeds germinated on day three, 18.4 on day five, 62.9 on day fifteen, 78.9 on day twenty, and 93.7 on day twenty-five, which accounted for 93.75% of the total number of seeds sown. At a temperature of 35°C, 45.44% of the seeds sown on days three and five germinated. At this temperature, no seed

germination was observed on subsequent days. The maximum temperature had a negative effect on seed germination and led to their drying out.

According to the results of the experiments, the most optimal temperature for germinating quinoa seeds (*Chenopodium quinoa* Willd) was +25°C, in this variant the germination rate was 93.8%.

It must be unequivocally stated that quinoa officinalis (*Chenopodium quinoa* Willd) seeds at a temperature of +10°C had a germination rate of 17.3%, with most of the seeds becoming moldy. At a temperature below +15°C, seed germination was delayed by 5-6 days, at a relatively high temperature the germination rate accelerated, and the seeds began to germinate 3-4 days after being placed for germination, and it was in these variants that the germination rate was high: at +25°C the highest seed germination rate was 93.7%; at a temperature of +30°C the germination rate of 65.4% of the seeds was determined.

The dynamics of quinoa (*Chenopodium quinoa* Willd) seed germination in laboratory conditions is completed after 24-25 days.

Table 1

Germination of quinoa (*Chenopodium quinoa* Willd) seeds in laboratory conditions (in %) (n=100) 2023

Number of seeds in a grain	Options	Number of sprouts that sprouted during the observation days, pcs.							Total seed germination %	V%
		3 day	5 day	10 day	15 day	20 day	25 day	30 day		
100	10°C	-	4,1	12,2	17,5	-	-	-	17,5 ± 1,21 %	13,8
100	15°C	1,1	8,3	16,4	22,7	28,6	-	-	28,6 ± 2,97 %	14,8
100	20°C	5,4	11,7	22,4	37,5	58,2	71,4	-	71,4 ± 1,68 %	3,4
100	25°C	6,5	18,4	39,7	62,9	78,9	93,7	-	93,8 ± 1,2 %	2,01
100	30°C	32,7	47,7	59,1	65,5	-	-	-	65,5 ± 3,39 %	7,2
100	35°C	30,2	45,4 4	-	-	-	-	-	45,44 ± 3,6%	11,9

*V– Variation

In laboratory conditions it was established that this indicator changes positively with increasing temperature. Thus, at a temperature of 15 °C, the germination rate was 14.8%, and the first seeds began to germinate on the 3-4th day after sowing, 22.7% of the seeds sown on the 15th day germinated, 28.6% - on the 20th day, and at a temperature of 15 °C, 28.6% of the total number of sown seeds germinated. At 20 °C, this indicator is 71.4%, which is 42.8% more than at 15 °C. At 25 °C, 93.8% of the total number of sown seeds germinated. This temperature turned out to be optimal for laboratory germination of quinoa seeds (*Chenopodium quinoa* Willd), and the maximum seed germination was observed on the 20-25th day.

During the seed germination period, the increase in temperature above 25°C acted as a limiting factor for seed germination, resulting in decreased germination. As a result, seed germination at 30°C decreased by 28.3%, while the total germination was 65.5%. Due to the increase in temperature, 65.5% of the seeds germinated within 15 days after sowing, whereas

no germination was observed for the seeds sown between 20 and 30 days. With further increase in temperature, i.e., at 35°C, only 45.44% of the seeds sown in the field germinated within 3-5 days.

It is a recurring assumption that the processes of generative (seed) propagation of the introduced quinoa plant (*Chenopodium quinoa* Willd) were carried out in the conditions of irrigated sierozem of the Andijan region, in crops of 90x15 cm, 60x30 cm, 90x30 cm, with a distance between plants of 20 cm, at a soil temperature of +6-8 °C.

When determining the optimal sowing dates for plants, it is important to study their field germination. We have not found any accurate data on the effect of sowing dates on the germination of quinoa seeds (*Chenopodium quinoa* Willd) in our country or abroad. To solve this problem, we set the task of studying the effect of sowing dates on the germination of quinoa seeds (*Chenopodium quinoa* Willd).

As a result of studying the ontogenesis of quinoa (*Chenopodium quinoa* Willd), it was found that high germination of its seeds depends on soil and climatic conditions and sowing methods.

Table 2

Effect of sowing dates on germination of quinoa (*Chenopodium quinoa* Willd) seeds in field conditions (n=200)

Seed sowing time	Number of germinated seeds (1m ²)	
	Piece	%
05.03.2023	106,0	53,0±1,47
15.03.2023	185,6	92,8±2,18
20.03.2023	164,2	82,1±1,79

As evidenced through methodological scrutiny to observe the field germination of quinoa (*Chenopodium quinoa* Willd) seeds, 200 whole, mature seeds were selected for each variant and sown in spring in March at three different times. The experiments were repeated four times. According to the data obtained, it was revealed that there are sharp differences in seed germination between the dates. Thus, the highest seed germination was observed in the variant with sowing on March 15.

When analyzing the obtained results, the seed germination rate was observed in the dates with sowing on March 15. In this case, 92.8% of the total number of sown seeds germinated. It was found that the germination of seeds sown on March 5 was 39.8% lower than on March 15. On March 20, this difference was 10.7% compared to March 15. 05.03. On March 20, the weather and low soil temperature had a negative effect on the germination of the planted seeds. As a result, 106 out of 200 planted seeds germinated. On March 20, an increase in weather and soil temperature, as well as a decrease in the soil moisture required for seed germination, had a negative effect on the germination of planted seeds. As a result, 164.2 of the total number of planted seeds germinated.

As exemplified in the subsequent section, in the first ten days of March, the weather, temperature and soil moisture were optimal for the germination of quinoa (*Chenopodium quinoa* Willd) seeds, which led to the germination of 185.6 of the total number of planted seeds.

It can be concluded that the study of the effect of the medicinal plant quinoa (*Chenopodium quinoa* Willd) on seed germination is an important ecological factor in the study of its growth and

development, the ontogenesis of the plant in introduced conditions and the achievement of high efficiency in growing and cultivating plants in specific conditions.

According to the results of our phenological observations carried out on 05.05.2025 in the experimental field, the height of the plants planted on 05.04 using the 90x60 method was 10 cm, the number of leaves was 8, the leaf length was 2.5-3 cm, the leaf width was 2.3 cm, and the root length was 2.7 cm. Four lateral branches were formed from the main stem. At the same time, in the plants planted using the 90x30 method, the plant height was 9.2 cm, the number of leaves was 6, the shoot length was 2.2-2.7 cm, the leaf width was 2.1 cm, the root length was 2.5 cm, and there were 2-3 lateral branches on the main stem.

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