Simple static hydroponic technology of Chenopodium quinoa Willd

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1 Introduction

Chenopodium quinoa Willd is a grain crop native to South America with a cultivation history of more than 7000 years. It is a kind of "total nutritious food" and is known as "the mother of grains". It is not only rich in protein, but also contains all essential amino acids. In addition, it is rich in unsaturated fatty acids, vitamins, minerals and a variety of bioactive substances, such as polyphenols, flavonoids, saponins and tannin, which are beneficial to health. At present, quinoa has been planted in many places in China, but the variety selection and cultivation technology have yet to be improved. Moreover, quinoa is suitable for cultivation in high-altitude areas and has strict climate restrictions, therefore, it is difficult to plant quinoa in eastern China. However, as far as the quinoa seedling is concerned, there are no region restrictions for its planting. Since the Colombian era, the leaves of quinoa have been eaten by native people. It was reported that quinoa leaves contain a variety of nutrient ingredients, such as carotene, vitamin E, vitamin C and microelements. The content of arotene in quinoa leaves is between 230.23 and 669.57 mg/kg[1], which is higher than spinach and amaranth[2-4]. The content of vitamin E (α-TE) and vitamin C is 29 mg/kg and 1.2-2.3 g/kg[5], respectively. The contents of calcium, iron and zinc in quinoa leaves is 3583-9601 mg/kg, 5.6-7.9 mg/kg and 0.7-42.6 mg/kg, respectively. The contents of protein, lipid and cellulose in quinoa leaves is 2.79-4.17%, 1.9-2.3% and 1.9%, respectively[6]. The antioxidation ingredients in quinoa leaves slow down the proliferation of cancer cells, anti-inflammatory, anti-microbial and other aspects[7,8].

In the recent ten years, quinoa has been cultivated as a grain in China, and the planting area was approximate to 12000 hectare. Up to now, the total output of quinoa grain is about 21600 tons per year. However, few attempts have been made to grow quinoa as a vegetable. At the present study, the simple hydroponic method for the cultivation of quinoa seedling was carried out. Unlike the traditional hydroponics, the simple static hydroponics method requires to buy a set of hydroponics cultivation facilities, but it does not need soils, which is beneficial to alleviate the shortage of urban land resources in China. Therefore, the hydroponic method of quinoa has a bright development prospect[9].

2 MATERIALS and METHODS

2.1 Variety selection

The Qingli II of Chenopodium quinoa Willd cultivated by Qinghai Academy of Agricultural and Forestry Sciences is selected as the experimental material.

2.2 Preparation of nutrient solution

The nutrient ingredients is the Hoagland general formula. The nutrient ingredients can be dissolved by tap water, reservoirs water, well water, non-polluted river water and rain water. The dosage of main compounds in formula is shown in Table 1, and the dosage of trace elements is shown in Table 2.

Table 1. Dosage of main compounds in the Hoagland general formula.
the nutrient solution cannot be touched the vermiculite, touch the liquid surface. Nevertheless, the upper part of the quinoa roots can be exposed to the air above the solution.

2.5 Temperature management

Quinoa has the characteristics of low temperature resistance but has no high temperature resistance. In general, the maximum temperature cannot exceed 35°C, and the suitable growth temperature is about 20°C. During the cultivation of *Chenopodium quinoa* Willd vegetables, the temperature at night should be maintained above 8°C and below 35°C during the day.

2.6 Light adjustment

Natural light can meet the quinoa requirement during the whole growth period. In order to make quinoa vegetables grow well, the hydroponics tray should be placed in a sunny place, and at least 3-4 hours of light time should be guaranteed every day. If artificial lighting is used, it is suggested that 8 hours of lighting and 16 hours of dark cycle can be used.

2.7 Disease and pest control

Quinoa vegetables have strong disease resistance. Because the growth period of quinoa seedling is short, only few diseases occur. Occasionally, there is leaf spot disease. If the disease is found, the whole plants should be pulled out. There are almost no insect pests in the growth period of quinoa seedling vegetables.

2.8 Test indexes

After sowing 3 days, it was needed to record the time of the emergence of seedlings, two true leaves and four true leaves. The quinoa vegetables were randomly selected at 18th, 23rd, 28th, 33rd and 38th days after sowing, then the plant height, leaf length, leaf width, and stem diameter were measured by using a vernier calliper. In addition, 50 fresh quinoa seedling vegetables should be taken. After drying in an electric thermostatic blast dryer, the fresh and dried weight of quinoa seedling were obtained. Moreover, the quality of quinoa seedling is determined by sensory quality evaluation. The sensory scoring criteria are shown in Table 3.

Table 3. Evaluation criteria of sensory quality of *Chenopodium quinoa* Willd vegetables.

| Indicators                  | Characteristics                      | Scoring range |
|-----------------------------|--------------------------------------|---------------|
| Freshness (25 scores)       | Fresh, crisp                         | 20–25         |
|                             | Relatively Fresh, relatively crisp   | 10–19         |
|                             | Turn tender, no crisp                | 0–9           |
| Color and luster (25 scores)| Bright green, normal color           | 20–25         |
|                             | Relatively green, relative good color| 10–19         |
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3 Results and analysis

3.1 The growth periods of hydroponic quinoa vegetables

The growth periods of hydroponic quinoa vegetables are shown in Table 4. According to the instructions of the seeds, it takes 5-7 days to emerge in the field, it takes about 15-20 days to grow two true leaves, and it takes about 25-28 days to grow four true leaves. It can be seen from Table 4 that the Chenopodium quinoa Willd cultivated by hydroponic method started to germinate after three days of sowing, which was earlier than that planted in the soils. The appearance of two true leaves in nutrient solution was 2 to 5 days earlier than those in soils, and the appearance of four true leaves in nutrient solution was 4 to 7 days earlier than those in soils. The above results indicated that the hydroponic cultivation of quinoa vegetables can shorten the growth periods.

Table 4. Growth periods of hydroponic Chenopodium quinoa Willd vegetables.

| Sowing date | Germination (day) | Emergence rate (%) | Grow two true leaves (day) | Grow four true leaves (day) |
|-------------|-------------------|--------------------|----------------------------|-----------------------------|
| March 25th  | 3-5               | 93                 | 13-15                      | 21-23                       |

3.2 Agronomic traits of Chenopodium quinoa Willd vegetables at different growth time

The agronomic traits of Chenopodium quinoa Willd vegetables at different growth time is shown in Table 5. With the extension of the growth time, the plant height, leaf length, leaf width, stem diameter and leaf number of Chenopodium quinoa Willd vegetables initially increased rapidly, then gradually became slow. After 38 days of cultivation, the sensory evaluation of quinoa decreased but the yield reach the highest. Although the 18-day-cultivated Chenopodium quinoa Willd vegetables are fresh and tender, the yield is quite low and the cost of cultivation is high.

Table 5. Agronomic traits of Chenopodium quinoa Willd vegetables at different growth time.

3.3 Fresh weight and dry weight of quinoa vegetables at different growth time

Fresh weight is a common indicator of the moisture status of plant tissues. For normal growing tissues, the amount of water content can elucidate the growth status of the plant to a certain extent. The dry weight reflect the amount of nutrient substances, so it is very important to measure the fresh and dry weight of quinoa. It can be seen from Table 6 that both fresh and dry weight of quinoa vegetables increased rapidly during the growth period of 18-28 days, and after 28 days, the increase rate became slow. During the growth period of 18-38 days, dry matter content showed a slowly increasing trend, indicating that the nutrient ingredients are gradually accumulating. Although the fresh and dry weight reached the maximum at harvest time of the 38 days, considering the production efficiency and economic benefits, 28-33 days are the appropriate harvest period.

Table 6. Comparison of fresh and dry weight of Chenopodium quinoa Willd vegetables at different growth time.

| Growth time | Plant height (cm) | Leaf length (cm) | Leaf width (cm) | Stem diameter (mm) | Leaf number (piece) |
|-------------|-------------------|------------------|-----------------|-------------------|--------------------|
| 18          | 12.5±1.77         | 1.70±0.35        | 1.15±0.27       | 0.73±0.18         | 2.0±0              |
| 23          | 13.9±1.37         | 2.10±0.32        | 1.71±0.29       | 1.38±0.42         | 4.0±1.3            |
| 28          | 20.25±2.04        | 2.73±0.51        | 2.10±0.52       | 1.51±0.27         | 7.0±1.0            |
| 33          | 23.73±2.76        | 2.97±0.40        | 2.60±0.31       | 1.63±0.37         | 9.1±1.2            |
| 38          | 23.91±2.54        | 3.47±0.52        | 3.06±0.60       | 2.20±0.43         | 10.0±1.4           |

3.4 Sensory quality evaluation of quinoa vegetables at different growth time

It can be seen from Table 7 that the sensory score of quinoa harvested at 28 th day was the highest, and the sensory score of quinoa harvested at 18 th day was the lowest. According to the results of sensory quality evaluation, it is suitable for quinoa seedling to be harvested between 28th day to 33rd day after cultivation.
Table 7. Sensory quality evaluation of quinoa vegetables at different growth time.

| Growth time (day) | Sensory scores |
|-------------------|----------------|
| 18                | 81.1±8.3       |
| 23                | 82.6±15.4      |
| 28                | 89.1±7.9       |
| 33                | 87.6±9.7       |
| 38                | 83.3±7.1       |

4 Conclusion

The plant height, leaf length, leaf width, stem diameter, leaf number, fresh weight, dry weight and sensory quality evaluation of quinoa vegetable are important indicators, which are related to the quality of quinoa vegetable. The research results indicated that quinoa seedling can be cultivated in nutrient solution, and the suitable harvest time of quinoa vegetable is between 28th to 33rd after sowing. The static hydroponics provided an alternative method for quinoa cultivation.

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