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The Crop Production Capacity of Quinoa (*Chenopodium quinoa* Willd.)—A New Field Crop for Russia in the Non-Chernozem Zone of Moscow's Urban Environment

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Abstract: The article presents the research findings from the analysis of the growth, development, and yield formation characteristics as well as grain amino acid composition of quinoa (*Chenopodium quinoa* Willd.). The aim of this research was to assess the adaptability of quinoa, a new alternative crop for the Non-Chernozem conditions of Moscow's urban region. Five quinoa cultivars were tested, namely Brighest Brillian, Red Faro, Cherry Vanilla, Titicaca, and Regalona and were grown on sod-podzolic soil with wide-row hill-drop planting. For four years, the quinoa cultivars produced high yields without fertilizer and pesticide application—on average, 2.08–2.59 tons of grain per hectare—with a high content of protein and essential amino acids, primarily valine, lysine, and threonine. The Cherry Vanilla and Regalona cultivars had the highest grain yield on average (2.59 and 2.39 t/ha, respectively). Being able to produce crops in years with different temperatures and moisture supply, they were described as cultivars with high flexibility. However, none of the studied cultivars provided a sustained yield. The total protein content in the quinoa grains grown in 2020 ranged from 12.50 to 13.96% with high essential amino acids scores, such as valine, lysine, and threonine. The cultivar Red Faro was characterized by the highest ecological plasticity, stability, and resistance to the environmental conditions of Moscow's urban region.

Keywords: quinoa cultivars; wide-row hill-drop planting; yield structure; protein content; amino-acid composition

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1. Introduction

One of the ways to improve nutritional quality and create a greater product range is to introduce new processed foods from nontraditional plant raw materials [1–3]. The exceptional nutritious components of interest include high protein contents combined with a high quality, regarding the essential amino acid contents, lipids, minerals, vitamins, other substances and high nutritious, taste, therapeutic, and preventive properties [4–6].

Quinoa (*Chenopodium quinoa* Willd.) is an annual dicotyledonous herbaceous crop of the Amaranthaceae family, native to the Andean region [7–9]. In the 21st century, quinoa is expected to become one of the crops from which different food products and additives for different functional purposes will be obtained [2,4]. The main direction of use is the consumption of the grain for food and the processing of the grain into flour. Quinoa grains are important for a healthy diet. They have a high nutritional value and a unique chemical composition; their protein content (12–16% and higher) covers all the most important amino acids, polyunsaturated fatty acids, vitamins, and macro- and microelements, especially K, P, Mg, Ca, Na, Mn, and Fe [1,5,10]. Quinoa does not include gluten and has a low glycemic index [11–13]. Moreover, quinoa is considered an alternative to meat, and it decreases greenhouse gas emissions and grain usage and increases biodiversity utilization [5,6,11]. Additionally, quinoa is utilized as an ingredient to improve the nutritional value of bakery products [14].

The adaptation potential of the plant allows growing quinoa under a wide range of agroecological conditions. This plant has high environmental flexibility [15,16] and resistance to abiotic (drought, low temperatures, and salinity) [17–24] and biotic (disease tolerance) [25,26] stresses. Nowadays, the crop is grown not only in its native land, near Titicaca Lake (bordering Bolivia and Peru), where quinoa has been cultivated for more than five millennia [7–9], but also in several European countries [22,26–30]. Additionally, quinoa is cultivated in the USA, Canada, [31,32], and some African countries, such as Kenya, Zambia, Uganda, and Morocco [18,20,24,33,34], as well as in the Himalayas, India, Pakistan, and other world regions [35,36]. The International Year of Quinoa (2013) became the catalyst for crop production and consumption growth and resulted in a high demand for quinoa and its production and study globally [3]. According to the Food and Agriculture Organization of the United Nations (FAO), the world quinoa production in 2020 was over 175 thousand tons from an area of 188.9 thousand hectares [37].

In early publications (1839), quinoa is mentioned as a valuable food crop that was imported from France and cultivated in the northwestern regions of Russia (St. Petersburg). The authors drew attention to the fact that despite the high nutritional value of quinoa grain, it did not find wide distribution, because the population was not ready to abandon the usual cereal crops (wheat, rye, and barley) used for food. The authors recommended the cultivation of quinoa in those regions where low yields of winter cereals occurred, due to the unfavorable conditions in winter [38]. Vavilov made a significant contribution to the study of the cultures of the New World, including quinoa, with his works in the 1920s. As a result of the systematic collection of cultivated plants and their differentiated botanical and geographical studies worldwide, Vavilov discovered a new world of cultivated plants with all its diversity, created a new direction in the science of cultivated plants, and developed the doctrine of the source material for Soviet breeding and the basics of plant introduction to Russia. In his article "The great agricultural cultures of pre-Columbian America and their relationship", Vavilov refers to two types of quinoa as grain crops [39].

In Russia, quinoa is not widespread as an agricultural crop, yet there has been some practical experience of its cultivation [1], primarily in the Moscow urban territory (Russian State Agrarian University–Moscow Timiryazev Agricultural Academy (RSAU–MTAA)) [40]. Scientific research has also been conducted to assess the possibility of quinoa cultivation; agricultural techniques are being developed as well [41–44]. The aim of our research was to evaluate the growth features, crop development and formation, yield determination, crop structure, and amino acid composition of the grain in harvest conditions of four quinoa cultivars. Moreover, we also aimed to estimate the crop's adaptability to the agroecological conditions of the Non-Chernozem zone in the central part of the Russian Federation, as well as to identify the most productive and suitable cultivars to be cultivated.

2. Materials and Methods

2.1. Field Experiment

The experimental field was situated in Moscow, Russia [55°50′29.73″ N, 37°33′38.93″ E], belonging to RSAU–MTAA. The experimental plot soil is typical of the region, soddy-weakly podzolic, medium loamy in granulometric composition, and on moraine loam. The thickness of the arable horizon is 20–22 cm; the humus content (according to Tyurin) is 2.0–2.2%, and the mobile phosphorus and potassium contents (according to Kirsanov) are 230–250 mg P_2O_5 and 105–115 K_2O/kg of soil, respectively. The soil pH is 6.0. Groundwater is found at the depth of more than 3 m. Crop rotation includes mostly cereals, such as winter wheat, spring barley, and soybean. After harvesting cereals, the conventional tillage system consists of stubble tillage (~15 cm), followed by moldboard ploughing (~20 cm), disking, and tooth harrowing to prepare the seedbeds for winter crops. In the fall, spring cereals are ploughed, and tillage systems are prepared. The sowing scheme was 50 × 25 cm, and three plants were left in the hole (after thinning). The sowing density for harvesting was 240 thousand plants/ha.

2.2. Plant Material and Growing Conditions

The research was carried out in 2017–2020. Five quinoa cultivars from various ecological and geographical origins (Brightest Brilliant, Red Faro, and Cherry Vanilla (USA); Titicaca (Denmark); and Regalona (Chile)) were used. Seeds of the American varieties Red Faro, Cherry Vanilla, and Brightest Brilliant were purchased in the USA, as non-GMO varieties (Baker Greek Heirloom Seed Company). The seeds of the Titicaca and Regalona varieties were kindly provided by farmers from Kyrgyzstan, which they received from the ICBA (International Center for Biosaline Agriculture, UAE, Dubai). (Table 1).

Table 1. Origin of the quinoa cultivars used in the field experiment.

No	Cultivar	Origin	Notes
1	Red Faro	North of Chile, Chile	Bred by Frank Morton of Wild Garden Seeds
2	Cherry Vanilla	Oregon, USA	Bred by Frank Morton of Wild Garden Seeds
3	Brightest Brilliant	Oregon, USA	Bred by Frank Morton of Wild Garden Seeds
4	Titicaca	Denmark	Bred by Sven-Erik Jacobsen
5	Regalona	Chile	Semillas Baer, Chile

According to the varietal characteristics, these cultivars are used for food and seed production [5,12,26,29,31,33]. Figure 1 shows panicle close-ups of the selected quinoa cultivars during physiological maturity one month before harvest.

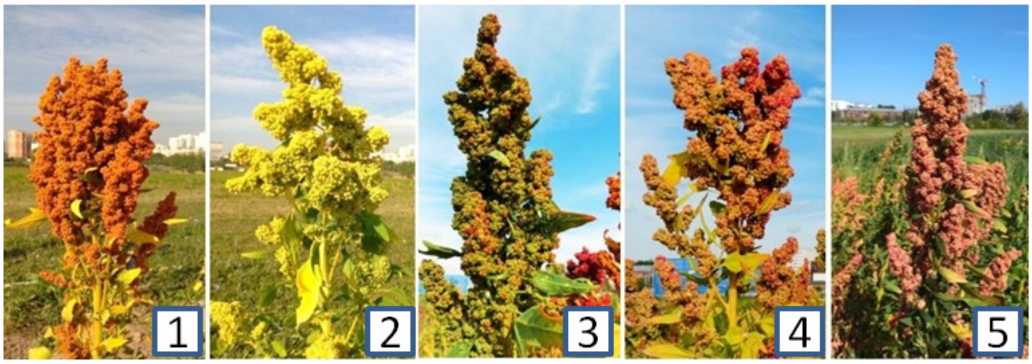

Figure 1. Quinoa inflorescence (panicles) at the grain maturation period: (**1**). Titicaca; (**2**). Regalona; (**3**). Brightest Brilliant; (**4**). Red Faro; and (**5**). Cherry Vanilla (Field station of RSAU–MTAA, 2020).

2.3. Weather and Meteorological Data

The sum of the precipitation and the average temperature were collected and analyzed for the years 2017, 2018, 2019, and 2020 in the study site from April to October during the quinoa vegetation season. There was a distance of 0.64 km between the observed field and the university's weather station. The research years were noticeably different in terms of the heat and moisture supply from the average long-term data (Table 2, Figure S1).

Table 2. Meteorological conditions during the quinoa growing season, April to October (data from the V.A. Mikhelson Observatory, Moscow).

Meteorological Data	2017	2018	2019	2020
Sum of temperatures ≥ 10 °C	2295	2702	2356	2344
Average temperature, °C	15.6	18.6	17.1	17.8
Precipitation, mm	413	279	244	526

In 2017, it was warm and rainy, but in the first half of the growing season, the average daily air temperature was 2.1–2.5 °C lower, and the amount of precipitation was 60 mm higher than average annual indicators. In 2018, it was hot and dry. The sum of the active temperatures during the quinoa growing season was 2702 °C, and it was 380 °C higher than the average annual temperature. The precipitation in 2018 was 279 mm, which was 85 mm less than the average annual amount.

In terms of the sum of active temperatures, 2019 did not differ from the long-term average data as markedly as 2018. The sum of the active temperatures was 80 °C higher than the long-term average. The precipitation in 2019 was 120 mm less than the average annual value. In general, in terms of the temperature regime and moisture supply, 2020 was favorable for quinoa growth and development. In total, the precipitation amount was 526 mm during the quinoa growing season, which exceeded the climatic model by 216 mm. The average daily air temperature during the growing season was 16.2 °C, which was 0.4 °C higher than the climatic average.

2.4. Measurements and Crop Data

The small-plot field experiment was established according to the method of organized repetitions (n = 4). Each cultivar occupied an area of 9 m^2 (3 × 3). The recorded plot area in the experiment was 1.25 m^2. Seeds were sown manually, immediately after the pre-sowing soil cultivation with a combined unit [predecessors: plant family Brassicaceae (2017); quinoa (2018 and 2019); and winter triticale (2020)]. The sowing method was wide-row hill-drop planting with the scheme 50 × 25 cm and 7–10 seeds per hole. The seeding scheme was chosen according to the recommendations developed by the UN FAO in the framework of the project on quinoa testing and promoting [3]. The seeds were embedded in the soil to a depth of 1.3–1.5 cm. After 3–4 true leaves had appeared, thinning was carried out, and a certain density of plants was formed. Three plants were left in each hole. During the growing season, three weedings (manually), small hilling of plants (at a height of 25–30 cm), and three treatments against beet leaf aphid (*Aphis fabae*) were carried out using an environmentally friendly preparation based on natural fats, vegetable oils, and fir extract (Green soap). Fertilizers were not applied in the trial. Harvesting, threshing grain (after plant drying), and sorting were performed manually.

2.5. Nutritional Content Analysis of Quinoa Grains

The protein content in the quinoa grain (mass fraction of crude protein) was determined according to the All-Union State Standard 32044.1-2012 (ISO5983-1:2005). The protein amino acid composition was determined by the capillary electrophoresis method (MI 04-38-2009. Determination of proteinogenic amino acids in feed and raw materials).

2.6. Statistical Analysis

Experimental data were statistically processed by analysis of variance (ANOVA) and Duncan's multiple range tests at α = 0.05 with AGROS software (version 2.11, Moscow, Russia), as well as standard MS Excel software packages. Field experiments were carried out in fourfold repetition (n = 4). Two-way analysis of variance (ANOVA) (factors A and B were quinoa cultivar and year, respectively) was used. The data are presented as mean value ± standard error (SE) at α = 0.05.

3. Results and Discussion

3.1. Basic Statistics: Variability of Quinoa Growth and Yield

In quinoa plant development, two periods are commonly distinguished, namely vegetative, or the active growth period, and reproductive, the period of inflorescence (panicles) formation and seed production and maturation [45]. The duration of each period in our experiments did not differ much; during the sowing, at the end of the first ten-day period, and the beginning of the second ten-day period of May, shoots appeared within 6–8 days (cotyledon leaves above the soil surface), and the start of the inflorescence formation on plants was noted at the end of June. The growth of the panicles, flowering, seed formation, and maturation continued until the middle of the third ten-day period at the end of September. The total growing period was 135–140 days; in some years with early sowing, this period lasted 150 days.

The results of the two-way ANOVA test show statistical differences at the 5% significance level in the plant height among different quinoa cultivars and environmental factors during the 2017–2020 growing seasons (years). Additionally, the differences were significant for the interaction of the factors «cultivar × year». (Table S1). In the years of our research, the quinoa plants differed significantly in height, which might be associated with the growing conditions and varietal characteristics (Table 3).

Table 3. Quinoa height (cm) before the harvest.

Cultivar	2017	2018	2019	2020	Mean (Cultivar) *
Brightest Brilliant	108 ± 3	126 ± 5	114 ± 5	121 ± 5	117 c
Red Faro	112 ± 3	132 ± 6	129 ± 6	126 ± 4	125 d
Cherry Vanilla	105 ± 3	134 ± 6	128 ± 6	118 ± 5	121 d
Titicaca	78 ± 2	103 ± 5	95 ± 4	103 ± 4	95 a
Regalona	84 ± 2	107 ± 5	111 ± 4	109 ± 4	103 b
Mean (year) **	97 a	120 c	115 b	115 b	-

The table shows mean values ± SE at $\alpha = 0.05$ according to the ANOVA test. Means followed by the same letter are not significantly different at $\alpha = 0.05$ according to Duncan's multiple range test. *—influence of cultivar on the plant height. **—influence of meteorological conditions of the year on the plant height.

The height of the quinoa plants in the phase of full-grain maturation under experimental conditions varied based on the cultivar and meteorological conditions of the year from 78 cm (cv. Titicaca, 2017) to 134 cm (cv. Cherry Vanilla, 2018). In all observation years, the plants of the American cultivars were significantly higher (117–125 cm) than the genotypes of the other ecological and geographical groups.

Yield is one of the most important indicators for assessing crop production efficiency under certain agroecological conditions. The results of the two-way ANOVA test showed statistical differences at the 5% significance level in the quinoa grain yield among different cultivars and environmental factors during the 2017–2020 growing seasons (years) (Table S2). Additionally, the differences were significant for the interaction of the factors «cultivar × year». As a result, the quinoa yield was meaningfully influenced by meteorological conditions of the growing season and the variety of adaptive characteristics of each genotype. The quinoa yield data are presented in Table 4.

Table 4. Productivity of quinoa grain, t/ha.

Cultivar	2017	2018	2019	2020	Mean (Cultivar) *
Brightest Brilliant	1.01 a	1.21 bc	2.59 h	3.52 np	2.08 a
Red Faro	1.44 df	1.64 g	2.92 j	3.14 km	2.28 b
Cherry Vanilla	1.31 ce	1.56 fg	3.69 pq	3.81 q	2.59 d
Titicaca	1.46 eg	1.01 a	2.83 ij	3.21 lm	2.13 a
Regalona	1.62 g	1.04 a	3.22 m	3.67 oq	2.39 c
Mean (year) **	1.37 b	1.29 a	3.05 c	3.47 d	-

The table shows mean values according to the two-way ANOVA test ($\alpha = 0.05$). Means followed by the same letter are not significantly different at $\alpha = 0.05$ according to Duncan's multiple range test. *—influence of cultivar on the grain yield. **—influence of meteorological conditions of the year on the grain yield.

On average, over the four years of research, 2.08–2.59 t/ha were obtained depending on the cultivar. The cultivars Cherry Vanilla and Regalona produced the highest grain yield (2.59 t and 2.39 t/ha, respectively). The high flexibility of all the studied quinoa cultivars should be underlined; during their cultivation, they were able to produce crops in years that were different in terms of heat and moisture supply. However, all cultivars had reduced yields in years with high precipitation and low average air temperature (2017), as well as high air temperatures with a lack of precipitation (2018). The highest quinoa yield was 3.53–3.81 t/ha obtained by growing the cultivars Brightest Brilliant (2020), Regalona (2020), and Cherry Vanilla (2019 and 2020). The lowest yield of quinoa (1.01–1.04 t/ha) was obtained growing the cultivars Brightest Brilliant (2017), Titicaca (2018), and Regalona (2018). The cultivar Red Faro was characterized by the highest ecological plasticity, stability, and resistance to adverse meteorological growing conditions (2017–2018).

The grain yield and its size in the experiment with the same plant density for harvesting for all cultivars were determined by the weight of the grain from one plant and thousand-seed weight, respectively (Table 5). The results of the two-way ANOVA test show statistical differences at the 5% significance level for all characteristics of the quinoa yield structure among different cultivars and environmental factors during the 2017–2020 growing seasons (years). Additionally, the differences were significant for the interaction of the factors «cultivar × year» (Table S3).

Table 5. Quinoa yield structure.

Cultivar	Grain Weight g/Plant	Grain Amount in the Panicle, per Unit	Thousand-Seed Weight, g
		2017	
Brightest Brilliant	4.20 a	1367 a	3.19 kl
Red Faro	6.00 be	2469 ef	2.43 cd
Cherry Vanilla	5.46 ae	1896 cd	2.88 f
Titicaca	6.08 ce	1930 d	3.15 jl
Regalona	6.79 e	2515 f	2.70 ef
		2018	
Brightest Brilliant	5.04 ad	3130 i	1.61 a
Red Faro	6.83 e	3925 kl	1.74 a
Cherry Vanilla	6.50 de	3066 hi	2.12 b
Titicaca	4.21 a	1595 ab	2.64 e
Regalona	4.33 a	1672 bc	2.59 de
		2019	
Brightest Brilliant	10.79 fh	2862 gh	3.77 n
Red Faro	12.17 hk	3938 l	3.09 gl
Cherry Vanilla	15.38 no	4882 np	3.15 il
Titicaca	11.79 gi	3468 j	3.40 m
Regalona	13.42 kl	4142 l	3.24 m
		2020	
Brightest Brilliant	14.71 lo	5489 qr	2.68 ef
Red Faro	13.08 ik	4955 op	2.64 e
Cherry Vanilla	15.87 o	5119 p	3.10 hl
Titicaca	13.41 jl	4841 mo	2.77 ef
Regalona	15.30 mo	5543 r	2.76 ef

The table shows mean values according to the two-way ANOVA test. Means followed by the same letter are not significantly different at $\alpha = 0.05$ according to Duncan's multiple range test.

In 2020, the production of the highest yields by the cultivars Brightest Brilliant, Regalona, and Cherry Vanilla was ensured largely due to more full-bodied panicles (with a grain weight of 14.71–15.87 g/plant), and the Cherry Vanilla cultivar had even larger grains.

In 2018, compared to 2017, 2019, and 2020, the thousand-seed weight in all cultivars was lower, especially in the American cultivars Brightest Brilliant and Red Faro (1.61 and 1.74 g, respectively). In 2018, the formation of the finer grains by the quinoa plants was apparently associated with the meteorological conditions of the growing season. For almost the entire growing season, the plants were under unfavorable conditions in terms of moisture supply, which were aggravated by high average daily air temperatures.

Under favorable environmental conditions, the quinoa plants produced rather large (up to 30 cm long and more) and branched panicles with many grains (up to 5.1–5.5 thousand grains per panicle). The quinoa grain is not very large; the thousand-seed weight varied from 1.61 g (cultivar Brightest Brilliant, 2018) to 3.40–3.77 g (cultivars Titicaca and Brightest Brilliant, 2019), and the grain diameter varied from 0.5 to 2.0 mm. Accordingly, a four-year field trial of various quinoa genotypes grown in the Non-Chernozem zone of Moscow's urban environment without applying chemical fertilizers and pesticides revealed comparable grain yields to some European and African countries in both favorable conditions [27,29] and abiotic stresses induced by drought and soil salinity. The Russian Federation is a state located in eastern Europe and northern Asia. Occupying about one third of the territory of Eurasia and one eighth of the entire terrestrial landmass, it is not only the world's largest state by territory, but it is characterized by a variety of agroclimatic regions and edaphoclimatic conditions. Currently, the population of the Russian Federation is more than 145 million people; the projected population growth implies not only a need for an increase in the production of food grains but also the need for a transition to environmentally safe and sustainable agriculture. Quinoa can play an important role in the future diversification of agricultural systems in Russia. The conducted studies show that this crop can be successfully grown in the conditions of the Non-Chernozem zone of the Russian Federation. The high adaptability and unique amino acid composition of quinoa grains allow us to consider quinoa as a crop with high commercial potential for Russia [22,24].

3.2. Evaluation Results of Protein Content and Amino Acid Composition in Quinoa Grains

According to numerous studies, the main quinoa feature is that its grain is a source of high-quality protein [2,4,6,11]. Although the overall protein content of quinoa is higher than that of major grains (wheat, corn, and rice), quinoa is best known for its high amino acid protein content [2,15,31].

Table 6 presents the comparative assessment of the protein content and some amino acid compositions in the grains of various quinoa cultivars grown in 2020.

Table 6. Total protein content and amino acid composition of quinoa grains.

Amino Acid	Amino Acid Content, g/100 g of Protein					
	Brightest Brilliant	**Red Faro**	**Cherry Vanilla**	**Titicaca**	**Regalona**	**Reference Protein**
Valine	4.32 ± 0.11	3.96 ± 1.02	3.84 ± 0.81	3.87 ± 0.84	3.24 ± 0.52	5.00
Leucine + Isoleucine	7.78 ± 0.09	9.20 ± 1.02	8.72 ± 1.11	8.23 ± 1.12	8.84 ± 0.81	11.00
Lysine	5.64 ± 0.14	5.36 ± 0.94	4.98 ± 0.94	4.86 ± 0.87	5.11 ± 1.14	5.50
Methionine	1.32 ± 0.05	1.09 ± 0.04	0.85 ± 0.08	0.95 ± 0.05	1.11 ± 0.16	3.50
Threonine	3.86 ± 0.21	4.08 ± 0.51	3.97 ± 0.51	4.25 ± 1.07	4.23 ± 0.74	4.00
Phenylalanine	2.94 ± 0.11	3.31 ± 0.26	3.09 ± 0.42	3.11 ± 0.84	3.84 ± 1.06	6.00
Total protein	12.87 ± 1.02	13.96 ± 2.04	13.48 ± 2.11	13.23 ± 1.87	12.50 ± 1.84	-

The table shows mean values ± SE at α = 0.05 according to the ANOVA test. Total protein content did not differ significantly among quinoa cultivars.

The protein content in the quinoa grains of the studied cultivars grown without nitrogen fertilizer application was quite high (12.5 and 13.96% for the cultivars Regalona and Red Faro, respectively). However, the difference in the protein content was not significant among the studied quinoa cultivars (Table 6). In terms of the protein content of such essential amino acids, such as valine, lysine, and threonine, the protein in quinoa grains was close to the reference protein indexes and comparable with the amino acid content of other research [31,46].

4. Conclusions

This study shows that the production of quinoa, combining competitive yields with a high grain quality, is possible under environmental conditions in the Non-Chernozem zone of Russia. However, over the four growing periods, the five cultivars tested showed differences in the sensitivity against the different environmental conditions regarding yield parameters.

These changes were most probably attributed to the combination of high precipitation and low average air temperature (2017) and to the combination of high air temperatures with a lack of precipitation (2018). The Russian food market is constantly being enriched with new types of products, including crops previously unknown to the domestic consumer. This is largely due to the move toward a healthy lifestyle in the country and accordingly an increased requirement for highly nutritional products. Quinoa (*Chenopodium quinoa* Willd.) can belong to this group. Quinoa grains are rich in nutrients; the protein content is high (10–16% or more); the crop contains all essential amino acids, vitamins, and minerals, and it does not contain gluten, which is important for people with celiac disease. Currently, quinoa is mainly exported from Peru to Russia; however, the cost of grain is high. Thus, the introduction and possibility of growing quinoa within Russia is both promising and in demand. The introduction of Russian production will make a significant contribution to the economy, increasing the level of food security within the state. Quinoa has a high adaptive potential, allowing it to be cultivated in a wide range of agroecological conditions. Considering global climate change, the manifestation of which negatively affects the productivity of traditional agricultural crops, one cannot overemphasize the extreme resistance of quinoa to abiotic stresses (drought, low temperatures, salinity, etc.), a fact that is attracting new producers to this crop. In Russia, field research has been carried out to assess the possibility of quinoa cultivation, and agricultural techniques are being developed. Over four years, our study showed that it is possible to cultivate various quinoa cultivars under the environmental conditions of the Non-Chernozem zone in the central part of Russia and obtain 2.08–2.59 t/ha with a high protein and essential amino acids content (primarily valine, lysine, and threonine) on sod-podzolic soils without fertilizer and pesticide application. The Cherry Vanilla and Regalona cultivars had the highest grain yields during the experiment (2.59 and 2.39 t/ha, respectively). However, we have noted variations in yield depending on climatic conditions. The total protein content of quinoa grains grown in 2020 ranged from 12.50 to 13.96% with a high content of essential amino acids, such as valine, lysine, threonine. The Red Faro quinoa cultivar was characterized by the highest ecological plasticity, stability, and resistance to the environmental conditions of the Moscow city region.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy12123040/s1, Figure S1: Meteorological conditions during the quinoa growing seasons (2017–2020) (data from the V.A. Mikhelson Observatory, Moscow); Table S1: The results of two-way ANOVA test to evaluate the significance of quinoa cultivar and agroclimatic conditions each year on the plant height; Table S2: The results of two-way ANOVA test to evaluate the significance of quinoa cultivar and agroclimatic conditions each year on the grain yield; Table S3: The results of two-way ANOVA test to evaluate the significance of cultivar and agroclimatic conditions each year on the quinoa yield structure.

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