 DOI: 10.19601/j.cnki.issn1943 - 9903.2017.12.020

Study on Quinoa Characteristics in Central and Southern Hebei

Zhimin WEI, Hanzhang ZHOU, Fei LIU, Meng LIU, Yu ZHAO, Xueyan XIA, Shunguo LI, Wei LU*

Institute of Millet Crops, Hebei Academy of Agriculture and Forestry Sciences/Cereal Crops Research Laboratory of Hebei Province/National Foxtail Millet Improvement Center/National Semi-Arid Agricultural Engineering and Technology Research Center, Shijiazhuang 050035, China

Abstract Quinoa is rich in nutrients and has high economic value, which attracts people's attention. Given that the quinoa has not yet been planted in the low-altitude Central and Southern Hebei plain, we used the quinoa seeds from five different habitats in China to conduct a planting test under different date of seeding in the low-altitude Central and Southern Hebei plain, and obtained the comprehensive data about the phenophase and agronomic traits of quinoa in this region. The test results showed that the grain quinoa should not be planted in Central and Southern Hebei plain, the limiting factors were identified, and a new way for local development of vegetable quinoa was found.

Key words Quinoa, Central and Southern Hebei, Cultivation

1 Introduction

Quinoa (*Cheuopodium quinoa*), is a flowering plant in the amaranth family, and a herbaceous annual plant grown as a grain crop primarily for its edible seeds. Quinoa originated in the Andean region of Peru, Bolivia, Ecuador, Colombia and Chile, with 5 000 years of cultivation history. It is the main traditional food for the Inca indigenous population and is called the "mother of grain" by the Incas.

Quinoa has high and full nutritional value, and as one of the most promising crops, it is known as "nutritional gold", "super grain", "space food", and "future food". National Aeronautics and Space Administration (NASA) regards the quinoa as one of the ideal foods for the astronauts in long-term space missions. Food and Agricultural Organization of the United Nations (FAO) believes that quinoa is the only perfect food to meet the body need for all the essential nutrients, and 2013 is identified as "International Year of Quinoa". At present, it is grown in Xinjiang, Tibet, Gansu, Ningxia, Qinghai, Inner Mongolia, Shanxi and other high cold plateau regions in China, but it has not yet been planted in the plain areas of North China.

In this study, we introduced the quinoa for the first time to the plain areas in Central and Southern Hebei for planting experiment, and through the different seeding date test, we studied the phenophase and agronomic traits of quinoa in the Central and Southern Hebei plain areas, as well as the growth of quinoa in Central and Southern Hebei plain, in order to provide a theoretical basis for the quinoa cultivation in the low-altitude plain areas.

2 Materials and methods

2.1 Test materials Variety A (QA55, Crop Institute of Chinese Academy of Agricultural Sciences); Variety B (MYSQ-1, Gansu Academy of Agricultural Sciences); Variety C (Jiaqi No. 1, Shanxi Jiaqi Quinoa Co., Ltd.); Variety D (HT1, Oriental Broad Group); Variety E (Ningxiabai).

2.2 Overview of the test site The test site (114.6° E, 37.9° N) is located in Qiema Town, Luancheng District, Shijiazhuang City, it is in the southern sloping plain in front of eastern Taihang Mountains, consisting of southern alluvial fan of Hutuo River, northern alluvial fan of Huaisha River, and the depression in the fan, with an altitude of 51 to 65 m. The terrain is flat with small undulations.

The city's average temperature is 13.3 - 15.0℃, and the maximum temperature in 2016 was 37.8 - 39.8℃. The annual accumulated temperature is 4 400℃; the average annual rainfall is 474.0 mm; the average annual frost-free period is 205 d; the total annual sunshine time is 2 521.9 h; the average annual total amount of solar radiation is 125.438 kCal/cm.

2.3 Experimental design The pilot test was conducted in Qiema Town, Luancheng District, Shijiazhuang City during 2016 - 2017, and it was sown at different stages.

On April 12, it was sown at the first stage, one stage at an interval of 15 days, a total of 4 stages, with 3 replications. Based on the randomized block design, the artificial drill planting mode was used, with seeding depth of 2 - 3 cm, plot area of 2 m × 10 m, and spacing of 50 cm.

The determination indices included sowing date, seedling date, branching date, initial pistil stage, grain filling stage, maturity stage, plant height, plant type, main spike length, number of branches, diameter of the main ears, number of spikelets, pest incidence, lodging and so on.

2.4 Field management (i) Preparation before sowing. The plot was cleaned, the soil was scarified, the soil was leveled and the soil moisture was preserved.

(ii) Sowing. The drilling was generally adopted for the organic quinoa cultivation. The spacing was 50 cm, and the seeds should not be buried too deeply, usually 2 cm deep.

(iii) Thinning. The thinning was conducted when the seedlings

Received: September 15, 2017 Accepted: December 7, 2017
Supported by Research and Demonstration Project of Key Simplified Production Technology for the Cereals with Mountain Characteristics (17236405D).
* Corresponding author. E-mail: 1847626199@qq.com

grew to one inch, and the spacing was maintained at about 25 cm.

(iv) Fertilization. Before sowing quinoa, 10 000 kg/ha manure and 200 kg/ha compound fertilizer were applied as the basal fertilizer for quinoa growth.

(v) Dressing. After the emergence of quinoa, when the quinoa seedlings grew to 5 – 7 true leaves, the intertillage weeding and the topdressing of human and livestock manure were conducted.

(vi) Cultivation and earthing up. When the quinoa seedlings reached 5 – 7 true leaves, the intertillage weeding was done and the earthing up was also carried out at the same time, to prevent the late plant lodging.

(vii) Irrigation. The quinoa feared flood and drought, and it was necessary to pay particular attention to the soil moisture, and conduct timely watering during drought.

(viii) Disease prevention and pest control. The pests were dominated by the soil pests during the seedling period, and the borer harm was serious after the branching period. The systemic insecticides were sprayed, but there was little effect, because the quinoa stem lignification made the borer difficult to be killed in the late period.

3 Results and analysis

3.1 Phenophase As it can be seen from Table 1, in the four-seeding-stage test, the 5 quinoa varieties could grow normally during the emergence, branching, pollination and early grain filling periods, but in the later period, the heavy rain and high temperature made the grain all slowly rotten, with no harvest.

It can be seen from this experiment that quinoa could realize normal emergence, flowering, pollination and early filling in Central and Southern Hebei plain. However, in early August, the high air humidity, and high temperature caused mildewed ears, and the already filled grain became shriveled.

Table 1 The phenophase of 5 quinoa varieties

Variety	Date of seeding // m-d	Emergence date // m-d	Branching // m-d	Initial pistil stage // m-d	Grain formation // m-d	Rotten period // m-d
A	4 – 15	4 – 29	5 – 22	6 – 23	7 – 4	8 – 9
	4 – 30	5 – 13	6 – 4	7 – 4	7 – 16	8 – 15
	5 – 15	5 – 26	6 – 16	7 – 15	7 – 25	8 – 16
	5 – 30	6 – 10	6 – 29	7 – 27	8 – 9	8 – 20
B	4 – 15	4 – 30	5 – 23	6 – 24	7 – 4	8 – 8
	4 – 30	5 – 13	6 – 5	7 – 5	7 – 16	8 – 14
	5 – 15	5 – 27	6 – 17	7 – 16	7 – 25	8 – 16
	5 – 30	6 – 10	6 – 29	7 – 26	8 – 10	8 – 19
C	4 – 15	4 – 29	5 – 21	6 – 22	7 – 2	8 – 10
	4 – 30	5 – 13	6 – 3	7 – 2	7 – 15	8 – 14
	5 – 15	5 – 26	6 – 15	7 – 12	7 – 23	8 – 16
	5 – 30	6 – 10	6 – 28	7 – 25	8 – 8	8 – 19
D	4 – 15	5 – 1	5 – 23	6 – 24	7 – 5	8 – 10
	4 – 30	5 – 14	6 – 5	7 – 4	7 – 16	8 – 15
	5 – 15	5 – 28	6 – 17	7 – 17	7 – 26	8 – 17
	5 – 30	6 – 11	6 – 29	7 – 28	8 – 10	8 – 20
E	4 – 15	4 – 30	5 – 22	6 – 24	7 – 5	8 – 11
	4 – 30	5 – 13	6 – 3	7 – 5	7 – 16	8 – 16
	5 – 15	5 – 26	6 – 15	7 – 17	7 – 26	8 – 19
	5 – 30	6 – 10	6 – 28	7 – 26	8 – 10	8 – 21

3.2 The agronomic traits of varieties As can be seen from Table 2, both the plant height and main spike length of the early sown quinoa were greater than those of the late sown quinoa, and the number of branches of the early sown quinoa was large.

The diameter of main spike was also related to the date of seeding, the number of quinoa spikelets had little to do with the date of seeding, and the borer incidence decreased with the delayed date of seeding.

The lodging rate of the early sown quinoa was high, because the early sown quinoa generally had large biomass; at the same time, the early sown quinoa was heavily damaged by the borer, leading to high lodging rate after heavy rains.

The plant type of Variety E was loose, and the borer incidence and lodging rate of Variety E were significantly lower than those of other varieties sown in the same period.

4 Conclusions and discussions

(i) The quinoa could realize the normal pollination in the Central and Southern Hebei plain, and the grain filling was normal at the early stage. Therefore, the hot weather combined with high humidity in the late period of filling might be the main cause of quinoa crop failure. The test results showed that it was not suitable for planting quinoa in the Central and Southern Hebei plain.

(ii) The quinoa grain can not be harvested in the Central and Southern Hebei plain, but the normal emergence and growth could be realized. According to the test, it is found that the quinoa sown about 60 days, has rich nutrients, and can be used for cooking, with a refreshing taste. The biological production is also impressive, the yield can reach 1 000 kg per mu in one season, and it can be grown for three seasons.

Table 2 The agronomic traits of 5 quinoa varieties

Variety	Date of seeding//m-d	Plant height//cm	Plant type	Number of branches	The main branch spike length//cm	Main ear diameter//cm	Number of spikelets	Lodging rate//%	Borer incidence//%
A	4 -15	135.35	Compact	22.86	46.73	12.38	229.81	89.45	71.54
	4 -30	132.23	Compact	22.22	46.23	11.82	230.74	83.82	67.86
	5 -15	130.58	Compact	21.95	45.31	11.94	230.15	78.71	59.95
	5 -30	130.42	Compact	21.34	44.98	11.72	229.58	72.69	48.85
B	4 -15	168.82	Compact	21.51	51.82	14.95	297.84	91.93	75.52
	4 -30	167.61	Compact	20.87	51.21	14.31	298.57	84.85	69.69
	5 -15	165.86	Compact	20.24	50.68	14.12	296.83	79.58	58.25
	5 -30	163.12	Compact	20.19	49.98	13.87	295.47	76.92	52.59
C	4 -15	174.82	Compact	24.22	60.92	14.15	309.82	93.89	68.85
	4 -30	171.52	Compact	23.87	58.13	14.11	308.46	85.82	67.66
	5 -15	172.67	Compact	23.97	59.16	14.21	307.86	81.54	52.95
	5 -30	170.82	Compact	23.14	57.91	13.82	309.27	85.65	49.56
D	4 -15	170.74	Compact	22.65	81.26	16.14	297.59	89.85	67.82
	4 -30	172.51	Compact	21.97	82.73	15.73	296.94	88.54	68.69
	5 -15	169.82	Compact	21.67	80.96	15.16	295.98	79.95	53.54
	5 -30	168.34	Compact	21.74	80.15	14.38	296.12	77.52	55.98
E	4 -15	186.92	Loose	24.87	44.31	11.92	345.82	70.51	68.54
	4 -30	185.72	Loose	24.58	43.86	11.37	341.54	68.12	62.42
	5 -15	183.85	Loose	23.88	42.98	10.96	339.71	66.13	59.82
	5 -30	184.71	Loose	24.41	43.41	10.84	338.56	66.98	51.13

Note: in different sowing period, the yield of varieties A, B, C, D, and E was zero.

The next step of our research team is to take the vegetable quinoa breeding and cultivation measures as the research direction.

References

[1] GONGBU ZX, WANG M, ZHANG CX, *et al.* Study on the biological characteristics of *Chenopodium quinoa* Willd[J]. Tibetan Journal of Agricultural Sciences, 1994, 16(4): 43 -48. (in Chinese).

[2] ZHOU HT, LIU H, *et al.* The performance and evaluation of *Chenopodium quinoa* Willd in Zhangjiagai Area[J]. Journal of Plant Genetic Resources, 2014,15(1):222 -227. (in Chinese).

[3] GUO XF. On the promotion prospect and cultivation techniques of *Chenopodium quinoa* Willd[J]. Modern Agriculture, 2015(2): 61 -63. (in Chinese).

[4] YU HY, JIANG YR, MAO ZY, *et al.* Optimization of the callus induction system of *Chenopodium quinoa* Willd[J]. Jiangsu Agricultural Sciences, 2015, 43(3): 26 -30. (in Chinese).

[5] GONGBU ZX, WANG M, ZHANG CX, *et al.* Study on the biological characteristics of *Chenopodium quinoa* Willd[J]. Tibetan Journal of Agricultural Sciences, 1994, 16(4): 43 -48. (in Chinese).

[6] JIA Q. *Chenopodium quinoa* Willd: The ideal food of supplementing the brains[J]. Farm Products Processing, 2013(11): 66. (in Chinese).

[7] WANG CJ, ZHAO XW, LU GQ, *et al.* A review of characteristics and utilization of *Chenopodium quinoa*[J]. Journal of Zhejiang Forestry College, 2014, 31(2): 296 -301. (in Chinese).

(From page 81)

5.3 Ornamental plant matching analysis The ornamental flower plants account for about 35%, colored foliage plants account for about 23%, and fruit-effect plants account for about 17%. The existing plant species is abundant, and we can appropriately increase the types and quantity of colored foliage plants, to enrich the landscape diversity of the park and the beautification effect brought by seasonal changes, so that the plant arrangement is more abundant in the park.

5.4 Shortcomings of plant arrangement and recommendations There are few plant species in Binjiang Park, and the seasonal changes are not obvious enough. In the plant arrangement, it lacks landscape levels, and the configuration mode is slightly single and weak. It is suggested to increase the plant species, enrich plant landscape, and create changes in different spatial environments. At the same time, we can use different trees, shrubs and grasses for rational arrangement, and allocation of trees and shrubs. Based on the local cultural characteristics of Jingzhou, we can select the native tree species for cultivation with local characteristics. At the same time, it is necessary to pay attention to the perfect combination of the park landscape design and plant design, not just plant cultivation. It is proposed to strengthen the park's plant management and conservation, and pruning in a timely manner, to ensure the overall ornamental feature of the park plant landscape.

In general, the plant arrangement of Binjiang Park needs to be improved, so as to create an agreeable pleasant environment for people to relax and better play the role of park in the city.

References

[1] SU XH. Plant landscape[M]. Beijing: China Forestry Publishing House, 1994. (in Chinese).

[2] WANG H, GU K. Landscape planning and design[M]. Nanjing: Southeast University Press, 2009. (in Chinese).

[3] WANG XJ. Landscape architecture design[M]. Nanjing: Jiangsu Science and Technology Publishing House, 2000. (in Chinese).

[4] ZHAO SW. Landscape design plant configuration and cultivation application of landscape design[M]. Beijing: China Agricultural Science and Technology Press, 2000. (in Chinese).

[5] YANG XD, WANG F. The functions of plants in the landscape design [J]. Forestry Science and Technology Information, 2006, 38 (2): 91 -92. (in Chinese).