# Climate Suitability Zoning of *Morinda officinalis* F. C. How and *Sarcandra glabra* (Thunb.) Nakai Planting in Xinfeng County Based on GIS

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**Abstract** Based on the meteorological data of 24 automatic stations in Xinfeng County, combined with the climatic conditions for the growth of *Morinda officinalis* F. C. How and *Sarcandra glabra* (Thunb.) Nakai, the climate suitability zoning indicators of *M. officinalis* and *S. glabra* in Xinfeng County were constructed by relevant statistical methods, and the climate suitability zoning indicators were divided into four grades: most suitable, suitable, subsuitable and unsuitable. According to the results of expert scores, the relevant growth impact factors were assigned weight values. Based on geographic information system (GIS), the climate suitability zoning of *M. officinalis* and *S. glabra* planting in Xinfeng County was carried out. The results show that most areas of Xinfeng County were suitable for planting *M. officinalis* and *S. glabra*. Among them, the most suitable planting areas of *M. officinalis* were mainly distributed in most of Huilong Town, from Jiangnan Community of Fengcheng Street to Yuntianhai area of Meikeng Town, Matouwantian Village and areas to the south, and areas to the south of Zhutong Village, Fengcheng Street. The most suitable areas for *S. glabra* planting were mainly distributed in Puchang Village of Huilong Town, the northeast of Huangzhai Town, the south of Fengcheng Street, and the central-southern part of Matou Town. The zoning results provide a scientific basis for the rational layout of *M. officinalis* and *S. glabra* planting in Xinfeng County.

**Key words** *Morinda officinalis* F. C. How; *Sarcandra glabra* (Thunb.) Nakai; Climate suitability; Geographic information system; Xinfeng County

**DOI** 10.19547/j.issn2152 - 3940.2025.01.006

According to the deployment of the county Party committee, it is needed to highlight green development, and strive to create a new benchmark of ecological economy, promotes the development of modern agriculture around the "tea pot", "vegetable basket", "fruit plate" and "medicine garden" of the "double zones" during the "14th Five-Year Plan" period. Especially in recent years, Xinfeng County has promoted southern medicine planting and actively explored the new development path of "planting a variety, forming an industry, and making people rich". Among them, two southern medicines *Morinda officinalis* F. C. How and *Sarcandra glabra* (Thunb.) Nakai are included. Therefore, in order to make full use of favorable climate resources in Xinfeng County, and provide scientific basis for the rational distribution of introduced *M. officinalis* and *S. glabra* in Xinfeng County, it is necessary to study the climate suitability zoning of *M. officinalis* and *S. glabra* in Xinfeng County.

Many scholars have studied the climate suitability zoning of crops[1-6], and different scholars have analyzed the relationship between local crop production and climate conditions through mathematical statistics, experimental observation and other methods and means, or discussed the climatic conditions required in the critical growth period of crop production and meteorological disasters affecting planting. For instance, Mo Jianguo *et al.*[7] studied and formulated the geographical regionalization of climate risk for the planting southern medicines in Guizhou Province by combining meteorology and implantology. Li Binyan *et al.*[8] analyzed the relationship between the growth and development cycle, harvesting and other different periods of southern medicine and meteorological conditions, and climate adaptability and adverse meteorological conditions were concluded. Zhang Huilian[9] studied favorable climatic conditions such as temperature, moisture and light in Yongding County, and analyzed the effects of common meteorological disasters on the growth and development of *M. officinalis*.

Based on the meteorological data of 23 automatic stations and the ground meteorological observation station in Xinfeng County over the years, combined with the climatic conditions for the growth of *M. officinalis* and *S. glabra*, the climate suitability zoning indicators of *M. officinalis* and *S. glabra* in Xinfeng County were constructed through relevant statistical methods, and the climate suitability zoning of *M. officinalis* and *S. glabra* in Xinfeng County was conducted based on the geographic information system technology (GIS).

## 1 Data and methods

**1.1 Data sources and processing** In this study, the data of annual average temperature, annual extreme minimum temperature, average temperature in the coldest month, average temperature in the hottest month, and annual precipitation in 24 meteorological stations in Xinfeng County since the establishment of the

Received: January 8, 2025 Accepted: February 19, 2025

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stations were all from Xinfeng Meteorological Bureau. Data on the climatic growth conditions of *M. officinalis* and *S. glabra* were obtained by field consultations and from related literature. The geographic information data were from the National Basic Geographic Information Center.

Due to the difference between understory temperature and non-understory temperature, the data of non-understory weather stations were processed in a linear manner, in which the vertical change rate of annual average temperature, annual extreme minimum temperature, average temperature in the hottest month, and average temperature in the coldest month was 0.6, 0.37, 0.54, and 0.5 ℃/100 m, respectively. Then, the relationship between understory temperature and non-understory temperature was obtained by comparing understory station Wantian Village (114.36° E, 24.02° N) with non-understory station Tongmushan Village (114.35° E, 24.02° N). Among them, understory annual average temperature was 0.6 ℃ higher than non-understory annual average temperature, and understory annual extreme minimum temperature was 3.4 ℃ higher than non-understory annual extreme minimum temperature; understory average temperature in the hottest month was 0.43 ℃ higher than non-understory average temperature in the hottest month, and understory average temperature in the coldest month was 1.85 ℃ higher than non-understory average temperature in the coldest month.

**1.2 Zoning method** *M. officinalis* prefers a warm and moist growing environment. The most suitable temperature for the growth of *M. officinalis* is 22 – 25 ℃. If temperature is lower than 15 ℃ or higher than 27 ℃, it will be affected, and grows slowly. If it encounters frost weather with temperature of below 0 ℃, it will drop leaves, be frostbitten or freeze to death. In areas where annual rainfall reaches more than 1 200 mm, it can grow normally. When annual average rainfall is more than 1 600 mm, its growth and development are better. However, excessive water often causes root rot and even death of the whole plant[10]. When annual average temperature is 12 – 18 ℃, average temperature in the coldest month is 5 – 8 ℃, average temperature in the hottest month is 24 – 28 ℃, and annual rainfall is between 1 000 and 1 400 mm, *S. glabra* grows well. Too much rain may also lead to water accumulation in fields, thereby causing root rot.

In summary, according to the climate growth habits of *M. officinalis* and *S. glabra*, combined with field research and consulting experts, the climate suitability zoning indicators were divided into four grades: most suitable, suitable, sub-suitable and unsuitable. The growth and planting indicators are shown in Table 1 and Table 2. According to the scores scored by the experts in meteorology, agriculture, forestry and other fields, weight values were assigned to the relevant growth impact factors. For *M. officinalis*, the weight of annual average temperature, annual extreme minimum temperature and annual precipitation was 0.4, 0.3 and 0.3, respectively. For *S. glabra*, the weight of annual average temperature, average temperature in the coldest month, average temperature in the hottest month, and annual precipitation was 0.4, 0.2, 0.2 and 0.2, respectively.

**Table 1 Climate suitability indicators for the growth and planting of *M. officinalis***

| Grade | Annual average temperature//℃ | Annual extreme minimum temperature//℃ | Annual precipitation//mm |
|---|---|---|---|
| Most suitable | 22 – 25 | >2 | 1 200 – 1 600 |
| Suitable | 19 – 22 | 0 – 2 | 1 000 – 1 200, 1 600 – 2 000 |
| Sub-suitable | 15 – 19, 25 – 27 | –2.5 – 0 | 800 – 1 000, 2 000 – 2 400 |
| Unsuitable | <15, >27 | < –2.5 | <800, >2 400 |

**Table 2 Climate suitability indicators for the growth and planting of *S. glabra***

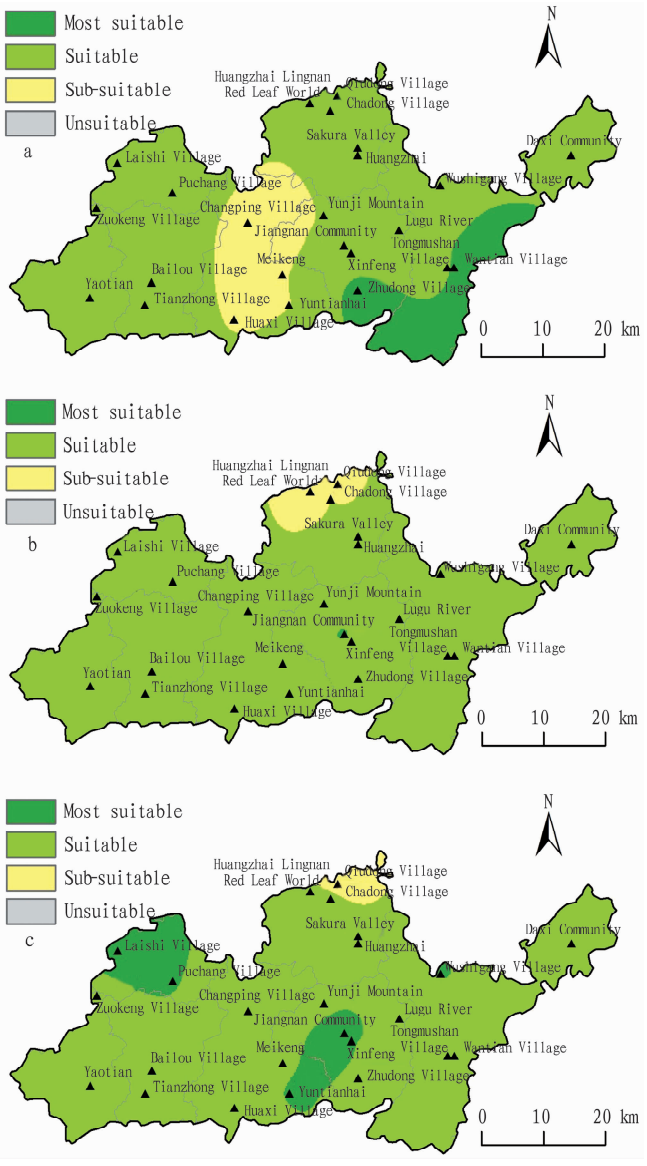
| Grade | Annual average temperature//℃ | Average temperature in the coldest month//℃ | Average temperature in the hottest month//℃ | Annual precipitation//mm |
|---|---|---|---|---|
| Most suitable | 12 – 18 | 5 – 8 | 24 – 28 | 1 000 – 1 400 |
| Suitable | 8 – 12, 18 – 22 | 3 – 5, >8 | 22 – 24, 28 – 30 | 800 – 1 000, 1 400 – 1 800 |
| Sub-suitable | 4 – 8, 22 – 26 | 1 – 3 | 20 – 22, 30 – 32 | 600 – 800, 1 800 – 2 200 |
| Unsuitable | <4, >26 | <1 | <20, >32 | <600, >2 200 |

## 2 Results and analysis

### 2.1 Results of climate suitability zoning of *M. officinalis*

**2.1.1** Single-factor suitability zoning. Seen from the distribution of annual average temperature (Fig. 1a), it was 15 – 19 ℃ in the northern area of Huangzhai Town, that is, it was sub-suitable; it was 19 – 22 ℃ in the other areas, that is, it was suitable. As shown in Fig. 1b, the annual precipitation of Matouwantian Village and areas to the south, and areas to the south of Zhutong Village, Fengcheng Street was 1 200 – 1 600 mm, that is, it was the most suitable. Most areas of Meiceng Town and the northwest part of Fengcheng Street had annual precipitation of more than 2 000 mm, so they were sub-suitable areas. The annual precipitation of the remaining areas was 1 600 – 2 000 mm, so they were suitable areas. According to annual extreme minimum temperature (Fig. 1c), most areas of Huilong Town, the middle and southwest of Fengcheng Street, and the area near Yuntianhai in Meikeng Town were the most suitable areas, with annual extreme minimum temperature of above 2 ℃. The annual extreme minimum temperature in the northern area of Huangzhai Town ranged from –2.5 to 0 ℃, so it was a sub-suitable area. That of the remaining areas

was 0 – 2 ℃, so they were suitable areas.




Note: a. Annual average temperature; b. Annual precipitation; c. Annual extreme minimum temperature.

**Fig. 1 Results of single-factor suitability zoning of *M. officinalis* planting in Xinfeng County**

**2.1.2** Comprehensive suitability zoning. According to the comprehensive climate suitability zoning map of *M. officinalis* in Xinfeng County (Fig. 2), most areas of Xinfeng County were suitable for *M. officinalis* cultivation, among which the most suitable areas were mainly distributed in the majority of Huilong Town, the area from Jiangnan Community of Fengcheng Street to Yuntianhai area of Meiceng Town, Matouwantian Village and areas to the south, and areas to the south of Zhutong Village, Fengcheng Street. The annual average temperature in these areas was 19 – 22 ℃, and the annual precipitation was 1 200 – 2 000 mm, while the annual extreme minimum temperature was higher than 0 ℃.

Suitable areas were mainly distributed in Yaotian Town, Shatian Town, part of Huilong Town, part of Fengcheng Street, north-central part of Matou Town, southwestern Meikeng Town, and south-central part of Huangzhai Town. The annual average temperature in these areas was 19 – 22 ℃, and the annual precipitation was 1 600 – 2 000 mm, while the annual extreme minimum temperature was 0 – 2 ℃.

Sub-suitable areas were mainly distributed in most of Meikeng Town and the northern area of Huangzhai Town. The annual average temperature in these areas was between 15 and 22 ℃, and the annual precipitation was 1 600 – 2 400 mm, while the annual extreme minimum temperature was 0 – 2 ℃.

Unsuitable areas were mainly distributed in Chadong and Qiudong Village of Huangzhai Town. The annual average temperature in these areas was 15 – 19 ℃, and the annual precipitation ranged from 1 600 to 2 000 mm, while the annual extreme minimum temperature was between – 2.5 and 0 ℃.

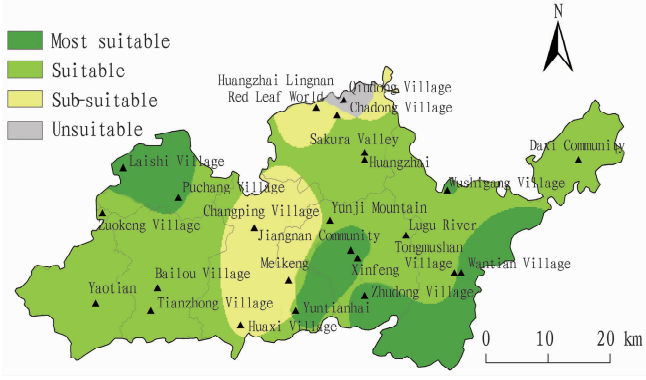


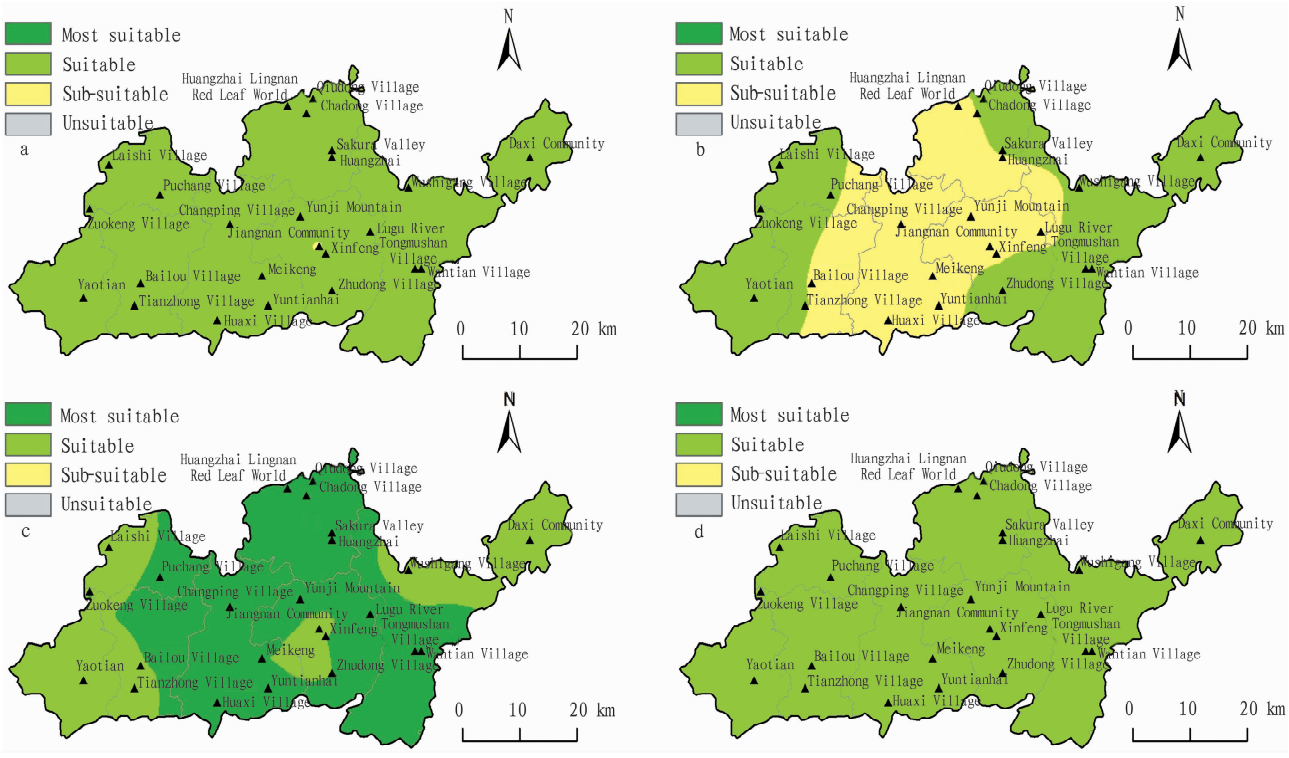

**Fig. 2 Results of comprehensive climate suitability zoning of *M. officinalis* planting in Xinfeng County**

## 2.2 Results of climate suitability zoning of *S. glabra*

**2.2.1** Single-factor suitability zoning. As shown in Fig. 3a, the annual average temperature in Jiangnan community was 22 – 26 ℃, so it was a sub-suitable area. The annual average temperature in the remaining areas was between 18 and 22 ℃, so they were suitable areas. According to the distribution of annual precipitation (Fig. 3b), it was 1 400 – 1 800 mm in Yaotian Town, the west of Shatian Town, the central-western part of Huilong Town, the northeast of Huangzhai Town, most of Matou Town, and the south of Fengcheng Street, and they were suitable areas. The annual precipitation of the remaining areas was 1 800 – 2 200 mm, and they were sub-suitable areas. Seen from Fig. 3c, the average temperature in the hottest month was 24 – 28 ℃ in the east of Huilong Town, the east of Shatian Town, Meiceng Town, Huangzhai Town, most of Fengcheng Street, and the central-southern part of Matou Town, and theses areas were the most suitable areas. It was 28 – 30 ℃ in the remaining areas, and they were suitable areas. As shown in Fig. 3d, the average temperature in the coldest month in Xinfeng County was higher than 8 ℃, so it was a suitable area.

**2.2.2** Comprehensive suitability zoning. According to the comprehensive climate suitability zoning map of *S. glabra* in Xinfeng County (Fig. 4), most areas of Xinfeng County were suitable for planting *S. glabra*, and the most suitable areas were mainly distributed in Puchang Village of Hulong Town, northeast of Huangzhai Town, south of Fengcheng Street, and central-southern part of

Matou Town. The annual average temperature in these areas ranged from 18 to 22 ℃, and the annual precipitation was 1 400 – 1 800 mm; the average temperature in the hottest month was 24 – 28 ℃, and the average temperature in the coldest month was higher than 8 ℃.




Note: a. Annual average temperature; b. Annual precipitation; c. Average temperature in the hottest month; d. Average temperature in the coldest month.

**Fig. 3 Results of single-factor suitability zoning of *S. glabra* planting in Xinfeng County**

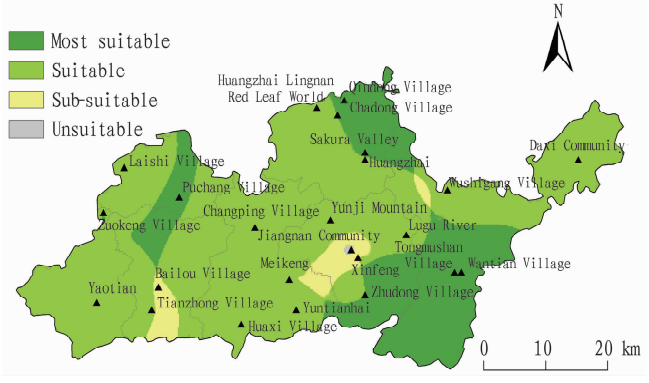



**Fig. 4 Results of comprehensive climate suitability zoning of *S. glabra* planting in Xinfeng County**

Suitable areas were mainly distributed in Yaotian Town, most of Shatian Town, most of Huilong Town, Meikeng Town, the north of Fengcheng Street, the north of Matou Town, from Chadong Village, Huangzhai town to areas to the south of Sakura Valley. The annual average temperature in these areas was 18 – 22 ℃, and the annual precipitation was 1 400 – 2 200 mm; the average temperature in the hottest month was 24 – 30 ℃, and the average temperature in the coldest month was higher than 8 ℃.

Sub-suitable areas were mainly distributed in Bailou Village of Shatian Town, and from Jiangnan Community of Fengcheng Street to Yuntianhai area of Meikeng Town. The annual average temperature in these areas was 18 – 22 ℃, and the annual precipitation was 1 800 – 2 200 mm; the average temperature in the hottest month was 28 – 30 ℃, and the average temperature in the coldest month exceeded 8 ℃.

The unsuitable area was mainly distributed in Jiangnan Community of Fengcheng Street. It was just in the county town, where the annual average temperature was 22 – 26 ℃, and the annual precipitation was 1 800 – 2 200 mm; the average temperature in the hottest month was 28 – 30 ℃, and the average temperature in the coldest month was over 8 ℃.

## 3 Conclusions and discussion

Temperature is the main factor affecting the climate suitability of *M. officinalis* planting in Xinfeng County. For example, the high altitude in the north of Huangzhai town leads to low annual average temperature and low annual extreme minimum temperature. *M. officinalis* is not tolerant to frost, so it cannot grow steadily here. Therefore, before the arrival of extreme low-temperature weather, measures such as covering thermal insulation film and building greenhouses can be taken to provide a warm environment for *M. officinalis*. The main factor affecting the climate suitability of *S. glabra* planting in Xinfeng County is annual precipitation. Excessive annual precipitation may lead to water accumulation in soil, thus affecting root respiration and nutrient absorption of

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700 hPa. Consequently, it exhibited the same snowfall range and magnitude as the former event.

## 4 Discussion

The two snowstorm events in Beijing were both influenced by the combination of the 700 hPa southwesterly warm-wet jet stream and the near-surface easterly wind return flow. The overall description of snowfall process by numerical prediction was relatively accurate, and the deviations in the forecasted snowfall amounts were primarily due to the inaccuracies in predicting the position of the 700 hPa southwesterly warm-wet jet stream. When discrepancies between the observed and forecasted snowfall were identified, it should timely analyze the reasons, and update the warning and forecast conclusions. With the collaboration of relevant departments, the deviation in the initial snowfall forecasts could be significantly mitigated, ensuring the safety and efficiency of people's travel.

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*S. glabra*. Meanwhile, water accumulation may reduce the oxygen content in soil, resulting in breathing difficulties for *S. glabra* roots, which in turn affects its normal growth. Therefore, when *S. glabra* is planted, it is necessary to control soil moisture reasonably and choose areas with good drainage to avoid the occurrence of water accumulation.

In this study, based on meteorological data and climatic conditions for the growth of *M. officinalis* and *S. glabra*, the climate suitability zoning indicators of *M. officinalis* and *S. glabra* in Xinfeng County were established by relevant statistical methods, and the climate suitability zoning of *M. officinalis* and *S. glabra* planting in Xinfeng County was carried out based on geographic information system (GIS). However, in addition to the meteorological factors in this study, the growth of *M. officinalis* and *S. glabra* is also affected by factors such as concealability and soil, and the specific local conditions should be considered in actual application. In further studies, these indicators should be considered to make suitability zoning results more realistic and lay a foundation for the development of understory southern medicines.

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