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Crop development peculiarities among quinoa foreign varieties (*Chenopodium quinoa* willd.) in agriclimatic conditions of Crnbez

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ABSTRACT

The modern Russian food market is constantly enriched with new types of products obtained from the crops previously unknown to the domestic consumer. One of the plants of interest in this regard is quinoa, *Chenopodium quinoa* Willd., a pseudo-grain culture from the Amaranthaceae Juss family of the Chenopodioideae Burnett subfamily. Grain quinoa has a high nutritional value and a unique chemical composition: it has a high protein content (up to 20%), which contains the most important amino acids. It does not contain gluten, and is rich in polyunsaturated oils, vitamins and minerals. The adaptive potential of quinoa allows it to be cultivated in a wide range of agricultural-ecological conditions. It should be noted that quinoa is resistant to abiotic stresses, which is important, taking into account global climate changes, the manifestations of which negatively affect the productivity of traditional agricultural crops.

Keywords: Quinoa, Chenopodium quinoa Willd., Pseudo-grain crop, Yield, Yield structure, Adaptive potential.
Article type: Research Article.

INTRODUCTION

Quinoa, *Chenopodium quinoa* Willd. is a pseudo-grain crop of the Amaranthaceae family of the Chenopodioideae subfamily, cultivated for several thousand years in South America. The value of quinoa is mainly in the high content of protein, vitamins, minerals and the absence of gluten. Quinoa is one of the main food crops in the Andean mountains, but interest in the product has increased recently in the United States, Europe and Asia. Quinoa has been selected by FAO as one of the crops for food security in the next century. The genetic variability of quinoa is enormous, and quinoa varieties are adapted to the cold high-altitude climate and subtropical conditions. The main limitation to growth in northern Europe, Canada and the highlands is the short growing season, as it takes about 150 days to harvest quinoa seeds. The main direction of use is the processing of grain into cereals and flour (Hernández-Ledesma 2019; Hinojosa *et al.* 2019; Hu *et al.* 2017; Kukharenkova 2018; Naik *et al.* 2020). The grain is characterized by high nutritional value, intended for healthy food production. Quinoa plants are characterized by high ecological plasticity and resistance to abiotic stresses (drought, low temperatures, salinity), and almost are not affected by diseases. They can be grown in various soil and climatic conditions (Naik *et al.* 2020; Pereira *et al.* 2019; Repo-Carrasco *et al*. 2003).

MATERIALS AND METHODS

In the field experiment, we studied the features of growth and development, the yield formation of five foreign varieties of quinoa: Q1, Q2, Q3, Q4, Q5 from the selection of the International Center for Biosaline Agriculture (ICBA), United Arab Emirates. An assessment of their productivity was carried out in order to establish the most productive and adapted to regional agroecological and agroclimatic conditions. The studies were carried out at

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the Field Experimental Station of the RSAU-MAA named after K.A. Timiryazev. In 2020, they performed observations of quinoa plant yield growth, development and formation during microfield experiments on the plots with an area of 1.12 m^2 (2.50 × 0.45), fourfold replication. Sowing of seeds was carried out manually immediately after pre-sowing treatment of soil with a combined unit (predecessors - winter triticale). Dotted sowing was carried out according to the scheme of 45 × 10 cm with a row spacing of 45 cm to form a plant density of 222.22 thousand plants/ha. The seeds were embedded in the soil to the depth of 1 cm. When the third true leaf appeared in the plants, thinning was carried out. Crop care included weeding (manually), small hilling of plants (at the height of 25-30 cm) and the treatment of plants against beet leaf aphid (Aphis fabae) using a biological product Fitoverm. Harvesting, threshing of grain (after plant maturing and drying) and sorting was carried out manually. Crop data were processed statistically by dispersion analysis using Microsoft Office Excel 2013 software.

RESULTS

The productivity of quinoa varieties was assessed when they were grown without the use of fertilizers on medium-cultivated soddy-weakly podzolic medium loamy soil with a plow horizon depth of 20-22 cm and a humus content of 2.0-2.2%. According to the mobile phosphorus content, the soil belongs to the V-th class (high supply), mobile potassium - to the III-rd class (average supply), pH sol 5.6-5.8. The year of the research differed in terms of heat and moisture supply from the average long-term data. The first half of the growing season of quinoa plants in 2020 fell on difficult meteorological conditions - the air temperature and the amount of precipitation significantly exceeded the average annual indicators (Fig. 1).

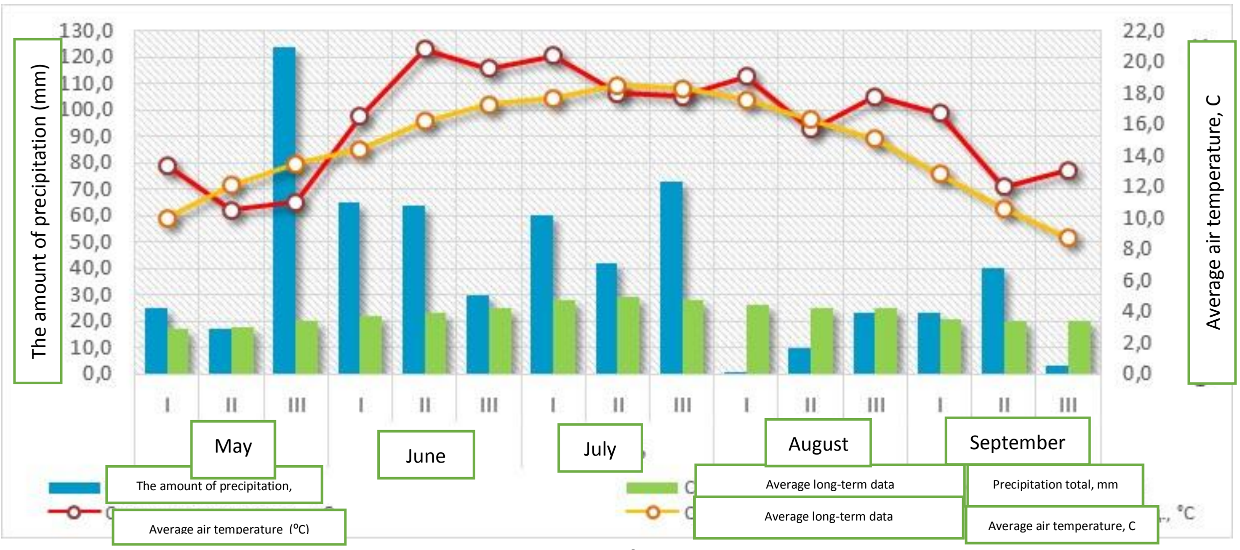

Fig. 1. Meteorological conditions for the growing season 2020.

Two periods are distinguished conventionally in the development of quinoa plants: vegetative, or the period of active growth, and reproductive - the period of inflorescences (panicles) formation, the formation and maturation of seeds (Hernández-Ledesma 2019; Fig. 2). The duration of each period in our experiments did not differ much in almost all varieties: when sowing at the end of the third decade of May, shoots appeared after 10-12 days (cotyledon leaves above the soil surface). In the second decade of July, the beginning of inflorescence formation on plants was noted among the varieties Q1, Q2, Q3, Q5. The variety Q4 had lower rate of panicle formation (Fig. 3). The harvesting of plants was carried out at the end of the third decade of September. The studies noted a significant variability of quinoa plants in terms of plant morphoarchitectonics, which was mainly determined by the plant genotype and vegetation conditions (Table 1). The varieties varied within a fairly wide range in terms of yield - from 1.65 ton ha^{-1} for the Q4 variety to 4.23 ton ha^{-1} for the Q5 variety. The quinoa grain did not exceed 2 mm in diameter, and the weight of 1000 grains varied from 1.66 g for the Q4 variety to 3.23 g for the Q3 variety. The least productive variety was Q4, despite the fact that it had the longest panicle length for harvest (Fig. 3, Table 2). The formation of the highest yield in variety Q5 was ensured due to more full-bodied panicles: the number of grains in one panicle was 6476 pcs. for this variety, and the grain weight of one panicle was 19.04 g (Table 2).

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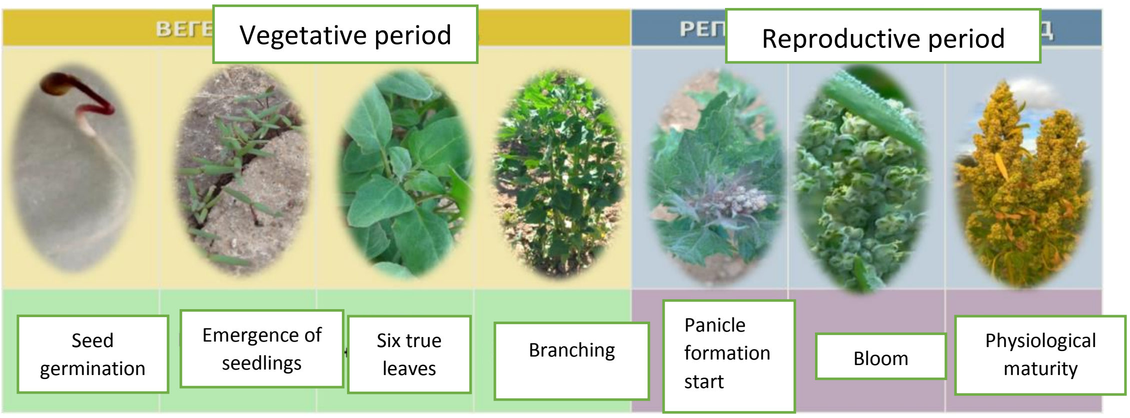

Fig. 2. The periods of quinoa plant growth and development (photo by EM Kurenkova).

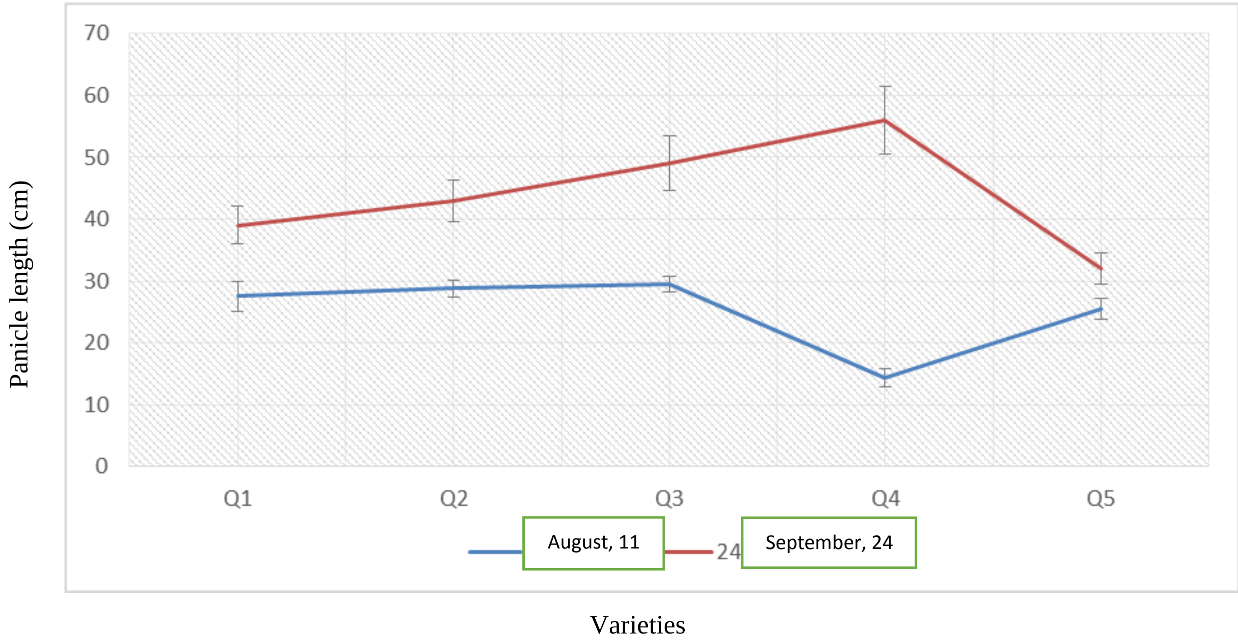

Fig. 3. The panicle length (cm) of the studied varieties in 2020.

Table 1. Morphoarchitectonics of quinoa plants.

Variant	Root system			Side shoots				Leaves			
	Root length (cm)	**Wet weight (g)**	**Dry weight (g)**	**Upper tier (cm)**	**Middle tier (cm)**	**Lower tier (cm)**	**Total (cm)**	**Upper tier (cm)**	**Middle tier(cm)**	**Lower tier (cm)**	**Total (cm)**
Q1	14.0 ± 1.4	2.07 ± 0.19	0.51 ± 0.05	6.0 ± 0.5	6.0 ± 0.6	7.0 ± 0.6	19.0 ± 1.0	31.0 ± 2.9	28.0 ± 1.4	32.0 ± 1.3	91.0 ± 3.6
Q2	17.0 ± 1.0	2.74 ± 0.12	0.67 ± 0.03	7.0 ± 0.7	7.0 ± 0.6	6.0 ± 0.5	20.0 ± 1.0	42.0 ± 2.3	45.0 ± 4.4	38.0 ± 3.5	125.0 ± 6.2
Q3	11.0 ± 0.9	3.39 ± 0.33	1.00 ± 0.10	6.0 ± 0.6	6.0 ± 0.5	7.0 ± 0.4	19.0 ± 0.8	39.0 ± 3.9	39.0 ± 3.7	36.0 ± 3.0	114.0 ± 6.6
Q4	15.0 ± 0.6	2.90 ± 0.19	0.72 ± 0.05	7.0 ± 0.3	8.0 ± 0.4	7.0 ± 0.4	22.0 ± 0.8	43.0 ± 3.2	50.0 ± 1.7	29.0 ± 2.8	123.0 ± 6.5
Q5	11.0 ± 1.1	2.31 ± 0.22	0.60 ± 0.06	8.0 ± 0.5	7.0 ± 0.6	7.0 ± 0.5	22.0 ± 0.8	43.0 ± 1.8	39.0 ± 2.2	22.0 ± 1.7	104.0 ± 2.3

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Table 2. Quinoa yield and crop structure, 2020.

Variety	Panicle length . (cm)	Weight of 1000 grains (g)	Grain weight of the first panicle (g)	Grain number in one panicle . pcs.	Crop yield (ton ha^{-1})
Q1	39 ± 3 .0	3 .05 ± 0 .04	12 .89 ± 0 .92	4226 ± 305	2 .86 ± 0 .20
Q2	43 ± 3 .4	3 .00 ± 0 .04	14 .97 ± 1 .20	4990 ± 414	3 .33 ± 0 .27
Q3	49 ± 4 .4	3 .23 ± 0 .05	13 .96 ± 1 .15	4322 ± 373	3 .10 ± 0 .25
Q4	56 ± 5 .4	1 .66 ± 0 .03	7 .44 ± 0 .74	4482 ± 414	1 .65 ± 0 .17
Q5	32 ± 2 .5	2 .94 ± 0 .03	19 .04 ± 1 .61	6476 ± 547	4 .23 ± 0 .36

Our study has shown that it is possible to cultivate quinoa in the agroecological and agroclimatic conditions of the CRNBEZ. When growing certain varieties of quinoa using the elements of agricultural technology that are optimal under these conditions, it is possible to obtain up to 4.23 ton ha^{-1} of grain without the introduction of fertilizers and pesticides.

DISCUSSION

Quinoa (Chenopodium quinoa) is recognized worldwide as a complete food culture, not only for its high protein content, but also for its excellent amino acid balance. Quinoa is an important source of minerals and vitamins, and also contains such compounds as polyphenols, phytosterols, and flavonoids with clear nutraceutical benefits (Sezgin & Sanlier 2019; Vilcacundo & Hernández-Ledesma 2017). Quinoa has processing properties such as solubility, water retention, gelling, emulsification and foaming that allow for diversified use. Besides, quinoa is considered an oilseed crop (Omega-6 and vitamin E). Quinoa starch has physical-chemical properties such as viscosity, freeze resistance, which give it functional properties when used again. Quinoa has a high nutritional value and has recently been used as a new functional food because of all these properties, and is undoubtedly a promising crop for cultivation throughout the world. In conclusion, Thus, the studies have shown that it is possible to cultivate quinoa in the agroecological and agroclimatic conditions of the CRNBEZ. When growing certain varieties of quinoa using the elements of agricultural technology that are optimal under these conditions, it is possible to obtain up to 2.1-2.5 ton ha-1 of grain (without fertilizers and pesticides).

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