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# Influence of light intensity and water content of medium on total dendrobine of *Dendrobium nobile* Lindl

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ABSTRACT

**Objective:** To ascertain the influence of light intensity and water content of medium on the total dendrobine of *Dendrobium nobile (D. nobile)*.

**Method:** The principal component analysis combined with total dendrobine accumulation was conducted to assess the yield and quality of *D. nobile* in all treatments. In the experiment, *D. nobile* plants were cultivated in greenhouse as tested materials, and complete test of 9 treatments was adopted with relative light intensities 75.02%, 39.74%, 29.93% and relative water content of medium 50%, 65%, 80%. The plants were treated in June and harvested till December. Indexes including agronomic traits, fresh weight and dry weight of stem and leaf, ash content, extract, and dendrobine were measured.

**Results:** Under the light intensity treatments of 75.02% with 50%, 65%, 80% water content of medium, the basal stems of plants were comparatively thicker with more leaves, and the fresh weight and dry weight of stems and leaves were significantly higher than other 6 treatments. Leaves in all treatments contained dendrobine. Under the light intensity treatments of 75.02% with 50%, 65%, 80% water content of medium, dendrobine content of leaves was lower while dendrobine contents of other treatments were more than 0.60%. After comprehensive assessment through the principal component analysis and total dendrobine accumulation, the results showed that 3 treatments with relative light intensity of 75.02% ranked the top three.

**Conclusions:** In brief, the moderately strong light intensity and water content of medium from low to medium can facilitate the growth and yield of *D. nobile* plants, while light intensity from moderately weak to weak can enhance the dendrobine content.

## 1. Introduction

*Dendrobium nobile (D. nobile)* is a rare traditional Chinese medicine with effective alkaloids, which has many pharmacological effects including immune regulation, anti-tumor, anti-oxidation, hypoglycemia and bacteriostasis. Now the demand for *D. nobile* is ever-increasing, while the wild resources of *D. nobile* can't meet the market requirement. Thus, artificial cultivation of *D. nobile* is extremely urgent.

Dendrobine, a major component of *D. nobile*, increasingly draws attention for its wide applications in health care. In recent years, researches on dendrobine mainly focused on the Dendrobium alkaloid structure [1,2], the metabolism [3], pharmacological effects and functions [4–7], molecular biology [8,9], while researches on breeding and planting mainly focused on tissue culture and seed germination [10], influence of culture substrate on growth of *D. nobile* [11,12], influence of growth regulator on growth of *D. nobile* [13], among which only a few reports were about the standardized cultivation technology of *D. nobile*. *D. nobile* plants have an inclination for the warm, humid and shady environment, and commonly grow in the rock or tree trunk with aggregated humus in the landform of mostly cliffs [14]. *D. nobile* with abundant wild resources and excellent quality in Chishui City of Guizhou Province has been ranked as valuable and rare

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traditional Chinese medicine with the national second-class protection. In 2006, it was awarded as the China Geographical Indication Protection Product. Presently, the planting area is more than 3 000 ha with imitating wild mode. It was found that the light, temperature and water in the environment are vital to the growth of *D. nobile*. The temperature of 25 °C and light intensity of 320 $\mu mol \cdot m^{-2} \cdot s^{-1}$ were suitable for the growth of *D. nobile* plants [15]. The bionic cultivation of *D. nobile* needs overshadowing as well as water sources. In addition, with the continuous development of facility cultivation, the greenhouse cultivation of *D. nobile* is on the rise. However, there is no detailed report about how much light intensity and water could lead to high yield and high quality of *D. nobile* currently. For this purpose, this test will provide scientific basis for the yield and quality of *D. nobile* in the bionic cultivation and facility cultivation through researching the influence of different light intensity and water content of medium on the yield and quality of *D. nobile*.

## 2. Materials and methods

### 2.1. Tested materials

*D. nobile* seedlings were provided by Chishui Xintian Traditional Chinese Medicine Industrial Development Co., Ltd.

### 2.2. Design

This test was carried out in the greenhouse of Teaching Experimental Field of Guizhou University in 2015. Light intensity had 3 gradients, *i.e.* 75.02% (natural light of greenhouse), 39.74% (1-layer sunshade net), and 20.93% (2-layer sunshade net). The light intensity of all treatments was measured by illuminance meter respectively in 9 a.m., 12 a.m. and 3 p.m. in the 5th day, 10th day, 15th day, 20th day, 25th day and 30th day every month of 2015. Each light intensity was measured for 12 times repeatedly, meanwhile the natural light intensity outside the greenhouse was measured as contrast. Relative light intensity = Treatment light intensity/Natural light intensity. The relative value of light intensity in all treatments was the average value of yearly data. Relative light intensity had 3 gradients, *i.e.* 75.02%, 39.74% and 20.93%. With the medium water content of 100%, the relative water content of medium had 3 gradients, *i.e.* 50%, 65% and 80%. The various levels of relative light intensity and water content of medium were full combined. The experiment showed the 9 treatments in total. Complete test design was adopted with 3 repetitions, and random arrangement.

In March 2015, *D. nobile* seedings were transplanted into boxes with the specification of length, width and height of 80 cm × 60 cm × 20 cm, and the culture medium was organic substrate of moss peat soil manufactured by Denmark Pindstrup. Seedlings were cultivated at earlier stage, and experimental treatments were carried out in June after seedlings being in normal growth condition. After harvest and agronomic measurement in December, the treatment materials were dried to constant weight at 55 °C, and crushed for quality test.

### 2.3. Measuring method

Water, ash, extract, and dendrobine content were measured according to methods stipulated in Part Ⅰ of Chinese Pharmacopoeia in 2015 edition [16].

### 2.4. Data analysis

Data statistic analysis was made by the software of Excel 2007 and SPSS13.0. Principal component analysis was carried out through the factor analysis module of SPSS software. The difference significance test of data was performed with Duncan.

## 3. Results

### 3.1. Influence of different light intensities and water content of medium on agronomic traits of D. nobile plants

The basal stems of *D. nobile* plants treated by relative light intensity of 75.02% were significantly higher than the stems of other treatments, while basal stems treated by the relative light intensity of 39.74% and 20.93% were respectively different slightly. The number of leaves of *D. nobile* plants treated by the relative light intensity of 75.02% in 3 treatments was significantly more than that of other 6 treatments. The more the number of leaves in the stem node of *D. nobile* plants is, the more the number of new stem nodes is. The minimum stem length variable coefficient showed slight difference in the stem length among all treatments. In conclusion, 3 treatments with the relative light intensity of 75.02% had thicker basal stem, more stem nodes and leaves, slight difference in the stem length among all treatments, comparatively small spacing of stem nodes, and thickness. On the contrary, other 6 treatments were characterized by thin stem, large spacing among nodes, and thinness (Table 1).

### 3.2. Influence of different light intensities and water content of medium on yield of D. nobile

The fresh weight and dry weight in 3 treatments with the relative light intensity of 75.02% were significantly higher than those in other 6 treatments which have a slight difference. The stem drying rate rose with the increase of medium water content under the same light intensity. It indicated that the higher the medium water content was, the lower the stem water content was, which caused stem more drier and growth vigor of *D. nobile* poorer (Table 2).

As shown in Table 3, The fresh weight and dry weight of *D. nobile* leaves in 3 treatments with the relative light intensity of 75.02% and 39.74% respectively were different slightly, but significantly higher than those in 3 treatments with the relative light intensity of 20.93%, which showed that the growth of *D. nobile* plants needed definite light intensity, and the weak light was not suitable for its growth.

### 3.3. Influence of different light intensities and water content of medium on quality of D. nobile

The water content of dry stem of *D. nobile* is ≤ 12.0%, and the ash content is ≤ 5.0% which are both stipulated in Chinese Pharmacopoeia 2015 edition. From Table 4, the water content of *D. nobile* stem in all treatments with different light intensities and water content of medium was within the range of 9.33%–10.44%, and the ash content was 3.20%–4.57%. The water content of *D. nobile* leaves in all treatments was within the range of 9.15%–10.45%, and the ash content was 3.08%–4.29%

**Table 1**

Influence of different light intensities and water content of medium on agronomic traits of *Dendrobium nobile* Lindl.

| Relative light intensity | Relative water content | Basal stem (mm) | Stem length (cm) | Leaf number ($n$) |
|---|---|---|---|---|
| 75.02% (I) | 50% (1) | 6.71 ± 0.06[a] | 11.59 ± 0.13[b] | 5.00 ± 0.10[a] |
| | 65% (2) | 6.19 ± 0.04[b] | 10.80 ± 0.25[c] | 4.53 ± 0.06[b] |
| | 80% (3) | 5.40 ± 0.01[c] | 11.41 ± 0.24[b] | 4.30 ± 0.10[c] |
| | 50% (1) | 4.63 ± 0.05[e] | 9.66 ± 0.18[cd] | 4.00 ± 0.10[ef] |
| 39.74% (II) | 65% (2) | 4.61 ± 0.04[f] | 10.19 ± 0.10[c] | 4.13 ± 0.06[de] |
| | 80% (3) | 4.64 ± 0.06[e] | 9.04 ± 0.05[d] | 3.10 ± 0.10[h] |
| | 50% (1) | 4.81 ± 0.05[d] | 11.56 ± 0.27[b] | 4.27 ± 0.06[cd] |
| 20.93% (III) | 65% (2) | 4.70 ± 0.05[e] | 12.32 ± 0.21[a] | 3.97 ± 0.06[f] |
| | 80% (3) | 4.02 ± 0.05[g] | 9.88 ± 0.15[cd] | 3.40 ± 0.10[g] |
| Variable coefficient (%) | | 16.97 | 10.13 | 13.92 |

Variable coefficient = standard deviation/mean.

Different letters in a column mean significant difference among treatments at the 5% level.

**Table 2**

Influence of different light intensities and water content of medium on stem fresh weight, dry weight and drying rate of *Dendrobium nobile* Lindl.

| Relative light intensity | Relative water content | Fresh weight (kg/m$^2$) | Dry weight (kg/m$^2$) | Drying rate (%) |
|---|---|---|---|---|
| 75.02% (I) | 50% (1) | 2.510 ± 0.013[a] | 0.340 ± 0.002[a] | 13.55 |
| | 65% (2) | 2.270 ± 0.029[b] | 0.330 ± 0.004[a] | 14.54 |
| | 80% (3) | 1.700 ± 0.023[c] | 0.270 ± 0.004[b] | 15.88 |
| | 50% (1) | 1.160 ± 0.042[e] | 0.190 ± 0.007[c] | 16.38 |
| 39.74% (II) | 65% (2) | 1.140 ± 0.004[e] | 0.180 ± 0.001[c] | 15.79 |
| | 80% (3) | 1.150 ± 0.018[e] | 0.200 ± 0.003[c] | 17.39 |
| | 50% (1) | 1.310 ± 0.019[d] | 0.200 ± 0.003[c] | 15.27 |
| 20.93% (III) | 65% (2) | 1.140 ± 0.012[e] | 0.200 ± 0.002[c] | 17.54 |
| | 80% (3) | 0.910 ± 0.009[f] | 0.170 ± 0.002[c] | 18.68 |
| Variable coefficient (%) | | 38.08 | 28.24 | 9.88 |

Variable coefficient = standard deviation/mean.

Different letters in a column mean significant difference among treatments at the 5% level.

**Table 3**

Influence of different light intensity and water content of medium on leaf fresh weight, dry weight and drying rate of *Dendrobium nobile* Lindl.

| Relative light intensity | Relative water content | Fresh weight (kg/m$^2$) | Dry weight (kg/m$^2$) | Drying rate (%) |
|---|---|---|---|---|
| 75.02% (I) | 50% (1) | 0.640 ± 0.004[a] | 0.110 ± 0.002[a] | 17.19 |
| | 65% (2) | 0.580 ± 0.005[b] | 0.100 ± 0.001[ab] | 17.24 |
| | 80% (3) | 0.510 ± 0.003[c] | 0.090 ± 0.001[bc] | 17.65 |
| | 50% (1) | 0.420 ± 0.003[d] | 0.070 ± 0.001[de] | 16.98 |
| 39.74% (II) | 65% (2) | 0.440 ± 0.001[d] | 0.080 ± 0.002[cd] | 18.18 |
| | 80% (3) | 0.410 ± 0.002[d] | 0.070 ± 0.001[de] | 17.07 |
| | 50% (1) | 0.310 ± 0.002[f] | 0.050 ± 0.001[fg] | 15.38 |
| 20.93% (III) | 65% (2) | 0.360 ± 0.004[e] | 0.060 ± 0.001[ef] | 17.78 |
| | 80% (3) | 0.260 ± 0.003[g] | 0.040 ± 0.001[g] | 15.63 |
| Variable coefficient (%) | | 28.29 | 30.63 | 5.51 |

Variable coefficient = standard deviation/mean.

Different letters in a column mean significant difference among treatments at the 5% level.

(Table 5). The water and ash content of stem and leaf in all treatments met the standard as stipulated in Pharmacopoeia.

The variable coefficients of extracts of *D. nobile* stem and leaf in treatments with different light intensities and water content of medium were less than 10.0%. As a whole, extract content of leaf was slightly higher than that of stem. Extract content of *D. nobile* stem with relatively weak light was high, while extract content of *D. nobile* leaf with relatively strong light and low water content of medium was high. Leaf is main organ for plant metabolism, and light intensity is the prime power for plant photosynthesis. It could be seen that light intensity could influence the extract content of *D. nobile* leaf. Moreover, the *D. nobile* stem is the storage organ, and the *D. nobile* plants with the weak light had weak growth vigor, slim stem and low yield, while extract content was slightly higher than that in the treatment with strong light.

Dendrobine is a content measurement index of *D. nobile*, which is stipulated $\geq$0.40% in Chinese Pharmacopoeia 2015 edition, and dendrobine content of *D. nobile* stem in treatments with different light intensities and water content of medium met the standard as stipulated in Pharmacopoeia. Dendrobine content in 3 treatments with relative light intensity of 75.02% was lower than that in other 6 treatments. Dendrobine content in treatment with relative water of 50% was minimum, and dendrobine content showed an increasing trend with the increase of medium relative water content. Dendrobine content of *D. nobile* leaf in treatments with different light intensities and water content of

**Table 4**

Influence of different light intensities and water content of medium on stem quality of *Dendrobium nobile* Lindl (%).

| Relative light intensity | Relative water content | Water content | Ash content | Extract content | Dendrobine content |
|---|---|---|---|---|---|
| 75.02% (I) | 50% (1) | 10.26 ± 0.21 | 3.79 ± 0.54 | 15.40 ± 0.11 | 0.52 ± 0.05 |
| | 65% (2) | 9.81 ± 0.13 | 3.45 ± 0.24 | 16.04 ± 0.15 | 0.62 ± 0.04 |
| | 80% (3) | 9.33 ± 0.24 | 3.20 ± 0.25 | 15.43 ± 0.32 | 0.72 ± 0.05 |
| | 50% (1) | 9.67 ± 1.15 | 4.13 ± 0.97 | 15.56 ± 0.64 | 0.75 ± 0.07 |
| 39.74% (II) | 65% (2) | 9.73 ± 0.53 | 4.02 ± 0.78 | 16.40 ± 0.31 | 0.73 ± 0.06 |
| | 80% (3) | 10.03 ± 0.14 | 3.97 ± 0.83 | 15.09 ± 0.34 | 0.74 ± 0.01 |
| | 50% (1) | 10.44 ± 0.15 | 4.57 ± 0.12 | 16.09 ± 0.73 | 0.75 ± 0.02 |
| 20.93% (III) | 65% (2) | 10.18 ± 0.20 | 4.22 ± 0.71 | 17.07 ± 0.84 | 0.75 ± 0.03 |
| | 80% (3) | 10.06 ± 0.14 | 4.31 ± 0.15 | 18.81 ± 0.37 | 0.73 ± 0.01 |
| Variable coefficient (%) | | 3.44 | 10.95 | 7.06 | 11.14 |

Variable coefficient = standard deviation/mean.

**Table 5**

Influence of different light intensities and water content of medium on leaf quality of *Dendrobium nobile* Lindl (%).

| Relative light intensity | Relative water content | Water content | Ash content | Extract content | Dendrobine content |
|---|---|---|---|---|---|
| 75.02% (I) | 50% (1) | 9.30 ± 0.88 | 3.12 ± 0.71 | 21.21 ± 0.67 | 0.30 ± 0.01 |
| | 65% (2) | 9.15 ± 0.93 | 3.90 ± 0.51 | 20.58 ± 0.69 | 0.34 ± 0.01 |
| | 80% (3) | 10.07 ± 0.20 | 3.38 ± 0.26 | 17.71 ± 1.16 | 0.46 ± 0.02 |
| | 50% (1) | 10.45 ± 0.22 | 4.29 ± 0.18 | 18.22 ± 0.09 | 0.64 ± 0.04 |
| 39.74% (II) | 65% (2) | 10.31 ± 1.00 | 4.21 ± 0.22 | 18.20 ± 0.35 | 0.68 ± 0.01 |
| | 80% (3) | 9.73 ± 1.10 | 3.54 ± 0.13 | 16.60 ± 0.14 | 0.61 ± 0.05 |
| | 50% (1) | 9.96 ± 0.88 | 3.88 ± 0.89 | 17.40 ± 0.72 | 0.62 ± 0.05 |
| 20.93% (III) | 65% (2) | 9.55 ± 1.08 | 3.31 ± 0.13 | 18.09 ± 1.46 | 0.61 ± 0.03 |
| | 80% (3) | 9.66 ± 0.22 | 3.08 ± 0.71 | 17.30 ± 1.57 | 0.82 ± 0.02 |
| Variable coefficient (%) | | 4.48 | 11.26 | 8.25 | 29.89 |

Variable coefficient = standard deviation/mean.

medium was within the range of 0.30%–0.82%, and the variable coefficient was up to 29.89%. It could be seen that, dendrobine content of *D. nobile* leaf in all treatments was significantly different. Dendrobine content of *D. nobile* leaf in all treatments was similar to the variation trend of stem.

### *3.4. Comprehensive assessment on D. nobile in treatments with different light intensities and water content of medium*

While making the principal component analysis for the agronomic trait and yield and quality indexes of *D. nobile* in treatments with different light intensities and water content of medium, there were 2 principal components with the eigenvalue of more than 1.000 0. The variance contribution rates of 2 principal components were 75.973 7% and 11.908 3% respectively. The cumulative contribution rate of the former 2 principal components was up to 87.882 0%, *i.e.* 2 principal components represented 82.994 0% information of 11 growth and physiological indexes in 9 treatments.

The eigenvalue of the first principal component was 8.357 1, and the variance contribution rate was 75.973 7%. From Table 6, the basal stem, fresh weight and dry weight of stem and leaf, extract of leaf, and the number of leaves had higher load on the first principal component, which indicated that the first principal component mainly reflected the information of indexes, such as basal stem, fresh weight and dry weight of stem and leaf, and extract. The eigenvalue of the second principal component was 1.309 9, and the variance contribution rate was 11.908 3%. The stem length, stem extract and the number of leaves had higher load on the second principal component, indicating that the second principal component mainly reflected the information of indexes, such as stem length, stem extract, and the number of leaves. It could be ascertained that the indexes including basal stem, fresh weight and dry weight of stem and leaf, leaf extract, the number of leaves, stem length, and stem extract, represented the information of yield and quality of *D. nobile* based on the load of different indexes on each factor. From the eigenvector of the principal component of each index, the principal component of *D. nobile* in treatments with different light intensities and water content of medium was mainly the yield-related index, and only the extract of stem and leaf belonged to the quality index.

Two principal components were used to assess the yield and quality indexes of *D. nobile* in different treatments. The comprehensive assessment function is F = 0.835 7 × F1 + 0.131 0 × F2. The principal component values, comprehensive component scores and ranking of the yield and quality indexes of *D. nobile* in different treatments were calculated by the comprehensive assessment function, as shown in Table 7. The first three

**Table 6**

Eigenvector of the principal component of each index.

| Source | U1 | U2 |
|---|---|---|
| Basal stem | 0.343 7 | 0.009 7 |
| Stem length | 0.148 2 | 0.645 2 |
| Leaf number | 0.293 5 | 0.300 7 |
| Stem fresh weight | 0.340 1 | 0.029 0 |
| Stem dry weight | 0.334 2 | 0.016 6 |
| Leaf fresh weight | 0.327 3 | −0.231 8 |
| Leaf dry weight | 0.317 1 | −0.240 1 |
| Stem extract | −0.182 5 | 0.581 9 |
| Stem dendrobine | −0.309 6 | −0.075 4 |
| Leaf extract | 0.311 1 | 0.177 8 |
| Leaf dendrobine | −0.335 8 | 0.068 6 |

**Table 7**

Overall scores and ranking of components.

| Relative light intensity | Relative water content | F1 | F2 | F | Ranking |
|---|---|---|---|---|---|
| 75.02% (I) | 50% (1) | 4.786 0 | 0.047 4 | 4.8334 | 1 |
| | 65% (2) | 3.232 0 | −0.001 1 | 3.2309 | 2 |
| | 80% (3) | 1.064 4 | −0.038 1 | 1.0263 | 3 |
| 39.74% (II) | 50% (1) | −0.983 3 | −0.140 2 | −1.1235 | 7 |
| | 65% (2) | −0.911 3 | −0.039 4 | −0.9507 | 5 |
| | 80% (3) | −1.622 1 | −0.310 4 | −1.9325 | 8 |
| 20.93% (III) | 50% (1) | −1.184 2 | 0.125 3 | −1.0589 | 6 |
| | 65% (2) | −1.047 1 | 0.208 5 | −0.8386 | 4 |
| | 80% (3) | −3.334 4 | 0.147 9 | −3.1865 | 9 |

**Table 8**

Total dendrobine content of *Dendrobium nobile* Lindl in treatment with different light intensity and water content of medium and its ranking (g/m$^2$).

| Relative light intensity | Relative water content | Stem total dendrobine content | Blade total dendrobine content | Total dendrobine content | Ranking |
|---|---|---|---|---|---|
| 75.02% (I) | 50% (1) | 1.77 | 0.33 | 2.10 | 3 |
| | 65% (2) | 2.05 | 0.34 | 2.39 | 1 |
| | 80% (3) | 1.94 | 0.41 | 2.36 | 2 |
| 39.74% (II) | 50% (1) | 1.43 | 0.46 | 1.89 | 5 |
| | 65% (2) | 1.31 | 0.54 | 1.89 | 5 |
| | 80% (3) | 1.48 | 0.43 | 1.91 | 4 |
| 20.93% (III) | 50% (1) | 1.50 | 0.30 | 1.80 | 6 |
| | 65% (2) | 1.50 | 0.39 | 1.89 | 5 |
| | 80% (3) | 1.24 | 0.33 | 1.57 | 7 |

treatments among 9 treatments were the treatments with the relative light intensity of 75.02%, and were ranked successively with the increase of medium water content. The first was the treatment with the medium relative water content of 50%. The second was the treatment with the medium relative water content of 65%. The overall scores of the treatments ranking the first and the second were far above the other treatments. The overall scores of components in the first three treatments were positive, and those in other treatments were negative. It was thus clear that, the yield and quality formation of *D. nobile* needed the moderately strong light intensity and low water content of medium.

### *3.5. Comprehensive assessment on total dendrobine of D. nobile in treatments with different light intensities and water content of medium*

The first three treatments were the treatments with the relative light intensity of 75.02%, and the total dendrobine content was more than 2.0 g/m$^2$. The first was the treatment with the medium relative water content of 65%, and the second and the third were with 80% and 50% relative water content respectively. The total dendrobine content of other 6 treatments was less than 2.0 g/m$^2$. It was thus clear that, the yield of stem and leaf played a leading role in the total dendrobine accumulation of all treatments (Table 8).

## 4. Discussion

In the case of the artificial cultivation of medicinal plants, the yield depends on the accumulation of the primary metabolite, while the quality depends on the accumulation of the secondary metabolite. The foundation for maintaining the quality and efficacy of medicinal material is the secondary metabolism of plants [17–19]. This research discovered that, the *D. nobile* in 3 treatments with the relative light intensity of 75.02% had good growth vigor, and the total dry matter quality of stem and leaf was significantly higher than other treatments, while the dendrobine content of stem and leaf was lower than other treatments. It fully reflects that the primary metabolite determines the yield, and the secondary metabolite determines the quality of medicinal material.

When plants are confronted with the environmental stress, some alkaloid metabolites can enhance the self protection and competitive capacity for existence of plants [20]. The *Festuca arundinacea* with high-level double pyrrolidine alkaloid has stronger drought tolerance than that with low-level alkaloid content [21]. In the condition of high temperature, drought, shading, and flooding, the camptothecin content of the *Camptotheca acuminate* rises by 2 times [22]. In this research, the dendrobine content of *D. nobile* in the treatments with moderately low and low relative light intensity was higher than that in the treatment with moderately strong light, which reveals that the dendrobine may participate in the process of the plants resisting the external environmental stress. It is thus clear that the *D. nobile* also manifests the increase of dendrobine contents under the weak light.

Three treatments with the relative light of 75.02% ranked the first three, and the overall score of the principal component was the positive value. The treatment with medium relative water content of 50% and 65% ranked the first and the second respectively, both of which had slightly different scores but had larger differences in the scores compared with other treatments. It indicates that the medium with moderately low water contents is suitable for the growth of *D. nobile*. The *D. nobile* grows mainly depending on the aerial root adsorbing on trunk or stone since the spongy tissue in the aerial root of *D. nobile* is developed with favorable aeration and water retention capacity [23]. Thus, the loose culture substrate which is not too wet with good vent ability and strong moisture retention is needed. At the same time, the *D. nobile* root system in imitating wild cultivation is basically bare and in the dry state, while the air humidity is large in the environment, which exactly meets the requirements of dendrobe aerial root. For *D. nobile* in the treatment with moderately strong light intensity, the dendrobine content shows an increasing trend with the increase of the relative water content of substrate, indicating that the adverse situation facilitates the dendrobine metabolism.

The previous researches found that, the moderately strong light intensity is suitable for the growth and development of *D. nobile*, and beneficial to the accumulation of more dry matters and enhancement of yield [24,25], which is consistent with the results of this research. Moreover, the growing environment of *D. nobile* in the imitating wild cultivation in Chishui has trees which can moderately overshadow the plant. Upon investigation, the overshadowing degree should be basically between 60% and 75%, which reveals that the slight overshadowing is suitable for growth and yield of *D. nobile*.

Presently, *D. nobile* commodity is acquired mainly by the means of imitating wild cultivation and facility cultivation. The light intensity and water status in the cultivation are the key factors for high yield and good quality of *D. nobile*. The research showed that, the moderately strong light intensity, and relative water content from low to medium facilitate the growth and yield of *D. nobile*, and light intensity from moderately weak to weak is beneficial to the increase of dendrobine content.

## Conflict of interest statement

The authors declare that they have no conflict of interests.

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