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Evaluation of Soil Fertility Quality and Environmental Driving Factors in Different Soil Types of Artificial Forests

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Abstract The aim was to clarify the environmental driving factors of soil fertility indicators in artificial forests of Guangxi and comprehensively evaluate the soil fertility level. By collecting data on the current status of soil in artificial forests, the spatial distribution of major soil fertility indicators was analyzed, and the distribution map of the fertility index of artificial forests in the entire region and the comprehensive fertility index of artificial forests of different soil types were obtained. Canonical correspondence analysis method was used to analyze soil fertility indicators and environmental factors, and the environmental driving factors of soil fertility indicators for artificial forests of the main soil types in Guangxi were obtained. The results showed that over 90% of the soil fertility index of artificial forests in the entire region was between 0.20 and 0.50. The order of soil fertility index of different soil types of artificial forests from high to low was yellow brown soil > yellow red soil > yellow soil > red soil > limestone soil > latosolic red soil > laterite. In artificial forests of latosolic red soil, the correlation between soil alkaline nitrogen and organic matter, annual average temperature was high, while the correlation between soil available phosphorus and organic matter, pH was high, and the correlation between soil available potassium and environmental factors such as slope, altitude, rainfall, accumulated temperature, and slope aspect was high. In artificial forests of red soil, the correlation between soil alkaline nitrogen and slope, altitude was high, while the correlation between soil available phosphorus and accumulated temperature, rainfall was high, and the correlation between soil available potassium and pH was high. In artificial forests of limestone soil, there was a high correlation between soil alkaline nitrogen and slope, organic matter, a high correlation between soil available phosphorus and accumulated temperature, rainfall, and a high correlation between soil available potassium and pH.

Key words Soil fertility index; GIS; Forest soil; Canonical correspondence analysis

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Soil fertility quality refers to the ability of soil to maintain plant productivity, maintain or improve water and air quality[1]. Therefore, maintaining soil fertility quality has become one of the important goals for sustainable management of artificial forests. The quality of soil fertility needs to be evaluated through monitoring and evaluating soil fertility indicators, fertility indices, and other parameters. Soil fertility indicators mainly include nutrient content such as nitrogen, phosphorus, and potassium in the soil. During the process of soil development, soil nutrient content varies based on soil type and region, mainly depending on the influence of soil parent material type, soil erosion[2], and human factors[1]. In addition, there are significant differences in the spatial distribution of soil nutrients at local and regional scales due to terrain attributes[3] and climate factors[4]. Artificial forest soil has complex terrain and diverse climate types. Therefore, it attempted to explore the environmental driving factors of soil fertility indicators in different soil types of artificial forests in Guangxi, providing technical support for solving the problem of soil quality decline under long-term management of artificial forests and ensuring the sustainable and healthy development of artificial forest soil ecology.

Soil is a complex ecosystem formed by the interaction between climate, geology, topography, biological activities, time, and land use. Terrain affects the distribution of soil nitrogen and phosphorus by controlling soil erosion and sediment deposition processes[5]. Terrain also affects the production and decomposition of plant litter[6]. Therefore, soil fertility indicators are closely related to terrain attributes such as slope and slope aspect[7]. In the investigation of forest ecosystems in China, scholars have found that total phosphorus gradually decreases with increasing soil depth in vertical distribution[8]. There are significant differences in total phosphorus of soil in different regions, and the vertical distribution of total phosphorus in forest soil shows irregular changes. The total phosphorus concentration in the soil gradually decreases from north to south. In each soil layer, the total phosphorus content of the soil surface layer is higher than that of the lower layer. The areas with the highest total phosphorus content in the soil are mainly distributed in temperate forests and the edge areas of the Qinghai - Tibet Plateau. The total phosphorus in soil increases significantly with the increase of latitude and altitude gradients, and decreases significantly with the increase of longitudinal gradients. Slope aspect also has a significant impact on the distribution of soil nitrogen and phosphorus[9-10]. In addition, climate factors such as precipitation and temperature also directly or indirectly affect the content and distribution of soil fertility indicators by affecting soil properties, plant and soil microbial activities[11-13]. Recently, research by Hou *et al.*[13] found that with the increase of annual av-

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erage precipitation and temperature, soil total phosphorus significantly decreased. Liu *et al*. explored the model of plant nitrogen and phosphorus stoichiometry and found that total phosphorus concentration of soil decreased with the decrease of annual average temperature[14]. Research has shown that climate has a significant impact on the distribution of total phosphorus in soil, and changes in solar radiation, temperature, rainfall, and moisture conditions may lead to material difference between different slope aspects[14]. Therefore, the distribution of phosphorus in alpine grassland ecosystems may also be influenced by these environmental factors[15]. Research also indicates that slope aspect affects the distribution of soil organic carbon (SOC), and valleys are usually reservoirs of soil SOC[16].

The evaluation methods for soil fertility quality have been developed very maturely. Soil fertility index is a common and simple method for quantifying soil fertility quality, which can improve understanding of soil ecosystems and provide effective scientific management. However, few studies have utilized canonical correspondence analysis to understand the relationship between the distribution of soil fertility indicators and environmental indicators. Therefore, the soil fertility of artificial forests in Guangxi was taken as the research object in this paper, to explore the distribution of soil fertility indicators and fertility indices of different soil types of artificial forests, and reveal the environmental driving factors of soil fertility indicators of main soil types, thereby providing theoretical basis for the soil ecological stability of artificial forests in Guangxi and the formulation of scientific forest management measures.

1 Materials and methods

1.1 Soil sample collection and preparation Adopting a grid based point layout method, 928 soil sampling points were set up in artificial forests of Guangxi from 2020 to 2021. 0 – 20 cm of soil was collected by using the S-shaped sampling method, and invasive substances were removed during collection. After the soil sample was mixed, 1 kg of soil was collected using the quartering method, and the sample was naturally air dried. After labeling, it was placed in a self sealing bag. After laboratory grinding and sieving, soil pH, organic matter (OM), alkaline hydrolyzed nitrogen (AN), available potassium (AK), and available phosphorus (AP) content were determined. Soil pH value was determined by potentiometric method; organic matter was determined by potassium dichromate external heating method; alkaline hydrolyzed nitrogen was determined by semi micro Kjeldahl nitrogen determination method; available phosphorus content was determined by fully automatic intermittent chemical analyzer after M3 solution extraction, and available potassium was determined by ammonium acetate extraction – flame photometer method[17].

1.2 Data acquisition The Guangxi meteorological background data was downloaded from the Resource Science and Data Center of the Chinese Academy of Sciences. This data set was based on the historical observation data of meteorological observation stations, and the spatial distribution data set of climate indicators with a spatial resolution of 500 m × 500 m was obtained by using the inverse distance weighted average method of interpolation. In this paper, the spatial distribution data of annual average temperature (AAT), annual average precipitation (Rainfall), and ≥10 ℃ accumulated temperature (MAT) were used as environmental indicators. DEM data came from ASTER GDEM series data products (30 m of resolution) of the Scientific Data Center of the Computer Network Information Center of the Chinese Academy of Sciences. The vertical accuracy of ASTER GDEM was up to 20 m, and the horizontal accuracy was up to 30 m. Using Arcgis10.2, three terrain factors: slope, slope aspect, and altitude in the study area were extracted.

1.3 Method for evaluating soil fertility quality Evaluation indicators for soil fertility level were selected based on the actual situation of the research area. The weights of the evaluation indicators were calculated using principal component analysis, and the membership degree of the indicators was determined using fuzzy mathematics, and the soil fertility index was calculated.

(1) Determination of evaluation indicators and weights. The weight represents the magnitude of the impact of each evaluation indicator on the evaluation object. The calculation methods for weights include Delphi method, analytic hierarchy process, principal component analysis, correlation coefficient method, *etc*. In this paper, principal component analysis was used to determine the weight values of indicators, which can avoid subjective interference and objectively evaluate the assigned indicators. Principal component analysis was performed on all evaluation indicators, and the ratio of the common factor variance of each indicator to the sum of the common factor variances of all indicators was the weight value of that indicator. The weights of evaluation indicators, including pH, organic matter, alkaline nitrogen, available phosphorus, and available potassium, were 0.24, 0.20, 0.18, 0.17, and 0.18.

(2) Determination of membership degree. The membership degree of soil organic matter, available phosphorus, available potassium, and alkaline nitrogen content was calculated using an S-shaped function:

$$f(x)=\begin{cases}1.0 & x\geqslant x_2\\ \dfrac{0.9(x-x_1)}{x_2-x_1}+0.1 & x_1<x<x_2\\ 0.1 & x\leqslant x_1\end{cases}$$

pH selected parabolic membership function:

$$f(x)=\begin{cases}0.1 & x<x_1,\ x>x_4\\ \dfrac{0.9(x-x_1)}{x_2-x1} & x_1<x<x_2\\ 1.0 & x_2\leqslant x<x_3\\ 0.1+\dfrac{0.9(x-x_3)}{x_4-x_3} & x_3\leqslant x<x_4\end{cases}$$

where x_1, x_2, x_3, and x_4 were the inflection point value of the membership function, referring to nutrient classification standards for the second national soil census.

culation formula for the integrated fertility index (*IFI*) was as follows: $IFI = \sum f_i \times \alpha_i$. *IFI* is the integrated fertility index; f_i is the membership degree of the i^{th} soil fertility evaluation index; a_i is the weight value of the i^{th} soil fertility evaluation index. *IFI* ranged from 0 to 1, with higher values indicating higher soil fertility quality.

1.4 Data processing Soil data was preprocessed and statistically analyzed using Excel, and descriptive statistics and principal component analysis were performed using SPSS, and geostatistical and spatial data analysis were performed using ArcGIS10.2.

2 Results and analysis

2.1 Descriptive statistical analysis of soil fertility indicators in artificial forests of Guangxi Based on the soil status data of artificial forest land in Guangxi during 2019 – 2023, the soil nutrient situation of artificial forest land in Guangxi was analyzed (Table 1). Evaluation indicators referred to the nutrient classification standards of the second national soil census[19]. The average pH value of artificial forest soil in Guangxi was 4.45, belonging to strongly acidic soil, with a minimum value of 3.98 and a maximum value of 6.28, a coefficient of variation of 5.36%, and little variability. The average value of soil organic matter content was 33.08 g/kg, which belonged to the moderate level. The minimum value was 11.47 g/kg, and the maximum value was 75.25 g/kg, with a coefficient of variation of 27.65%, indicating significant variability. The average alkaline nitrogen content in soil was 136.64 mg/kg, which belonged to a relatively high level. The minimum value was 48.14 mg/kg, and the maximum value was 297.54 mg/kg, with a coefficient of variation of 25.42%. The variability was significant, and the distribution was uneven. The average available phosphorus content in soil was 3.23 mg/kg, with a minimum value of 0.02 mg/kg and a maximum value of 14.22 mg/kg. The coefficient of variation was 28.18%, indicating significant variability. The average content of available potassium in soil was 60.51 mg/kg, with a minimum value of 8.25 mg/kg and a maximum value of 288.44 mg/kg. The coefficient of variation was 10.26%, and the variability was not significant.

Table 1 Overview of soil nutrients of plantation in Guangxi

Nutrient indicators	Mean	Min	Max	SD	CV//%	Evaluation
pH	4.45	3.98	6.28	0.24	5.36	Strong acidity
Organic matter//g/kg	33.08	11.47	75.25	9.15	27.65	Moderate
Alkaline hydrolysis N//mg/kg	136.64	48.14	297.54	34.73	25.42	High
Effective P//mg/kg	3.23	0.02	14.22	0.91	28.18	Low
Available K//mg/kg	60.51	8.25	288.44	6.21	10.26	Low

2.2 Comprehensive evaluation of soil fertility in artificial forests

2.2.1 Spatial distribution characteristics of soil fertility in artificial forests. Using geostatistical analysis method, interpolation analysis was conducted on soil pH, organic matter, available phosphorus, available potassium, alkaline nitrogen content, and comprehensive fertility index to obtain spatial distribution maps of each indicator (Fig. 1).

The spatial distribution characteristics of soil organic matter, alkaline nitrogen, and soil fertility index were similar, showing a latitudinal distribution pattern. As latitude increased, it gradually increased, and the spatial heterogeneity of soil pH was not significant. The soil organic matter content ranged from 11.47 to 75.25 g/kg, and forests with soil organic matter content above 40 g/kg were mainly distributed in high-altitude mountainous areas of northern Guangxi, such as Guilin, Hezhou, Liuzhou, and Hechi. The soil organic matter content in most areas of western and southern Guangxi was relatively low. The soil pH range was between 3.98 and 6.27. Forests with pH values above 5.5 were mainly distributed in a small part of the northern regions of Liuzhou, Hechi, and Baise. Forests with pH values below 4.5 accounted for more than 70% of the entire area. The range of soil alkaline nitrogen content was between 48.14 and 297.53 mg/kg. Forests with soil alkaline nitrogen content above 150 mg/kg were mainly distributed in high-altitude mountainous areas such as Hechi, Liuzhou, Guilin, Hezhou, and Laibin. Forests with alkaline nitrogen content below 90 mg/kg were mainly distributed in small and medium-sized areas of middle Guangxi and most areas of southern Guangxi. The range of soil available phosphorus content was between 0.02 and 14.22 mg/kg, but the majority of forest soil available phosphorus content was below 3.8 mg/kg. The soil available potassium content ranged from 8.25 to 288.44 mg/kg, with most forest soils having available potassium content below 68 mg/kg. According to the evaluation method of comprehensive soil fertility index, the forest land in the entire region was divided into 6 fertility levels. The first level had the highest fertility, with a fertility index range of 0.60 – 0.64, accounting for 0.01% of the area. The second level had a fertility index range of 0.50 – 0.60, accounting for 0.33% of the area. The third level had a fertility index range of 0.40 – 0.50, accounting for 26.75% of the area. The fourth level had a fertility index range of 0.30 – 0.40, accounting for 54.51% of the area. The fifth level had a fertility index range of 0.20 – 0.30, accounting for 17.95% of the area. The sixth level had a fertility index range of 0.14 – 0.20, accounting for 0.45% of the area. The proportion of forest areas with fertility index below 0.50 in grades III to VI was 99.66%.

2.2.2 Soil fertility index of main soil types of artificial forests. Statistical analysis was conducted on the soil fertility index of the main soil types in artificial forests. The results showed that the average soil fertility index of laterite was 0.30, which was the lowest, while the average fertility index of yellow brown soil was 0.45, which was the highest. The order of soil fertility index from high to low was yellow brown soil > yellow red soil > yellow soil > red soil > limestone soil > latosolic red soil > laterite. The maxihigh to low was yellow brown soil > yellow red soil > yellow soil > red soil > limestone soil > latosolic red soil > laterite. The maximum and minimum values both occurred in latosolic red soil and red soil. The range of variation in latosolic red soil and red soil was relatively large, indicating that the spatial autocorrelation range of soil fertility in the two soil types was relatively large. The range of variation in laterite soil and yellow brown soil was relatively small, indicating that the spatial autocorrelation range of soil fertility in the two soil types was relatively small.

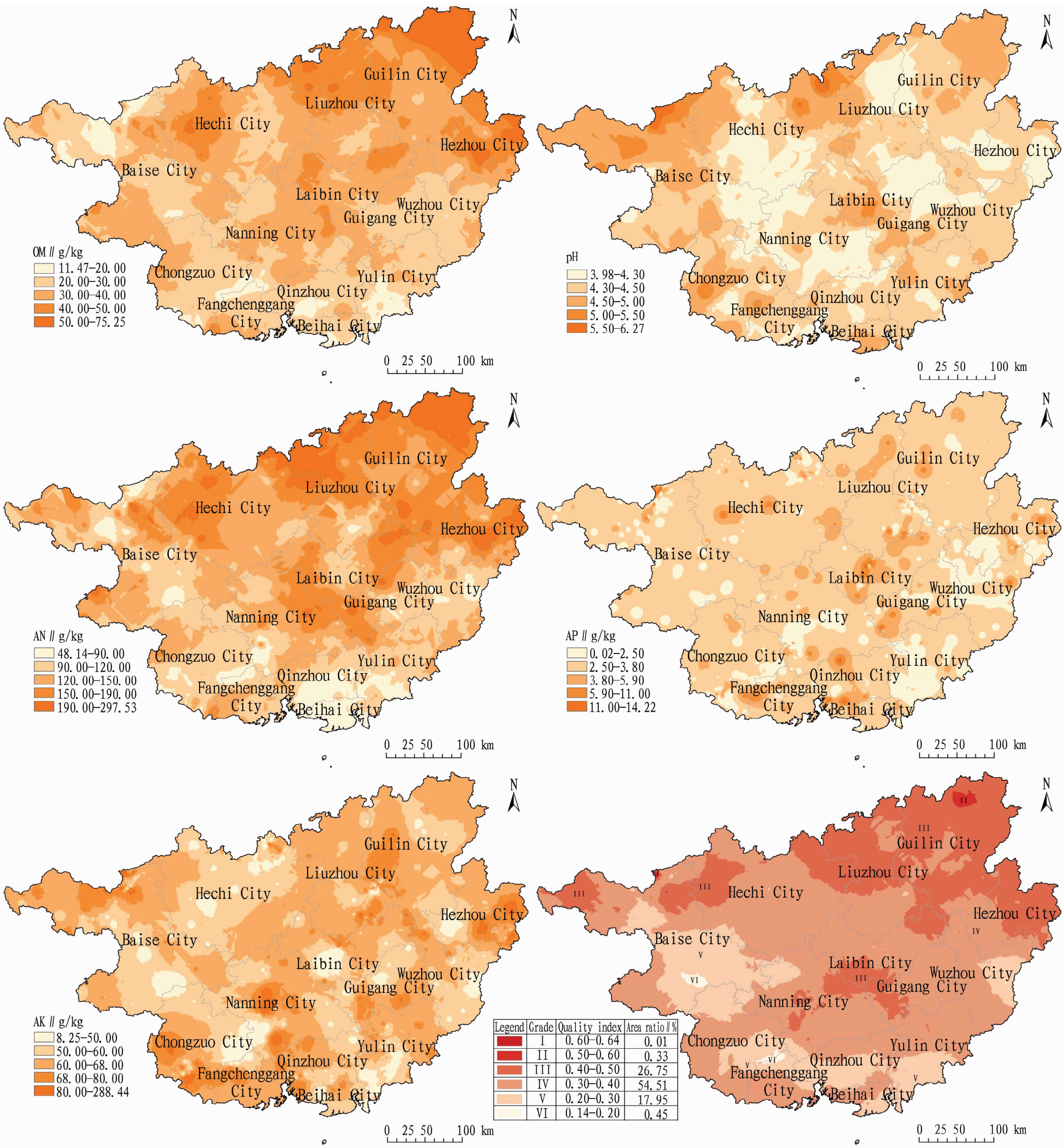


Fig. 1 Distribution of soil fertility indexes of plantation in Guangxi

2.3 Relationship between soil fertility indicators and environmental factors in artificial forests Canonical correspondence analysis (CCA) was conducted on soil fertility indicators and environmental factors in three soil types of main artificial forests in Guangxi, namely red soil, latosolic red soil, and limestone soil. In the sorting chart composed of the first and second sorting axis, and the quadrant where the arrow was located represented the positive or negative correlation between the environmental factors and the sorting axis. The length of the arrow line represented the influence degree of the environmental factor on soil fertility indicators, and the longer the line, the greater the impact. The angle between the arrow line and the sorting axis represented the correlation between the environmental factor and the sorting axis. The smaller the angle, the higher the correlation. Eight environmental factors, including altitude, slope, slope aspect, average annual rainfall, annual average temperature, ≥ 10 ℃ accumulated temperature, soil pH, and organic matter, were selected for canonical correspondence analysis with soil fertility indicators such as alkaline nitrogen, available phosphorus, and available potassium. Since soil organic matter and pH greatly affected the distribution of soil nitrogen, phosphorus, and potassium, they were used as environmental factors for analysis). The cumulative proportions of variance between the main soil fertility indicators and environmental factors in artificial forests of katosolic red soil, red soil, and limestone soil reached 80.16%, 83.88%, and 78.84%, respectively, indicating that the first two axes of CCA ranking can better reflect the relationship between fertility indicators and environmental factors, and the ranking results were highly credible.

Table 2 Overview of soil fertility index of different soil types of plantation

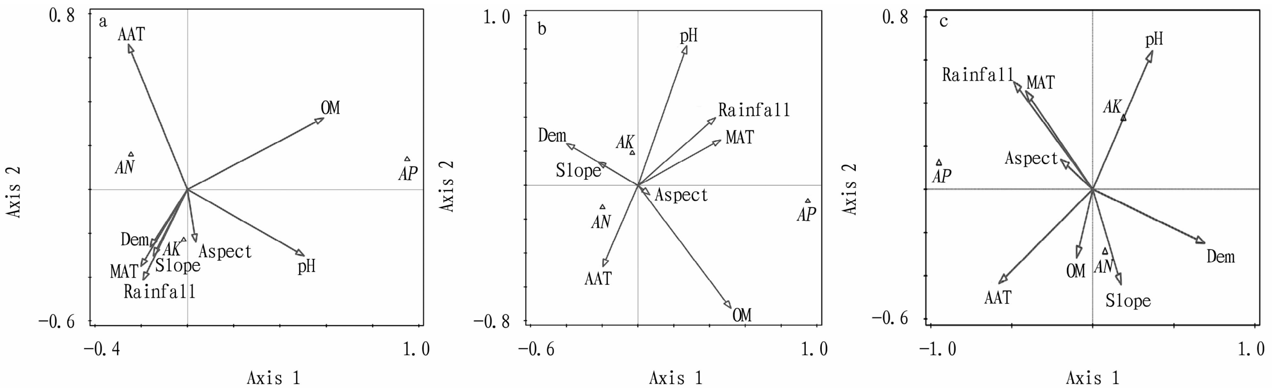
Soil types	Min	Max	Mean	STD
Laterite	0.22	0.37	0.30	0.02
Latosolic red	0.15	0.64	0.33	0.05
Limestone soil	0.18	0.51	0.36	0.06
Red soil	0.15	0.63	0.38	0.05
Yellow soil	0.17	0.53	0.41	0.05
Yellow red soil	0.25	0.60	0.42	0.05
Yellow brown soil	0.39	0.51	0.45	0.03

In the canonical correspondence results between soil fertility indicators and environmental factors in latosolic red soil of artificial forests (Fig. 2a), the first sorting axis had a significantly positive correlation with soil organic matter and pH, indicating a gradual increase in organic matter and pH from left to right. The second sorting axis had a significant correlation with average temperature, slope, slope aspect, altitude, and annual rainfall. Except for a positive correlation between annual average temperature and the second sorting axis, other environmental factors were negatively correlated with the second sorting axis, gradually decreasing from bottom to top. Soil alkaline nitrogen and available phosphorus were greatly influenced by the first sorting axis, while available phosphorus was mainly influenced by soil organic matter and pH, and available potassium was influenced by the second sorting axis, mainly influenced by terrain factors such as slope, slope aspect, and altitude.

In the canonical correspondence results between soil fertility indicators and environmental factors in red soil of artificial forests (Fig. 2b), the first sorting axis had a significant correlation with slope, slope aspect, altitude, and accumulated temperature. Slope aspect and accumulated temperature were positively correlated with the first sorting axis, while slope and altitude were negatively correlated with the first sorting axis. The second sorting axis had a significant correlation with pH, annual average temperature, and organic matter. pH was positively correlated with the second sorting axis, gradually increasing from bottom to top. The average annual temperature and organic matter were negatively correlated with the second sorting axis, gradually decreasing from bottom to top. The soil fertility indicators of alkaline nitrogen and available phosphorus were influenced by the first sorting axis. Alkaline nitrogen was greatly influenced by accumulated temperature, slope, and altitude, while available potassium was greatly influenced by the second sorting axis, mainly affected by factors such as pH, AAT, and organic matter. Soil available phosphorus was greatly influenced by the comprehensive effect of the first sorting axis.

In the canonical correspondence results between soil fertility indicators and environmental factors in limestone soil of artificial forests (Fig. 2c), the first sorting axis had a high correlation with slope aspect and altitude. Among them, altitude showed a positive correlation with the first sorting axis, that is, the altitude gradually increased from left to right, and slope aspect showed a negative correlation with the first sorting axis. The second sorting axis had a high correlation with pH, slope, and organic matter. pH was positively correlated with the second sorting axis and gradually increased from bottom to top. Organic matter and slope were negatively correlated with the second sorting axis and gradually decreased from bottom to top. The available phosphorus in soil fertility indexes was greatly affected by the first sorting axis; alkali hydrolyzed nitrogen and available potassium were greatly affected by the second sorting axis; alkali hydrolyzed nitrogen was mainly affected by factors such as slope and organic matter, and available potassium was greatly affected by pH, organic matter, and slope.

As a result, the higher the annual average temperature and organic matter content in the latosolic red soil of artificial forest, the higher the soil alkaline nitrogen content. The higher the soil organic matter and pH, the higher the available phosphorus content in the soil. The high value of soil available potassium was mainly distributed on semi shaded slopes with small slope, low altitude, high rainfall, and high accumulated temperature. In red soil of artificial forests with high slope and elevation, the soil alkaline nitrogen content was high. In artificial forests with high accumulated temperature and rainfall, the soil available phosphorus content was high, and the soil available potassium content was relatively high in areas with high soil pH. In limestone soil of artificial forests, mountainous areas with steep slope and high soil organic matter content had high alkaline nitrogen content, and mountainous areas with high accumulated temperature and rainfall had high available phosphorus content, and mountainous areas with high pH had relatively high available potassium content.



Note: a. Latosolic red soil; b. Red soil; c. Limestone soil. AAT: annual average temperature; MAT: ≥10 ℃ accumulated temperature; OM: organic matter; Dem: altitude; AN: alkali hydrolyzed nitrogen; AP: available phosphorus; AK: available potassium.

Fig. 2 CCA sequencing of soil fertility indexes and environmental factors in plantation

3 Conclusions and discussion

The spatial distribution characteristics of soil organic matter, alkaline nitrogen, and soil fertility index in the results of this study were similar. In forest soil, nitrogen content mainly depends on the repayment of understory vegetation and litter, as well as microbial nitrogen fixation. Organic matter mainly comes from the accumulation and decomposition of animal and plant humus. Therefore, from the source, soil organic matter and nitrogen are homologous, which may also be the reason for the similar distribution patterns of forest soil organic matter and alkaline nitrogen. The similar spatial distribution pattern of soil organic matter and soil nitrogen content has been verified in the research of many scholars[20-21]. The results of this study showed that the pH and available phosphorus content of artificial forest soil in Guangxi were both low. In soil with low pH, phosphate reacts with calcium carbonate in the soil to form carbonate hydroxyapatite precipitation, which reduces the concentration of available phosphorus in the soil. The study also indicated that there was a dynamic linkage between soil pH and the distribution of soil available phosphorus content. Therefore, increasing the pH of forest soil can enhance phosphatase activity and help improve the available phosphorus content in the soil.

The research results on the soil fertility index of artificial forests in the entire region showed that more than 90% of artificial forests had a soil fertility index between 0.20 and 0.50, indicating that the vast majority of artificial forests in Guangxi had poor soil fertility levels. The order of soil fertility index from large to small was yellow brown soil > yellow red soil > yellow soil > red soil > limestone soil > latosolic red soil > laterite soil, which was similar to the relevant research results in Jiangxi[22]. Yellow brown soil, yellow red soil, and yellow soil were all mountain soil types above an altitude of 700 m, while red soil, latosolic red soil, and laterite soil showed a latitudinal zonal distribution from north to south. Therefore, the distribution of forest soil fertility index in Guangxi showed a vertical zonal variation that gradually decreased from high-altitude mountainous areas to low-altitude mountainous areas, and a latitude zonal variation that gradually decreased from high latitude to low latitude. From the spatial distribution of soil fertility index and the sorting of soil fertility indexes for different soil types, it can be seen that the soil fertility index of artificial forests in Guangxi showed a trend of gradually increasing from low latitude to high latitude, and gradually increasing from low-altitude mountainous areas to high-altitude mountainous areas. This may be due to the fact that artificial forests are mainly distributed in middle and low altitude mountainous areas, while natural forests are more common in high-altitude mountainous areas.

The analysis of soil nutrients and environmental factors in artificial forests showed that the influence degree of environmental factors on available nutrients varied in different types of soil. The available phosphorus content in soil was mainly influenced by organic matter in latosolic red soil. If the soil organic matter content was high, the available phosphorus content in soil was higher. However, in red soil and limestone soil areas, it was mainly influenced by terrain factors such as altitude and slope aspect. Studies have shown that the phosphorus content in mountainous soil decreased with increasing altitude[23-25]. The variation of soil phosphorus with altitude was mainly due to differences in rainfall, temperature, and vegetation, which led to differences in soil matrix weathering rate and organic phosphorus storage[25]. The available potassium in soil was mainly influenced by terrain factors such as slope, slope aspect, and altitude in the latosolic red soil area. The available potassium in soil in the red soil area was mainly influenced by pH, organic matter, and annual average temperature. The available potassium in limestone soil area was mainly influenced by pH, organic matter, and slope. Alkaline nitrogen in soil was greatly affected by annual average temperature in latosolic red soil areas. Alkali hydrolyzed nitrogen in red soil was mainly affected by accumulated temperature, slope, and altitude. Alkali hydrolyzed nitrogen in limestone soil was mainly affected by factors such as slope and organic matter.

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meteorological departments at all levels should pay attention to the release of warning information of sudden disastrous weather of government departments, relevant units and key regions, make full use of telephone, mobile phone short messages, wechat, Douyin and other channels to call relevant responsible persons, release the forecast and warning information to farmers and herdsmen, agricultural production bases, *etc.*, and ensure that those responsible for disaster prevention and mitigation receive early warning information in a timely manner. While making preparations for hail suppression in advance, they should work with departments of agriculture, emergency management, transportation and natural resources to study agricultural defense and response measures, and actively cooperate with weather modification and hail suppression.

3.3 Implementing weather modification responsibilities In the implementation of artificial hail suppression operations, it is necessary to make post responsibilities clear, and strengthen the duty system and sense of responsibilities. The main responsible comrades adhere to the front line of disaster prevention and mitigation work, ensure the safety and reliability of operation points and operating equipment according to crop seedlings and other agricultural production conditions, conduct real-time command based on weather changes, and seize the favorable opportunity to carry out hail suppression operations in a timely manner. Besides, it is needed to strengthen the collection and report of severe convection weather, timely report major disasters, and make a summary of artificial hail suppression operations.

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