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Effects of Temperature on Growth and Quality of Dormancy-released *Sedum aizoon* L.

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Effects of Temperature on Growth and Quality of Dormancy-released *Sedum aizoon* L.

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Abstract. The effects of recovery growth were compared by measuring the biomass and quality indices when dormancy-released *Sedum aizoon* L. were treated at 25°C, 20°C and 15°C respectively. The results showed that with the increasing temperature, the plant height and aboveground fresh weight all showed an upward first and then downward trend. The contents of chlorophyll, carotenoids, calcium and zinc all showed an upward trend, while magnesium and iron all showed a downward first and then upward trend in fresh food part. The contents of soluble protein, vitamin C, free amino acid and flavonoid all showed a downward trend, while total soluble sugar, caffeine and oleanolic acid all showed an upward first and then downward trend. The plant height, aboveground fresh weight, the total chlorophyll to carotenoid ratio, the contents of total soluble sugar, caffeine and oleanolic acid were all the highest under 20°C. In conclusion, the best recovery growth temperature was 20°C for dormancy-released *Sedum aizoon* L.

1. Introduction

Sedum aizoon L. is a perennial fleshy root and facultative crassulacean acid metabolism plant of Sedum family. It is distributed in the Yangtze River Basin, the Yellow River Basin and even northeast China[1]. There is bud dormancy phenomenon in *Sedum aizoon* L., and the growth period is from March to September. The suitable growth temperature is from 15°C to 25°C. After November, the aboveground grow withered and fall off gradually, which are replaced by dormant buds[2,3]. In recent years, as a health care vegetable, *Sedum aizoon* L. has attracted more and more attention because of its outstanding nutritional and health functions. *Sedum aizoon* L. is rich in carbohydrate, dietary fiber, protein and other nutritional components[4]. In addition, the active ingredients such as caffeine, flavonoid and oleanolic acid and other bioactive substances have health functions including refreshing, antioxidant, protecting cardiovascular and cerebrovascular, promoting blood circulation and lowering blood glucose[5]. Temperature, as one of the important environmental factors in crop cultivation, has seriously affected the growth and quality of crops. In production, the research on optimum temperature of crop growth is more extensive, however, it is difficult to reach agreement on yield and nutrient composition at the same temperature. At present, the best method of releasing dormancy at low temperature has been known in previous experiments (not published), but it has not been reported about the effects of temperature on dormancy-released *Sedum aizoon* L. The aim of this experiment was to screen out the optimum recovering growth temperature to provide reference for winter cultivation of *Sedum aizoon* L., according to the changes of growth and quality.



2. Material and methods

2.1. Experimental materials

The experimental material was *Sedum aizoon* L. seedling with sprout, and *Sudum aizoon* L. was provided by Horticulture College of Sichuan Agricultural University.

2.2. Material preparation

In July, the upright and healthy *Sudum aizoon* L. with a diameter of 2 to 3 mm were selected to cut and propagate. The cuttings were cut from the top bud downward with a length of 6 to 7 cm, retained 3 to 4 leaves at the top bud, and removed the remaining leaves. Finally, the cuttings were retained with a length of 4 to 5 cm from the top bud to the incision. The cuttings were inserted into medium about 2 to 3 cm in 72 cell plug trays. The medium was comprised of nutrient soil, perlite and vermiculite, which was mixed in proportion according to 4:1:1 ratio. Watered once every 3 days after cuttage, the cutting seedlings could take root and recover growth after two weeks. After 30 days, the cutting seedlings with the same growth condition were transplanted in 12×13 cm (bottom × high) black nutrition bowl. Each bowl was only planted a cutting seedling and loaded with 250 g medium (The medium was the same as the above). The cutting seedlings continued to grow outdoors with uniform water and fertilizer management until the beginning of October in the same year. The aboveground parts were cut off uniformly before beginning the test at seven days, remaining sprouts for reserving.

2.3. Experimental design

The prepared *Sedum aizoon* L. seedling with sprout was placed in the artificial climate chamber with 70% relative humidity at 5°C for 5 days in darkness in order to release dormancy. And then the experimental and control groups materials that was watered every 3 days continued to recover growth for 30 days in the artificial climate chamber with 10 000 lux, 70% relative humidity, 5°C/15°C/20°C/25°C and 12 hours / 12 hours (Day / Night). At the end of the experiment, the growth parameters were measured immediately. The contents of chlorophyll, carotenoid, soluble protein and vitamin C were measured by fresh samples of functional leaves from the same part. The remaining aboveground parts were dried at 105°C for 30 minutes in oven and then at 70°C until constant weight (recorded before and after drying weight), which were used to determine the contents of total soluble sugar, free amino acids, mineral elements (calcium, magnesium, iron, zinc) and bioactive substances (caffeine, flavonoid, oleanolic acid).

2.4. Data processing and analysis

Data were analyzed with one-way ANOVA by Microsoft Excel 2007 and Origin Pro 2016 software, and compared the significant difference by new multiple range test ($P < 0.05$).

3. Results and Discussions

3.1. Growth performance

Different crops always did not showed best growth performance in the same temperature, for instance, the best aboveground fresh weight of lettuce at 30°C/12°C and chinese kale at 18°C/12°C[6,7]. The plant height, stem diameter, leaf thickness and aboveground fresh weight of *Sudum aizoon* L. were mainly affected by different recovering growth temperature after dormancy release (Table 1.). With the increase of temperature, the plant height and aboveground fresh weight increased first and then decreased, which increased by 293.33% and 105.92% at 20°C respectively compared with the control group at 5°C. The stem diameter gradually increased with the increase of temperature, which was the largest one at 25°C and higher than that of control group by 38.54%, however, there was no significant difference between 20°C and 25°C. The leaf thickness showed a downward trend with the increase of temperature, and decreased significantly by 38.75%, 16.22% and 12.61% (25°C, 20°C and 15°C)

compared with the control group, respectively (5°C). This indicated that the overall growth effect was the best in *Sedum aizoon* L. biomass at 20°C.

Table 1. Effects of different restored growth temperatures on biomass of dormancy-released *Sedum aizoon* L.

Temperature (°C)	Plant height (cm)	Stem diameter (mm)	Leaf thickness (mm)	Aboveground fresh mass (g)
25	5.1±0.35 ^b	2.66±0.07 ^a	0.80±0.015 ^c	5.61±0.13 ^b
20	5.9±0.41 ^a	2.63±0.06 ^a	0.93±0.038 ^b	6.26±0.26 ^a
15	3.6±0.28 ^c	2.02±0.20 ^b	0.97±0.081 ^b	4.29±0.20 ^c
5	1.5±0.11 ^d	1.92±0.12 ^b	1.11±0.08 ^a	3.04±0.21 ^d

Note: Data were analyzed by new multiple range test and different lowercase letters in the same column meant significant difference among treatments at 0.05 level. The same below.

3.2. Nutritional components

Nutritional components included carbohydrate, protein, dietary fiber, vitamins, etc, the contents of which always depended on different cultivation temperature in plants[6,7]. With the increase of temperature, the contents of soluble protein, vitamin C and free amino acid in *Sedum aizoon* L. showed a downward trend, while the content of total soluble sugar increased first and then decreased (Fig 1.). The contents of soluble protein and free amino acid were the highest at 15°C, which were significantly lower than those in the control group by 86.73% and 35.24%, respectively. However, soluble protein and free amino acid contents were not significantly different between 25°C and 20°C. The content of total soluble sugar was the highest at 20°C, which was significantly decreased by 72.43% compared with the control group, but there was no significant difference between 25°C and 20°C. There was no significant difference in the content of vitamin C between 25°C, 20°C and 15°C. It was indicated that the nutrient compositions were the best in *Sedum aizoon* L. at 20°C.

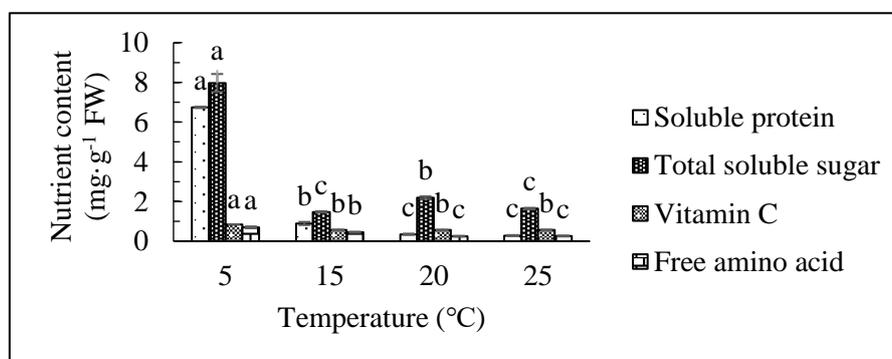


Fig 1. Effects of different restored growth temperatures on nutrient content of dormancy-released *Sedum aizoon* L.

Note: Different lowercase letters in the figure indicate significant differences exist among different temperatures under the same index. The same below.

3.3. Mineral element content

Mineral elements had played an important role in making up plant tissue, regulating osmotic pressure and participating in metabolism, which content were affected by temperature. The calcium and magnesium contents reached the maximum at 15°C of leaves in hydroponically-grown lettuce[8]. Iron and zinc contents reached the maximum from 8°C to 10°C, while the contents of calcium and magnesium reached the minimum from 14°C to 16°C in cucumber[9]. With the increase of temperature, the contents of magnesium and iron decreased first and then increased, while the contents of calcium and zinc increased gradually (Table 2.). Compared with the control group, the contents of calcium, magnesium and iron decreased significantly in every 100g fresh part of *Sedum aizoon* L. at 25°C, 20°C and 15°C, but the content of zinc increased significantly. Calcium and zinc contents were

the highest under 25°C treatment, which increased by 28.24% and 24.32% respectively compared with the control group, but there was no significant difference between 25°C and 20°C. The contents of magnesium and iron were the lowest at 20°C, which were 69.10% and 36.78% lower than those of the control group, but there was no significant difference between 25°C and 15°C. These data were indicated that mineral elements were the highest in *Sedum aizoon* L. at 25°C.

Table 2. Effects of different restored growth temperatures on mineral elements content of dormancy-released *Sedum aizoon* L.

Temperature (°C)	Calcium [mg·(100g) ⁻¹ FW]	Magnesium [mg·(100g) ⁻¹ FW]	Ferrum [mg·(100g) ⁻¹ FW]	Zinc [mg·(100g) ⁻¹ FW]
25	460.161±31.19 ^b	4.829±0.27 ^b	1.721±0.03 ^b	0.460±0.010 ^a
20	446.429±11.83 ^b	3.538±0.11 ^c	1.561±0.02 ^c	0.399±0.011 ^b
15	429.075±3.94 ^b	4.386±0.36 ^b	1.711±0.02 ^b	0.408±0.030 ^b
5	597.890±10.62 ^a	11.448±0.36 ^a	2.469±0.03 ^a	0.370±0.011 ^c

3.4. Bioactive substances

In addition to nutritional components, the contents of flavonoid, caffeine and chlorophyll, which are secondary metabolites in plants, are also affected by temperature. By studying the response of *Ginkgo biloba* flavonoid to temperature and drought stress, it was found that the highest content of flavonoid in leaves was day/night (25°C/15°C) and the highest biomass was day/night (35°C/25°C) when the field water holding capacity was 55%~60% for 28 days[10]. Caffeine content of tea was significantly higher in summer and autumn than in spring[11]. Low temperature or high temperature can affect the activity of related enzymes, resulting in the decrease of the appearance of products and chlorophyll content[12]. Chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents in *Sedum aizoon* L. increased with the increase of temperature, which were the highest at 25°C by 2.04, 2.35, 2.00 and 1.66 times of the control group respectively (Fig 2.). However, the ratio of chlorophyll content to carotenoid content increased first and then decreased with the increase of temperature (15°C, 20°C and 25°C), which was the highest at 20°C by 4.19. Fig 3. showed that with the increase of temperature, the contents of caffeine and oleanolic acid increased first and then decreased, while the content of flavonoid decreased gradually. The content of caffeine increased by 70.75% and oleanolic acid decreased by 29.97% compared with the control group, which were all the highest at 20°C. There was no significant difference in the content of oleanolic acid between 25°C and 15°C. The content of flavonoid was the highest at 15°C and decreased by 8.27% compared with the control group, however, there was no significant difference between 25°C and 15°C. The results showed that the content of bioactive substances was the best in *Sedum aizoon* L. at 20°C.

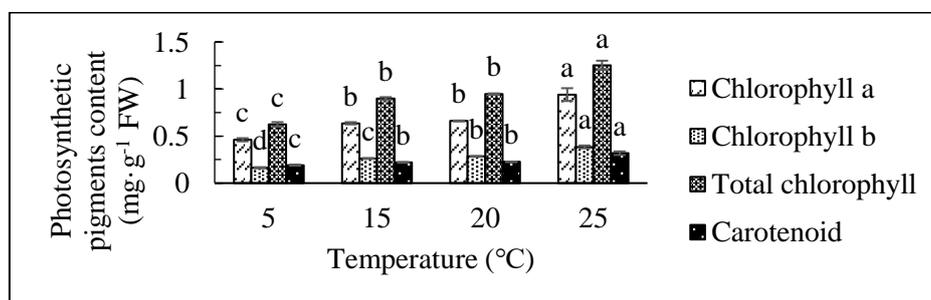


Fig 2. Effects of different restored growth temperatures on photosynthetic pigments content of dormancy-released *Sedum aizoon* L.

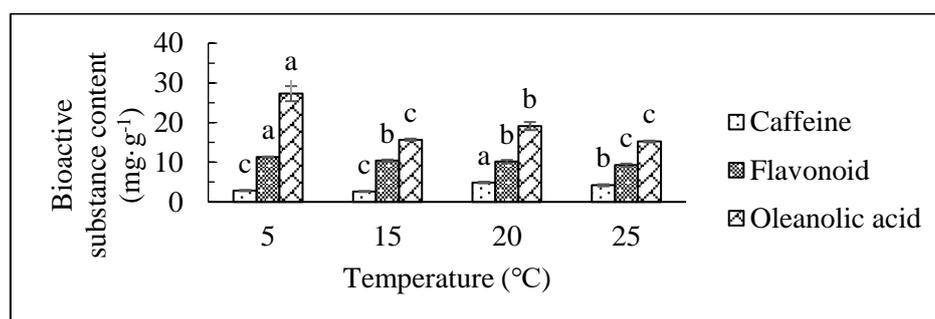


Fig 3. Effects of different restored growth temperatures on bioactive substance content of dormancy-released *Sedum aizoon* L.

4. Conclusion

The best temperature was 20°C for recovering growth of *Sedum aizoon* L. At this time, the biomass, the contents of total soluble sugar, oleanolic acid and caffeine were the highest. Comprehensive evaluation showed that the contents of soluble protein, vitamin C, total free amino acid, chlorophyll, carotenoids, flavonoids and mineral elements were the best at 20°C.

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