EFFECTS OF PEANUT PLANTING PATTERNS ON DESERTIFICATION IN THE AGRO-PASTORAL INTERLACED ZONE IN NORTHERN CHINA

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Abstract. As one of the important factors affecting land desertification, human activities have garnered increasing attention from scholars. Finding suitable land use patterns is of great significance to suppress land desertification. Therefore, this study takes the northern part of Zhangwu County, Liaoning Province, China as the research area to carry out correlation analysis of phenological characteristics and crop spectral characteristics of multi-temporal remote sensing images under different planting modes in 2020. On this basis, soil samples were collected on site. Chemical experimental methods combined with SPSS and other software were applied to build a desertification degree evaluation index system. The land desertification degree was divided into four levels: potential desertification, mild desertification, moderate desertification, and severe desertification by using the cumulative curve classification method. Analysis results were compared with the desertification database of the research group in the region in 2015 to test the degree of desertification. The results showed that the desertification reduction ability of the agroforestry complex model, the sand flat land shelterbelt-peanut model, the sandy hill shelter forest-peanut model, the sand flat land-peanut model, and the sandy hills-peanut model declined successively. The agroforestry model, the sand flat land shelterbelt-peanut model, and the sandy hill shelterbelt-peanut model all have the effect of reverse succession of desertification, but the degree of succession gradually decreases. Among them, the sandy hill shelter forest-peanut model has certain limitations. The sand flat land-peanut model and the sandy hills-peanut model all have the effect of positive succession of desertification, and the degree of succession gradually intensifies.
Keywords: *sandy desertification, GIS, evaluation system, ecology*

Introduction

Desertification refers to land degradation caused by various factors such as human activities and climate variability. It occurs widely all over the world and is one of the most serious socio-economic and environmental problems (Liao et al., 2020). Land desertification will affect crop yield and land sustainability, and even lead to the deterioration of human living environment (Jia et al., 2014). In the geographical environment of China is the last barrier to prevent desertification and desertification from moving eastward and southward. In particular, the northern agro-pastoral interlaced zone located to the north of the Great Wall and the eastern and southern sides of the grassland is an important ecological management area in China and an important ecological defense line in the northern region (Song et al., 2020; Wang, 2020). However, with the continuous increase of human intervention, unreasonable

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reclamation and grazing not only failed to make the ecologic barrier function of the ecologic zone, but also made it become an ecologically fragile zone (Ma and Yang, 2018). Based on the current situation, the problem of desertification in the agro-pastoral zone has already caused certain obstacles to China's social and economic development. At the same time, this issue has also aroused the general concern of the government and the scientific community.

The agro-pastoral zone in northern China lies at the intersection of semi-arid and arid climates. As an important water conservation belt in the Beijing-Tianjin-Hebei region and an important ecological security barrier in the central and eastern regions, this region is of great significance to maintaining the country's ecological security (Li et al., 2018). As an important part of the northern agro-pastoral staggered belt in Liaoning Province, it is located in the subsidence area of the Northeast Plain of China. It is the most important ecological barrier to prevent the Horqin Sandy Land from invading the North China Plain from the south and the Northeast Plain from the southeast (Jia et al., 2014). Due to the influence of low precipitation, high evaporation, arid climate and human disturbance, a series of changes have taken place in environmental factors such as vegetation, landforms and hydrological conditions in the region. The ensuing land desertification is also increasingly serious, and presents a trend of invasion to the south and southeast. Studies have shown that high vegetation coverage can effectively inhibit land desertification (Guo et al., 2020; Cui et al., 2020). The study area has a long history of peanut planting. Although high economic benefits have been obtained over the years, the old planting pattern has resulted in soil loss, coarsening of the soil surface and a sharp decline in soil fertility. Therefore, it is necessary to explore a suitable peanut planting model for the study area, which is of great significance for the sustainable use of land, preventing land desertification and protecting regional ecology. In this study, Zhangwu County, a typical area of the agro-pastoral interlaced belt in northern Liaoning Province of China, was selected as the research area. Based on the theories of multi-temporal remote sensing crop identification and land desertification evaluation, RS and GIS software are applied to achieve professional analysis. The land use vegetation coverage and soil quality were selected as evaluation indicators, and desertification evaluation was carried out on the land under different planting patterns. To explore the influence and direction of different planting patterns on desertification succession. At the same time, the advantages and disadvantages of different planting patterns were analyzed. The purpose is to provide reference for standardizing and improving unreasonable planting patterns.

Materials and methods

Research area overview

Zhangwu County is affiliated to Fuxin City, Liaoning Province, China, and is located in the northwest of Liaoning Province, Southern Horqin Sandy Land (*Fig. 1*). The research area involved in this study is the townships in the northern part of Zhangwu County, namely Zhanggutai Town, Daleng Township, Sihe Urban Township, and Aer Township, with a total cultivated area of 30,037.93 hm^2, of which the peanut planting area is 13,835.95 hm^2. The study area is located between 42°07'-42°51' north latitude and 121°53'-122°58' east longitude. The terrain is high in the north and low in the south, hills in the east and west, desert in the north, and plains in the middle and south. Zhangwu County is a temperate monsoon continental climate, which combines

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temperate monsoon climate and temperate continental climate. It is characterized by obvious four seasons change throughout the year, rain and heat in the same season, and sufficient sunlight. Zhangwu County has a land area of 362,300 hm^2, with a per capita land area of 0.91 hm^2. In this study, soil samples were sampled by layers with soil drill. The surface layer was divided into 2 layers (0 ~ 10 cm) and (10 ~ 20 cm), and the subsurface layer (20 ~ 40 cm).

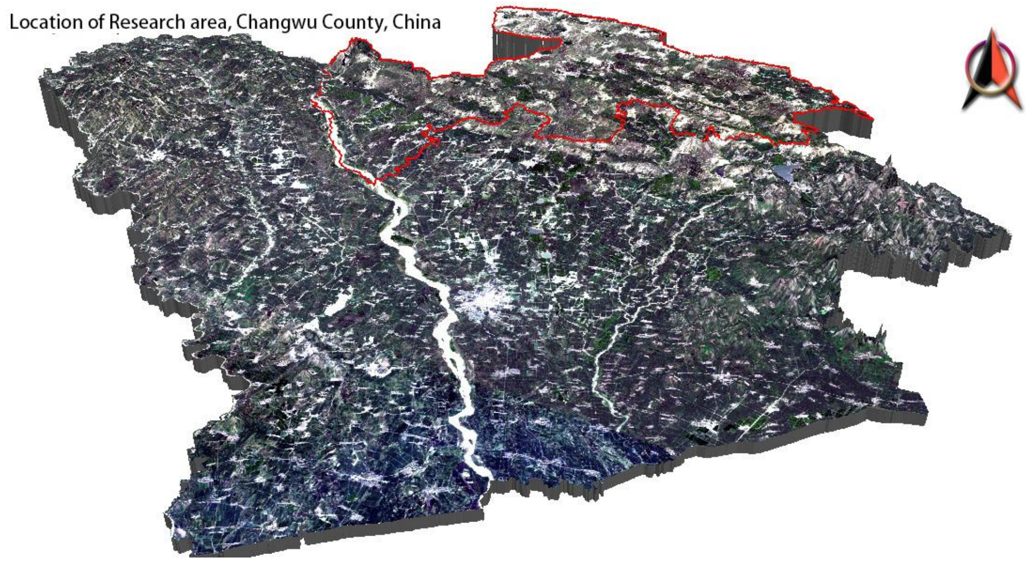

Figure 1. *Northern ZhangWu geographic locations in the study area*

Data sources

The applied data is the Landsat8 OLI data of Zhangwu County in 2015 and 2020. Zhangwu County statistical year data, Zhangwu County 1:10,000 land use status map and 1:10,000 topographic map, etc. Among them, the remote sensing data mainly use 4 and 5 band data. The data mainly come from Zhangwu County Natural Resources Bureau and Statistics Bureau.

Tailoring of the study area

First, import the 4 and 5 band image maps into ENVI4.5. Next, select the Vectors option in the Overlay menu to overlay the boundaries of the study area on the image. Then, in the File menu of the Vector Parameters dialog, open the Export Active Layer to ROIs option and select Convert all vectors to one ROI. Then, in the Tools menu, select the ROI Tool in the Region of Interest. In its dialog box, select the Subset Data via ROIs option in File, set the Background Value to 0, and save it in a new folder. The other data were processed in the same way.

Extraction and processing of remote sensing data of peanut planting area

Landsat 8OLI remote sensing images in 2015 and 2020 were used as basic data sources. The data basically have no cloud coverage, have been corrected by radiation and geometric correction, and the data quality is good. The administrative zoning map of the study area, 1:50 000 digital elevation model, 1:10 000 land use status map, field

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survey data, natural, social, economic and other written data are used as supplementary data. With the support of Arcgis 9.3, ENVI 4.7 and other remote sensing image processing software, multi-band image fusion is carried out.

Based on the extraction of remote sensing data and research needs, the preliminary interpretation of planting patterns based on remote sensing images was revised. According to the land use and cover status and terrain characteristics around the peanut growing area, five peanut planting patterns were selected. They are the Sand plant-peanut planting mode represented by Er Township, the sandy hill-peanut planting mode is represented by Daliang Township and Aer Township, the sand plant-peanut planting mode is represented by Zhanggutai Township, Sihe Township and Daliang Township, the sandy hilly shelter-peanut planting mode is represented by Daliang Township and Aer Township, and the agroforestry planting mode is represented by Zhanggutai Township and Daliang Township.

Determination of soil physical and chemical properties

The soil mechanical composition, organic matter, total nitrogen, and HA/FA (ratio of humic acid to fulvic acid) were measured by specific gravity method, potassium dichromate volumetric method, and Kjeldahl method (Huang, 2000).

Establishment of desertification evaluation index system

Using the expert scoring method (He et al., 2002) and combining with the actual situation of the study area, four major indicators including remote sensing, site conditions, physical and chemical properties and land use index were preliminarily selected (*Table 1*).

Table 1. *Northern ZhangWu desertification evaluation index system*

Target layer (G)	Criterion layer (B)	Index layer (C)	Data sources
Evaluation Index System of Desertification in the North of Zhangwu County	Remote sensing (B1)	Surface albedo (%) (C1)	Remote sensing survey, model calculation
		Normalized Difference Vegetation Index (%) (C2)	Remote sensing survey, model calculation
	Site conditions (B2)	Soil sand viscosity ratio (%) (C3)	Soil sampling test
		Slope (°) (C4)	DEM database
	Physical and chemical properties (B3)	Total nitrogen (g/kg) (C5)	Soil sampling test
		Humic acid/Fulvic acid (%) (C6)	Soil sampling test
		Soil organic matter (g/kg) (C7)	Soil sampling test
	Land use index (B4)	Average radius of forest (m)(C8)	Field investigation
		Completeness of farmland shelterbelts (%) (C9)	Field investigation

Indicator calculation formula:

$$NDVI = (B1 - B2)/(B1 + B2) \tag{Eq.1}$$

In *Equation 1*, B1 and B2 represent the near red and red bands, respectively.

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Using the Landsat-TM data inversion model (2) established by Liang (Huang et al., 2006) to estimate the surface albedo in the study area:

$$Albedo = 0.356 \times R_{blue} + 0.130 \times R_{red} + 0.373 \times R_{nir} + 0.085 \times R_{swir1} + 0.072 \times R_{swur2} - 0.0018 \quad \text{(Eq.2)}$$

R_{blue}, R_{red}, R_{nir}, R_{swir1}, R_{swur2} are the spectral reflectance of blue, red, near infrared, short wave infrared 1 and short wave infrared 2 bands corresponding to the sensor, respectively, and Albedo is the surface albedo.

In this study, the analytic hierarchy process was used to determine the weights of evaluation factors, and the weights were determined by establishing a hierarchical structure and constructing a judgment matrix, as shown in *Table 2*.

Table 2. *Desertification evaluation factor combination weight*

Level G	**Remote sensing B1**	**Physical and chemical properties B2**	**Site conditions B3**	**Land use index B3**	**Combination weight**
Surface albedo C1	0.0604	0.1623	0.2879	04894	∑CiAi
	0.2500				0.0151
NDVI C2	0.7500				0.0453
Total nitrogen C5		0.0669			0.0109
HF/FA C6		0.2200			0.0357
Soil organic matter C7		0.7132			0.1157
Soil sand viscosity ratio C3			0.1667		0.0480
Gradient C4			0.8333		0.2399
Average forest radius C8				0.2500	0.1224
Protection forest completeness C9				0.7500	0.3671

For the determination of the membership function of each evaluation factor, two types of functions are used in this study, namely, upper-type function and conceptual-type function.

Upper-type function model:

$$y_i = \begin{cases} 0 & u_i \le u_t \\ 1/\left(1+a_i\left(u_i-c_i\right)^2\right), & u_i < c_i \quad (i=1,\ 2,\ \ldots,\ m) \\ 1 & u_i \ge c_i \end{cases} \quad \text{(Eq.3)}$$

In the formula, y_i is the comment of the *i*-th factor, u_i is the sample observation value; c_i is the standard index value; ai is the coefficient; u_t is the lower limit value of the index.

The membership degree of the conceptual evaluation factor is obtained by the expert scoring method (He et al., 2006). Assign values directly according to the characteristics of the impact degree of the indicators on desertification (*Table 3*).

On this basis, carry out the calculation of comprehensive evaluation. However, among the evaluation factors, some evaluation factors have obvious restrictions on the degree of desertification, that is to say, some evaluation factors have limit values. When the value of these factors exceeds the limit value, the degree of desertification will be aggravated. This study draws on the existing relevant research data, adopts the Delphi

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method (Li, 2017), and finally determines the desertification degree limit factor and its limit value in the study area, that is, the slope is greater than or equal to 25° or less than 2°. The modified weighted index sum method is used to calculate the comprehensive index of each evaluation unit to determine the land suitability grade. Calculated as follows:

$$S_j = \begin{cases} \sum_{i=1}^{n} W_i \bullet P_{ij} \text{（The evaluation factor value does not exceed the limit value）} \\ 0\text{（Arbitrary evaluation factor value exceeds its limit value）} \end{cases} \quad \text{(Eq.4)}$$

In the formula, S_j represents the comprehensive index, W_i represents the weight of the evaluation factor, and P_{ij} represents the membership degree of the evaluation factor.

Table 3. *The membership degree of generalizing evaluation factors*

Evaluation factor	Grading	Membership
Average radius of forest	0	0.1
	≤50	0.4
	50-100	0.7
	≥100	0.9
Slope	≤2°	0.9
	2°-6°	0.5
	>6°	0.1
Completeness of Farmland Shelterbelt	no	0.1
	Medium	0.4
	Good	0.7
	Excellent	0.9

Determination of desertification level

In this study, the degree of desertification in the study area was divided by the cumulative curve classification method (Yin and Li, 2017). The degree of desertification in the study area is divided into 4 levels. They are no desertification (comprehensive score > 0.79), mild desertification (0.63-0.79), moderate desertification (0.40-0.63), and severe desertification (comprehensive score < 0.4).

Results and analysis

Soil texture under different planting modes

For the convenience of expression, we denote the five models of agroforestry, sand-flat shelterbelt-peanut, sandy hill shelterbelt-peanut, sandy-flat-peanut, and sandy hill-peanut as I, II, III, IV and V, respectively. It can be seen from the texture changes of the profiles of different planting patterns (*Fig. 2*) that the contents of sand, clay and silt in each depth layer of the five planting patterns decrease in turn. And the sand content is much larger than that of other grades. This shows that these five planting patterns have different degrees of desertification. The sand grains of the two planting modes of the agroforestry complex model, the sand flat land shelterbelt-peanut model increased with

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the increase of depth. That is, the sand content of 20-40 cm is the largest in all planting modes. The sandy hill shelter forest-peanut model does not change significantly with the increase of depth. In the sand flat land-peanut model, the sand content first increases and then decreases with the increase of depth. In the sandy hills-peanut model, the sand content gradually decreased with the increase of depth. Both silt and clay tended to decrease. Among them, the change of clay with the increase of depth was not obvious in the agroforestry complex model, followed by the cultivated land with shelterbelt. Without shelterbelt, silt and clay tended to increase with depth. This shows that the agroforestry complex model and the sand flat land shelterbelt-peanut model have different degrees of ability to prevent grain coarsening.

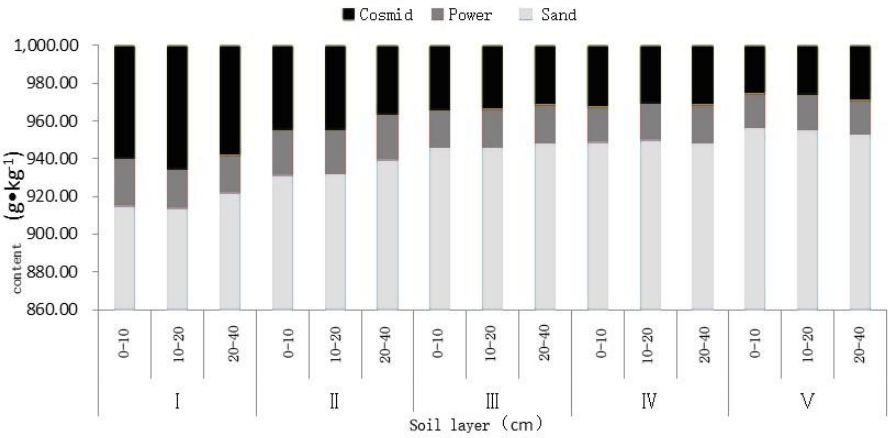

Figure 2. *Soil texture under different planting modes*

The soil sand-to-viscosity ratio (*Fig. 3*) increases sequentially at 0-10 cm and 10-20 cm in five modes: the agroforestry complex model, the sand flat land shelterbelt-peanut model, the sandy hill shelter forest-peanut model, the sand flat land-peanut model, the sandy hills-peanut model. And the soil sand-to-viscosity ratio in the sand flats showed a trend of first increase and then decrease. It may be due to the fact that after the peanuts were harvested, the exposed surface was protected to a certain extent, which means that there was a desertification attack at a certain time in the past, and now it has recovered. The three planting modes of the agroforestry complex model, the sand flat land shelterbelt-peanut model, the sandy hill shelter forest-peanut model, the sand-to-stick ratio increased with the depth of the plough layer. This shows that the degree of desertification now has been reduced compared with a certain period in the past. In the sandy hills-peanut model, the sand-to-viscosity ratio decreases with the increase of the depth of the plough layer, indicating that the degree of desertification now has increased compared with a certain period in the past.

Organic matter in different planting modes

The organic matter content of the surface aeolian sand at the sampling points of the five different utilization models varied from 1.76 to 21.34 $g \cdot kg^{-1}$, with an average of 6.58 $g \cdot kg^{-1}$. Soils with organic matter content below 6.58 $g \cdot kg^{-1}$ accounted for about 59% of the total samples. The variance analysis of the average organic matter content of the surface soil (0-20 cm) with different planting methods is shown in *Table 4*. It

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can be seen from the table that there are significant differences in soil organic matter content under the five different models. It shows that desertification has different effects on soil organic matter under different planting patterns. The average organic matter content of cultivated land is lower than that of forest land. This shows that after the fixed aeolian sandy forest land is opened up as farmland, its soil organic matter is more and more affected by human activities. Because agricultural production harvests the biomass on the ground, only the root system in the ground is the main source of organic matter. This reduces the input of organic matter. At the same time, as a cultivated soil, continuous farming activities accelerate the mineralization of the original organic matter. In this way, the organic matter content will continue to decrease. However, local measures such as high stubble, application of organic fertilizer and planting shelterbelts have played a certain role in the accumulation of organic matter in cultivated land. The overall change trend of soil surface organic matter content was that agroforestry model, sandy flat shelterforest-peanut model, sandy hilly shelterforest-peanut model, sandy flat plant-peanut model and sandy hilly and peanut model decreased successively.

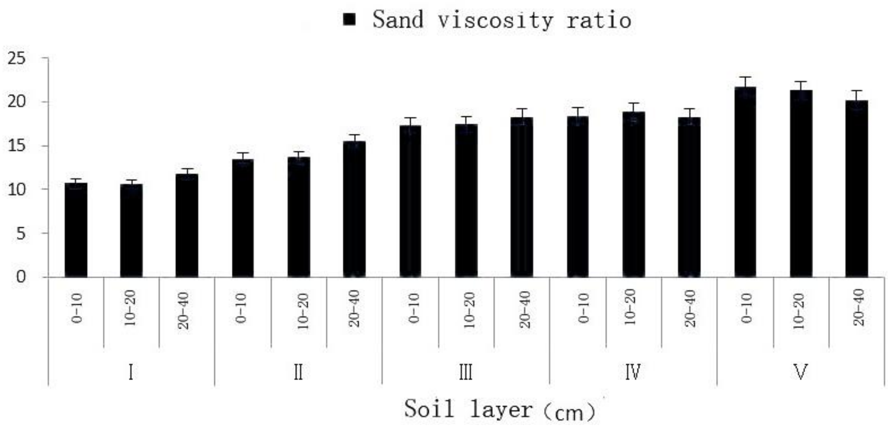

Figure 3. *Soil profile sand viscosity ratio under different planting modes*

Table 4. *The study area soil (0 ~ 10 cm) using mode analysis of variance results (HSD)*

Utilization pattern	Average content of organic matter ($g \cdot kg^{-1}$)	Significant difference	
		α = 0.05	α = 0.01
Agroforestry	8.49	a	A
Peanut in Shapingdi Shelterbelt	7.34	a	AB
Peanut in Sandy Hilly Shelterbelt	5.10	b	BC
Shaping ground peanuts	3.36	b	BC
Sandy Hilly Peanuts	2.56	b	C

The content of soil organic matter in each utilization model was affected by different degrees of desertification, and the content was generally low. Most of these soils are located in the wind-blown sand area and affected by wind erosion, the fine particles on the surface are eroded by wind, and the organic matter is lost by wind, which reduces the content of organic matter. At the same time, the surface soil is always in a good state of ventilation, and the aerobic decomposition property is strong, which is not conducive to the accumulation of organic matter. In terms of

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organic matter accumulation capacity, the agroforestry model is the strongest, and the sandy hill-peanut model is the worst. From the perspective of profiles, the distribution of organic matter in profiles under different utilization modes is shown in *Figure 4*. Among the 5 utilization modes, the organic matter content of agroforestry, sandy flat shelterforest-peanut and sandy hilly shelterforest-peanut models all showed a decreasing trend with the increase of depth in their respective profiles. The content of organic matter in the surface soil (0-10 cm) of the three utilization modes was the highest, and the content of organic matter in the surface soil was in the order of agroforestry model > sandy flat shelterforest-peanut model > sandy hill shelterforest-peanut model. The organic matter content of the sand-plane-peanut model and the sand-hill-peanut model basically increased with the increase of depth in their respective profiles, and the organic matter content of the sand-plane-peanut model increased first and then decreased, which may be due to the thicker dead leaf layer of the shelterbelt and the accumulation of organic matter. At the same time, the forest land also plays a certain role in wind prevention and sand consolidation.

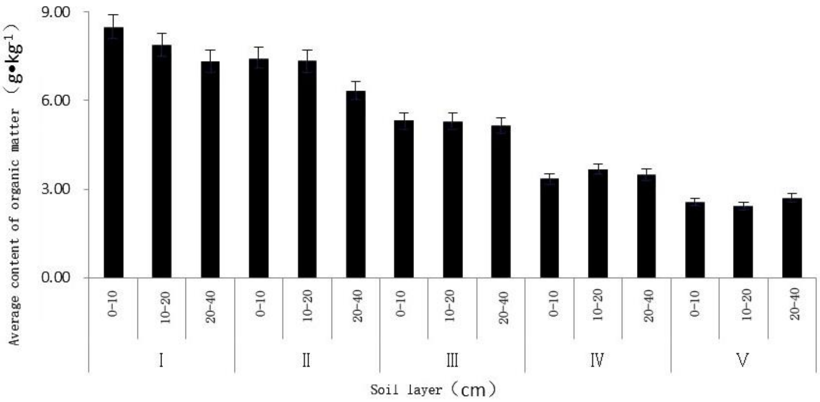

Figure 4. *Changes of profile organic matter under different utilization modes*

Total nitrogen in different planting modes

The total nitrogen content of the topsoil in the study area varies from 0.62 g•kg^{-1} to 1.59 g•kg^{-1}, with an average value of 0.94 g•kg^{-1}. According to the analysis results, it can be seen that soil nitrogen and organic matter have similar distributions. The total nitrogen content in the surface layer of aeolian sandy soil in the peanut model of sandy hills the sandy hills-peanut model is the lowest among the five models, with an average value of 0.69 g·kg^{-1}. The results of variance analysis of the average content of total nitrogen under different utilization modes are shown in *Table 5*. From *Table 5*, it can be seen that the average total nitrogen content of aeolian sandy soil decreases in the order of the agroforestry complex model, the sand flat land shelterbelt-peanut model, the sandy hill shelter forest-peanut model, the sand flat land-peanut model and the sandy hills-peanut model.

The soil total nitrogen content in the profiles of different planting patterns has a trend of decreasing with the increase of depth, but it is significantly larger than other layers at 0-10 cm. The main reason is that with the increase of soil vertical depth, biomass accumulation and decomposition intensity of organic matter are the main factors determining soil nitrogen content. Among them, the agroforestry complex model and

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the sand flat land shelterbelt-peanut model changed significantly with depth, while the other three changed more gently. This is because cultivated land is affected by human factors. The change of total nitrogen is relatively stable, and it also has a decreasing trend with the increase of depth. There is little difference between the three planting modes (*Fig. 5*).

Table 5. *Soil (0 ~ 10 cm) in the study area using the variance analysis results under the mode of total nitrogen content (HSD)*

Utilization mode	Average total nitrogen content (g•kg^{-1})	Significant difference	
		α = 0.05	α = 0.01
Agroforestry	1.02	a	A
Peanut in Shapingdi Shelterbelt	0.98	ab	A
Peanut in Sandy Hilly Shelterbelt	0.88	abc	AB
Shaping ground peanuts	0.74	bc	AB
Sandy Hilly Peanuts	0.69	d	B

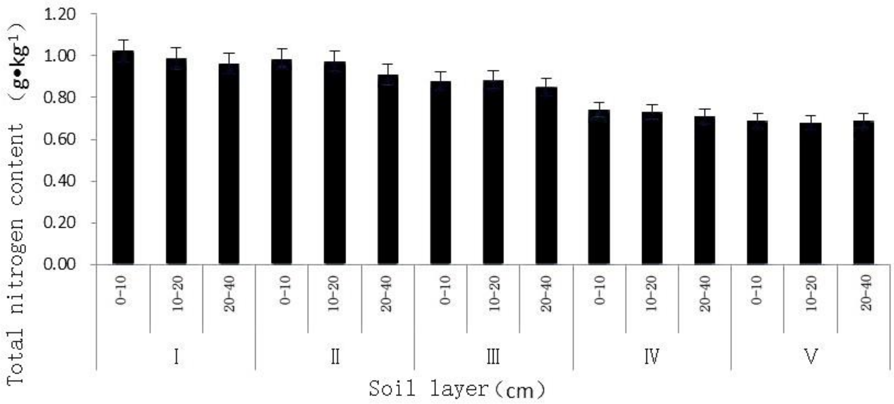

Figure 5. *Total nitrogen content of soil profile in different utilization modes*

HA/FA under different planting modes

The ratio of humic acid to fulvic acid is used to measure the quality of humus. The higher the proportion of humic acid, the stronger the activity of humus and the better the quality. The variation range of HA/FA of topsoil in the study area was 0.26-0.90. According to the degree of difference between the average value of various utilization patterns and the total average value, it can be seen that soil HA/FA and organic matter have similar distributions. The HA/FA of the sandy hills-peanut model aeolian sandy soil surface is the lowest among the five models, with an average value of 0.33. The surface HA/FA of the agroforestry complex model, the sand flat land shelterbelt-peanut model, the sandy hill shelter forest-peanut model, and the sand flat land-peanut model were 0.59, 0.54, 0.46, and 0.39, respectively. The results of variance analysis of HA/FA under different utilization modes are shown in *Table 6*. From *Table 6,* it can be seen that the average HA/FA of aeolian sandy soil decreases in the order of the agroforestry complex model, the sand flat land shelterbelt-peanut model, the sandy hill shelter forest-peanut model, the sand flat land-peanut model, and the sandy hills-peanut model. Therefore, the degree of decay also decreased in turn, and the difference between agroforestry and sandy hills was extremely significant.

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Table 6. *The study area soil (0 ~ 10 cm) using different mode of HA/FA variance analysis results (HSD)*

Utilization mode	HA/FA	Significant difference	
		α = 0.05	α = 0.01
Agroforestry	0.59	a	A
Peanut in Shapingdi Shelterbelt	0.54	ab	A
Peanut in Sandy Hilly Shelterbelt	0.46	abc	AB
Shaping ground peanuts	0.39	bc	AB
Sandy Hilly Peanuts	0.33	c	B

Soil humus has a complex composite structure, which affects the physical, chemical and biological properties of the soil. The formation of soil humus is an accumulation process, which can greatly affect the fertility of the soil and is the guarantee of crop quality and yield. The ratios of HF/FA in different planting modes in the study area have different laws, as shown in *Figure 6*. The variation of HA/FA in the surface layer 0-10 cm is in the agroforestry complex model > the sand flat land shelterbelt-peanut model > the sandy hill shelter forest-peanut model. However, the HA/FA of the sand flat land-peanut model and the sandy hills-peanut model in their respective profiles generally tended to increase with depth.

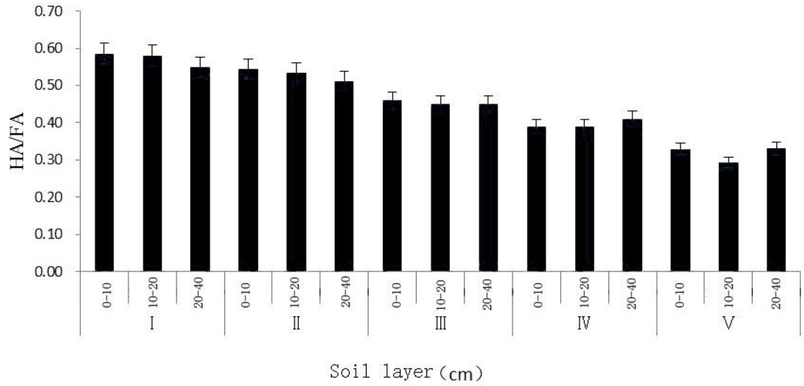

Figure 6. *HA/FA content in soil profiles of different utilization modes*

Analysis of desertification degree under different planting patterns

In 2020, under the agroforestry model, the number of samples without desertification was 7, the number of mild desertification was 3, the number of moderate desertification was 2, and the number of severe desertification was 0. However, according to the information extraction of desertification information at the same point in the agroforestry model in 2015, the number of non-desertification samples was 4, the number of mild desertification samples was 2, and the number of moderate desertification samples was 4. There are 2 cases of severe desertification, and it can be seen that both moderate and severe desertification have decreased, while both non-desertification and mild desertification have increased, and non-desertification has increased the most, indicating that a large degree of reverse succession has occurred in the desertified land in the past 5 years, and the soil physical and chemical conditions have been significantly improved.

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In 2020, under the sand flat shelterforest-peanut model, the number of undesertification sites was 2, mild desertification was 12, moderate desertification was 8, and severe desertification was 0. In the same point desertification information extraction of shelterforest-peanut model in 2015, there were 3 samples without desertification, 2 samples with mild desertification, 10 samples with moderate desertification, and 7 samples with severe desertification. Compared with 2020, it can be seen that severe desertification has decreased the most, and moderate desertification has also undergone reverse succession to mild desertification, while the non-desertification reduction may be due to incomplete shelterbelts or the reclamation of forest land into cultivated land at wind ports, which has caused some land degradation. In general, the desertification of shelterforest-peanut model is reverse succession, but the degree is lower than that of agroforestry model.

In 2020, under the sandy hilly shelterforest-peanut model, the number of undesertification sites was 0, mild desertification was 2, moderate desertification was 9, and severe desertification was 0. In the same point desertification information extraction of sandy hilly shelter-peanut model in 2015, the number of samples without desertification was 2, the number of samples with mild desertification was 0, the number of samples with moderate desertification was 5, and the number of samples with severe desertification was 4. Compared with 2020, it can be seen that severe desertification has decreased the most, and reverse succession occurs in desertification, while no desertification reduction indicates that sandy hills can aggravate the forward succession of desertification to a certain extent. In general, the sandy hilly shelterforest-peanut model can inhibit the positive succession of desertification on the severely or moderately desertified land, and the positive succession of desertification occurs on the non-desertified land and the mildly desertified land, which also indicates that the sandy hilly will accelerate the positive succession of desertification to a certain extent. Therefore, although the shelterforest-peanut model of sandy hills can play the role of wind prevention and sand fixation to reverse desertification succession, it has certain limitations.

In 2020, under the sand-groundnut model, the number of non-desertification sites was 0, the number of mild desertification sites was 0, the number of moderate desertification sites was 8, and the number of severe desertification sites was 4. In 2015 peanut model of the same point desertification information extraction, the number of non-desertification samples was 0, mild desertification samples were 2, moderate desertification samples were 6, and severe desertification samples were 4. Compared with 2020, it can be seen that mild desertification develops to moderate desertification, and severe desertification remains unchanged, which indicates that there is a certain degree of land degradation in the sand-groundnut model and a positive succession of desertification occurs.

In 2020, under the sandy hill-peanut model, the number of undesertification sites was 0, the number of mild desertification sites was 0, the number of moderate desertification sites was 0 and the number of severe desertification sites was 9. In the same point desertification information extraction of sandy hill-peanut model in 2015, the number of samples without desertification was 0, the number of mild desertification was 3, the number of moderate desertification was 4, and the number of severe desertification was 2. Compared with the year 2020, it can be seen that both mild and moderate desertification are succeeding in the direction of severe desertification, and the number of severe desertification is increasing significantly, which indicates that there is a large

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land degradation problem in the sandy hill-peanut model, and a positive succession of desertification occurs. Compared with the other 4 models, the positive desertification succession of sandy hilly peanut model is more intense, and the degree is large and the speed is fast, resulting in the deterioration of soil conditions in local areas. Therefore, the sandy hill-peanut model is the least reasonable model among the 5 models, and the relevant departments need to strengthen management efforts.

Discussion

Combating desertification is a common challenge faced by human beings, which requires the international community to jointly respond (Xinhua News Agency, 2017). Many scholars have studied desertification in northern China, but few have studied the effect of planting patterns on desertification. In this study, RS and GIS technology were used to analyze the changing trends of soil mechanical composition, soil organic matter content, soil HA/FA and soil total nitrogen content under different planting modes on the basis of processing remote sensing images. By constructing a land desertification evaluation index system, the influence of different planting patterns and the direction of desertification succession was explored. Analyze the pros and cons of different planting patterns, in order to standardize and improve unreasonable planting patterns. In this study, the difference analysis showed that the soil organic matter content of the five different models was significantly different. After the sandy forest land was opened up as farmland, the soil organic matter was more and more affected by human activities. Because agricultural production harvests the biomass above the ground, only the roots below the ground are the main source of organic matter, reducing the input of organic matter. Similarly, the difference analysis of soil nitrogen and HA/FA shows that it has a similar distribution to soil organic matter. At the same time, the results showed that the five modes: the agroforestry complex model, the sand flat land shelterbelt-peanut model, the sandy hill shelter forest-peanut model, the sand flat land-peanut model and the sandy hills-peanut model ability to reduce desertification decreased in turn. The agroforestry complex model, the sand flat land shelterbelt-peanut model, and the sandy hill shelter forest-peanut model all have the effect of reverse succession of desertification, but the degree of succession gradually decreases. Among them, the sandy hill shelter forest-peanut model has certain limitations. The sand flat land-peanut model and the sandy hills-peanut model have positive succession effect of desertification, and the succession degree is gradually intensified. At present, there are few reports on the research in this direction in the academic circle, but many scholars have carried out research on land desertification and its driving factors. Zhang et al. (2020) pointed out that human activities are an important factor affecting soil desertification, and different human activities have different effects on soil desertification. Ma et al. (2007) analyzed the collected data for 50 years and concluded that human activities play a major role in land desertification affecting Minqin County. Zhang (2010) took the Gonghe Basin as the study area, and concluded that human activities are the main factor affecting land desertification through the analysis of data in the past 50 years. Zhang et al. (2003) analyzed the factors of land desertification using the grey relational method. The conclusion is that the biggest factor affecting land desertification in Anxi County is overgrazing, followed by changes in population and land reclamation. caused by agricultural activities. Similarly, Talip and Kasimu (2017) analyzed the factors of land desertification in southern China, and pointed out that the

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factors causing land desertification are divided into natural factors and human factors. He et al. (2016) analyzed the influencing factors of land desertification in Hexi area. The results point out that human activities are an important influencing factor of desertification, among which human activities include land reclamation, grazing and other activities. It also pointed out that adjusting the industrial development model and making the industrial structure rational and advanced is an effective way to solve desertification. This is consistent with the research in this paper. That is to say, different planting patterns have different impacts on soil desertification, which may have both positive and negative impacts. The difference is that most of the current scholars' analysis of the driving factors is based on the analysis of the correlation between the driving factors and land desertification. However, it is rarely analyzed how various factors affect land desertification. In other words, it is difficult to determine which model has better suppression and improvement effects on land desertification. Therefore, it is of great significance to determine the specific impact relationship to establish a scientific and reasonable planting model, which is of great significance for the control of land desertification.

Author contributions. Conceptualization: LQ and LYN, Data curation: LQ and X X, Formal analysis: LYN, Funding acquisition: LQ and LYN, Investigation: LYN and X X, Methodology: LQ and X X, Project administration: LQ and YL, Resources: LQ and YL, Supervision: LQ, Writing-original draft: LQ, Writing-review and editing: LQ and LYN.

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Conflict of interest. Li Qi, Li Yanan Xie Xiao were employed by the company Shaanxi Provincial Land Engineering Construction Group Co., Ltd.

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