

# Analysis of Climatic Conditions for the Growth of Longhui *Lilium brownii* var. *viridulum*

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**Abstract** Based on the data of temperature, precipitation and sunshine at Longhui National Station from 1981 to 2023, the temperature data at 22 regional stations from 2011 to 2023, and lily planting data at *Lilium brownii* var. *viridulum* base, the feasibility of meteorological conditions for the growth of *L. brownii* var. *viridulum* was analyzed. The results showed that the climatic conditions in Longhui were generally suitable for planting *L. brownii* var. *viridulum*. The southern hilly area was the most suitable climate area, the northern mountainous area was the suitable climate area, and the northwest mountainous area was the more suitable climate area. It can provide favorable meteorological protection for farmers, reduce the impact of adverse meteorological conditions on *L. brownii* var. *viridulum*, and improve the economic benefits of lily production by making full use of Longhui climatic conditions and doing a good job in the meteorological service of *L. brownii* var. *viridulum*.

**Key words** *Lilium brownii* var. *viridulum*; Temperature; Precipitation; Sunshine; Climatic conditions

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Longhui is located in the southwest of central Hunan and the north of Shaoyang City, with a county area of 2 868 km<sup>2</sup>. By the end of 2023, the total population of Longhui County was 1 287 900, with a permanent population of 1 000 800. There are complete types of mountains, hills, hillocks and plains in the territory, with mountains accounting for 40.35%, hills accounting for 25.29%, hillocks accounting for 18.565%, mountains accounting for 7.53%, plains accounting for 5.64%, and waters accounting for 2.63%. Longhui County rises step by step from southeast to northwest, forming three geomorphic areas: southern hilly area, northwest mountainous area, and northern mountainous area. *Lilium brownii* var. *viridulum* is a traditional famous brand product in Longhui County, Hunan Province, and has been cultivated for more than 200 years. Shaoyang local chronicles said that "the lily produced in Shaoyang is extremely large and plump". Lily has the functions of nourishing Yin, moistening lung, relieving cough, and calming mind. It is mainly used for curing yin deficiency and dry cough, cough and hemoptysis, pulmonary fistula, deficiency heat, annoying noise and palpitation, insomnia, dreaminess, etc. It has the pharmacological effects of antitussive, antiasthmatic, expectorant, anti fatigue, sedation, hypnosis, improving immunity, and increasing peripheral white blood cells. Lily can be divided into Yao lily, Mi lily, Cai lily, Longya lily, Duxin lily, and Huzhua lily. Longya lily is the most precious one, and it is rich in alkaloids, proteins, mineral elements and so on. It is a treasure in food. Because of its high price, Longya lily is regarded as noble food. Relevant domestic experts have done some

research on the meteorological conditions of lily planting and cultivation, and some meaningful achievements have been made<sup>[1-6]</sup>, but the research on the meteorological conditions of *L. brownii* var. *viridulum* growth is relatively few at home and abroad. Wang Xinzong *et al.*<sup>[7]</sup> analyzed the climatic adaptability of Longshan lily planting. According to the test results, the suitable meteorological conditions of lily were preliminarily studied in combination with its growth environment and habits. It aimed to improve the yield and quality of *L. brownii* var. *viridulum*, provide favorable meteorological protection for lily growers, reduce the impact of adverse climatic conditions, and improve economic benefits.

## 1 Data and methods

The data used in this paper were the surface meteorological observation data of Longhui National Station from 1981 to 2023, and the average value of each item was the average of 43 a; the climatic value was the 30-a average from 1981 to 2010; monthly average temperature, average maximum temperature and average minimum temperature of 22 regional automatic stations in Longhui County from 2010 to 2023; the lily planting data provided by Longhui *L. brownii* var. *viridulum* production base, and the experimental period was during 2020–2022, a total of 3 a.

## 2 Requirements of the growth of *L. brownii* var. *viridulum* for meteorological conditions

*L. brownii* var. *viridulum* likes half shade environment and is one of the cold and heat resistant lilies. It is suitable for growing in loose and fertile sandy loam with deep soil layer and good drainage. In places with poor drainage, it is prone to disease and death. It prefers slightly acidic soil, but it can also adapt to light

calcareous soil.

**2.1 Requirements for temperature** *L. brownii* var. *viridulum*, a local specialty, requires an annual average temperature of 16.9 °C, no severe cold in winter, and a frost free period of 281 d. The suitable temperature is -10 - 39 °C, and the suitable temperature for growth period is 10 - 28 °C. When the temperature is  $\leq 5$  °C or  $\geq 30$  °C, the growth stops. If the temperature is above 40 °C or below -10 °C, the growth of lily will be adversely affected. Continuously high temperature above 35 °C for more than 3 d will lead to withered and yellow stems and leaves, and underground corms will enter the dormancy period.

**2.2 Requirements for precipitation** *L. brownii* var. *viridulum* needs wet soil at the root growth and seedling emergence stages. The field cannot be waterlogged, and the cohesive soil cannot be waterlogged. The water demand from the vegetative growth stage to the flowering stage is large, and the water demand is mainly concentrated from the flowering stage to the bulb expansion stage, which is 200 - 300 mm<sup>[4]</sup>. During the whole growth period, the soil humidity should not be too high, and the accumulated water after the rain should be removed in time, otherwise the bulb is easy to rot due to hypoxia, especially high temperature and humidity, which is more harmful, often resulting in withered and yellow plants and serious diseases and pests.

**2.3 Requirements for sunshine** It likes weak light conditions at the seedling stage and light conditions at the vegetative growth stage. Insufficient light has a great impact on plant growth and bulb expansion, especially at the budding and flowering stages. If the light is too weak and too little, the flower buds are easy to fall off, while the high temperature and strong light in summer will cause premature withering and yellowing of stems and leaves.

### 3 Analysis of climatic conditions for the growth of Longhui *L. brownii* var. *viridulum*

Longhui County has a subtropical monsoon humid climate, with mild climate, four distinct seasons, concentrated rainfall, and large differences between the north and the south. The annual average daily temperature is 10.9 - 17.2 °C. The annual average frost free period is 281.2 d. The annual average precipitation is 1 312.5 mm. Lily likes cold and humid climate and semi shady environment. It likes fertile, humus rich, well drained and loose sandy soil, and it is better to be slightly acidic. When the temperature is  $\leq 5$  °C or  $\geq 30$  °C, the growth stops. The test results showed that *L. brownii* var. *viridulum* grew fastest from the first ten days of April to the last ten days of August in Longhui. Generally, it could germinate at a temperature not lower than 5 °C, and the suitable growth temperature is 20 - 32 °C, but the suitable temperature for flower bud differentiation is 15 - 20 °C. The leaves of *L. brownii* var. *viridulum* of vigorous growth still remain green under the temperature of about 10 °C, but the high temperature above 38 °C has a certain effect on its growth. When the light is insufficient, the branches are tender and slender, the leaves are

small, the twining is strong, and the flower bud differentiation is less. Therefore, the flowers grow on the branches with sufficient sunshine, and it is suitable for planting in sunny and well ventilated areas. In Longhui *L. brownii* var. *viridulum* base and production area, the annual rainfall is more than 1 000 mm, generally 1 000 - 1 680 mm, and the annual sunshine hours are less than 1 450 h, generally 1 000 - 1 450 h. Temperature at Longhui national and regional stations is shown in Table 1.

### 4 Analysis of climatic regionalization in Longhui

Longhui County is located in the middle subtropical humid monsoon climate zone. There are four distinct seasons, but the duration is different. The spring and autumn are short, while the winter and summer are long. It is cold in winter and hot in summer. The rain is in the hot season. The rainy season is obvious, and the summer and autumn are dry. After 1978, the climate became warmer. There are great seasonal differences: affected by the monsoon circulation, Longhui is cold and dry in winter and hot and wet in summer. Controlled by the cold air in the north, temperature is low in winter, it is cold, and rainfall is less. In summer, controlled by the warm and humid climate in the south, temperature is high, it is hot, and rainfall is more. Taking Taohong Town as an example, the minimum monthly average temperature appeared in January, which was 5.5 °C, and the maximum appeared in July, which was 28.0 °C, with a difference of 22.5 °C; the maximum value of monthly precipitation occurred in June, which was 206.8 mm, and the minimum value occurred in December, which was 34.6 mm, with a difference of 172.2 mm. There are great differences between the north and the south: the southern hilly area is easy to wait for the cold wave, and the solar radiation is strong in summer, so it is cold in winter and hot in summer; the forest vegetation in the northern mountainous area is better than that in the south, so it is cold in winter and cool in summer. The temperature difference between the north and the south is as follows: the annual average temperature of Longhui County is 10.9 - 17.2 °C (the average temperature in January is 5 °C, and the extremely minimum temperature is -11.3 °C; the average temperature in July is 28.1 °C, and the extremely maximum temperature is 39.1 °C), the average maximum temperature is 21.5 °C, and the average minimum temperature is 13.8 °C. The annual average rainfall is 1 293.2 mm, and the frost free period is about 281.2 d. However, rainfall is mainly concentrated from April to June, which often leads to flash floods. There is less rainfall from July to September, forming autumn drought and affecting crop growth. As far as the climatic regionalization of Longhui is concerned, it can be divided into three regional climatic zones according to the terrain characteristics and climatic differences.

**4.1 Northwest high and cold mountainous area** It includes Xiaoshajiang Town, Matangshan Township, Huxingshan Township, and some townships in Jinshiqiao Town. This climatic zone covers less than one-third of the area. The annual precipitation is

1 547.3 – 1 712.8 mm, mainly concentrated in May – August. The annual average temperature is 10.9 – 11.8 °C, the hottest month occurs in July, and the extremely maximum temperature is 26.7 – 30.7 °C. It is the coldest in January, with an average min-

imum temperature of –5.8 – –7.6 °C. The extremely maximum temperature is 35.5 – 37.0 °C, and the frost free period is 208 – 215 d. This climatic area is more suitable for the growth of *L. brownii* var. *viridulum*.

Table 1 Temperature at Longhui national and regional stations

°C

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Average	Maximum average	Minimum average	Extreme minimum
Longhui National Meteorological Observatory	5.4	7.3	11.2	17.2	22.0	25.3	28.1	27.5	23.8	18.5	13.0	7.6	17.2	34.7	5.4	–6.9
Xiaoshajiang	0.5	0.8	6.8	12.0	15.4	16.6	20.8	20.6	16.9	12.0	7.7	0.9	10.9	27.9	2.3	–15.7
Luohong	3.8	6.1	10.0	16.0	20.7	24.0	26.8	26.2	22.1	17.0	12.0	6.2	15.9	34.6	4.8	–8.6
Simenqian	3.8	6.1	10.0	16.0	20.7	24.0	26.8	26.2	22.1	17.0	12.0	6.2	15.9	35.3	4.6	–9.0
Matangshan	0.8	1.2	7.0	12.2	15.7	16.9	21.2	20.9	17.2	12.4	7.9	1.4	11.2	27.7	2.8	–14.2
Dashuitian	3.5	5.8	9.7	15.6	20.4	23.6	26.4	26.0	21.8	16.6	11.8	6.0	15.6	33.6	3.5	–9.1
Muguashan Reservoir	3.6	6.0	9.8	15.7	20.6	23.7	26.5	26.0	22.0	16.8	11.9	6.1	15.7	33.8	3.6	–8.9
Gaoping	3.8	6.0	10.0	16.1	20.2	24.1	26.4	26.0	22.2	17.1	12.1	6.1	15.8	34.4	3.8	–8.5
Qijiang	3.8	6.1	10.0	16.0	20.7	24.0	26.8	26.2	22.1	17.0	12.0	6.2	15.9	35.5	3.8	–8.8
Yankou	5.4	7.2	11.0	17.1	21.7	25.1	27.9	27.2	23.6	18.5	13.0	7.4	15.9	37.7	5.2	–7.9
Tantou	5.0	7.0	11.1	17.0	21.8	25.1	27.5	27.0	23.4	18.2	12.7	7.3	16.9	35.4	5.0	–7.5
Yatian	5.0	7.0	11.0	17.1	21.7	25.0	27.5	27.0	23.2	18.2	12.7	7.2	16.9	36.0	5.0	–7.8
Zhouwang	5.0	7.0	11.0	17.0	21.8	25.0	27.6	27.1	23.4	18.3	12.8	7.1	16.9	34.0	5.0	–7.9
Taohuaping	5.2	7.1	11.1	17.0	22.0	25.1	28.0	27.3	23.6	18.4	13.0	7.4	17.1	35.8	5.2	–7.1
Sangesi	5.0	7.0	11.1	17.0	21.8	25.1	27.5	27.0	23.4	18.2	12.7	7.3	16.9	34.9	5.0	–7.4
Beishan	5.1	7.0	11.0	17.0	21.7	25.0	27.7	27.2	23.3	18.1	12.8	7.2	16.9	35.9	5.1	–7.6
Nanyue Temple	5.1	6.7	10.7	16.8	21.6	24.7	27.7	27.2	23.1	17.8	12.3	7.0	16.6	33.7	5.1	–7.6
Qishi Reservoir	3.8	6.1	10.0	16.0	20.7	24.0	26.8	26.2	22.1	17.0	12.0	6.2	15.9	34.5	5.8	–7.8
Shanjie	5.4	7.3	11.2	17.2	22.0	25.3	28.1	27.5	23.8	18.5	13.0	7.6	17.2	34.9	5.4	–7.9
Huxingshan	1.1	1.6	7.7	13.4	16.0	17.4	21.7	21.2	17.8	13.1	8.8	1.9	11.8	26.7	5.5	–15.1
Jinshiqiao	3.8	4.5	10.6	15.6	17.0	21.5	23.2	22.9	19.2	15.3	10.9	4.8	14.1	33.1	5.8	–9.5
Liuduzhai Reservoir	5.1	7.0	11.0	17.0	21.7	25.0	27.7	27.2	23.3	18.1	12.8	7.2	16.9	35.3	5.1	–8.0
Hetian	3.9	6.3	10.5	16.3	21.0	24.3	26.9	26.4	22.4	17.3	12.4	6.5	16.2	34.5	3.9	–7.8
Average	4.0	5.8	10.2	16.0	20.4	23.5	26.3	25.8	22.0	16.9	11.8	6.0	15.7	33.9	4.3	–9.0

**4.2 Northern mountainous area** It includes Jinshiqiao Town, Yatian Town, Simenqian Town, Luohong Township, Qijiang Township, Dashuitian Township, Yankou Town and some townships of Gaoping Town. The area of this climatic zone is nearly one third, and the annual precipitation is 1 324.3 – 1 567.4 mm, mostly concentrated in May – August. The annual average temperature is 14.3 – 15.5 °C, and the hottest month mostly occurs in July, with the highest of 35.9 – 37.1 °C. The coldest month occurs in January, and the extremely minimum temperature is –15.6 – –14.3 °C. The frost free period is 246 – 265 d. This climatic area is suitable for the growth of *L. brownii* var. *viridulum*.

**4.3 Southern hilly area** It includes Taohong Town, Hexiangqiao Town, Yushan Town, Zhouwang Town, Liuduzhai Town, Beishan Township, Tantou Town, *etc.* The annual precipitation is 1 210.3 – 1 354.5 mm, mostly concentrated in May – August. The annual average temperature is 16.7 – 17.0 °C, and the hottest month mostly occurs in July, with the highest of 38.5 – 39.1 °C. The coldest month occurs in January, and the extremely minimum temperature is –6.0 – –6.9 °C. The frost free period is 277 – 283 d. This climatic area is the most suitable area for the growth of *L. brownii* var. *viridulum*.

**5 Conclusions**

There are many factors affecting the growth of *L. brownii* var. *viridulum*, but the most important factor is temperature, followed by precipitation and sunshine. Through the analysis of these meteorological elements, it is found that the favorable factors are that the temperature, humidity and light of Longhui can meet the growth needs of *L. brownii* var. *viridulum*. Before the bud stage, light, temperature and water are well coordinated, and the climatic conditions in most planting areas are within the suitable climatic area for the growth of *L. brownii* var. *viridulum*. During the flowering and bulb expansion period from late May to early and middle July, sufficient sunshine can meet the needs of flowering, and abundant precipitation can meet the water requirements of lily expansion and growth. From late July to August, the rainy season finishes, and the climate conditions of high temperature and little rain are conducive to the accumulation of nutrients in lily bulb. The adverse factors are as follows: due to the obvious vertical climate, the temperature in the alpine mountains is low. For example, the growth period of *L. brownii* var. *viridulum* in Xiaoshajiang, Huxingshan and Matangshan is relatively late, so

(To page 30)

and climate characteristics are stable pressure with less sudden changes, small changes in wind direction and speed, low temperature, small temperature difference, no obvious precipitation. However, it is easy to produce fog when the weather is fine, wind is light and water vapor is abundant, and it is easy to produce haze and other weather phenomena with visual obstruction as water vapor conditions are poor. The southward movement of polar air mass, strong northerly gale with long duration, a large drop in temperature, and common relative humidity are not conducive to the generation of fog and haze. In the case of southerly warm and humid air, weak precipitation will be formed. For the aviation meteorological services, the force of gale, crosswind, precipitation (snow), visual obstruction phenomenon, and ground ice are the main influencing factors. According to the model test, the performance of situation field data of EC forecasting model and numerical forecasting model was stable and reliable. In general, it is conducive to the development of the aviation meteorological services.

### 3 Conclusion and discussion

Compared with other meteorological support services, aviation meteorological support services have high requirements on the demand for meteorological data, the duration of forecast cycle, the diversity of service products, the accuracy of forecast time and the division and coordination of personnel. It is necessary to clarify the specific requirements of aviation meteorological service objects, be familiar with the weather and climate characteristics of the local service period, carry out long-term tracking, monitoring and forecasting, and rationally use meteorological data.

In terms of complexity, safety and forecast accuracy, aviation meteorological support services are conducted better in winter than

summer. In winter, the strength, track and region of the weather system are relatively stable, and the forecasting and warning time is longer. In summer, the weather phenomenon is sudden, and the timeliness of early warning is low. For the test results of each forecasting model, those of the situation field and numerical forecasting model are stable and reliable in winter, and severe weather forecast is weak or missing in summer.

Aviation meteorological support services require long-term establishment of climate trend, medium- or short-term, near and hourly meteorological support services. They periodically use 30-year meteorological consolidation data, surface and upper air weather charts, situation prediction models, numerical prediction models, and timely conduct ground and radar weather monitoring.

In practical applications, due to the complexity and uncertainty of meteorological conditions, it is difficult to make accurate forecasts. With the gradual improvement of users' requirements, the requirements for aviation weather forecasting are virtually increased<sup>[3]</sup>. Meteorological departments lack such comprehensive meteorological support service experience, which also raises meteorological service support to a new height, and the problems and challenges that need to be faced are more severe.

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(From page 23)

the sowing time should be appropriately postponed. The rain concentration period is from May to June, with frequent rainstorms, which is easy to cause secondary geological disasters such as landslides, and water accumulation in the field. Special attention should be paid to strengthening prevention. From July to August, there will be short-term high temperature weather above 38 °C in the southern hilly area, so it should pay attention to prevention. According to the historical experience of planting lily, all regions should combine the climate and weather forecast of local meteorological stations to timely sow seeds, prevent the impact of adverse weather, and improve the yield and quality of *L. brownii* var. *viridulum*.

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