THE EFFECT OF STUMPING ON VEGETATION CHARACTERISTICS AND SOIL PHYSICAL AND CHEMICAL PROPERTIES OF *SALIX PSAMMOPHILA* ARTIFICIAL FOREST IN IN ORDOS CITY, CHINA

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Abstract. This study explores the impact of stumping intervals on the stability of artificial *Salix psammophila* forests in Hangjin Banner, Ordos City, China. We compared *S. psammophila (Salix psammophila)* forests with stumping intervals of 1, 2, and 3 years to those with non-stumping intervals of 5 + years. Stumping positively affects *S. psammophila* regeneration, with growth indicators improving with longer intervals. Herbaceous diversity and biomass increase post-stumping, peaking at 3-year intervals. Soil erosion occurs immediately after stumping, but the soil gradually stabilizes. Stumping also affects soil water storage, with moisture content increasing as the *S. psammophila* grows. Soil nutrient accumulation is impacted, with available phosphorus, organic matter, total carbon, and alkaline nitrogen peaking at 3-year stumping intervals.
Keywords: *artificial forests, nurturing and regeneration, diversity of herbaceous plants; soil factors*

Introduction

Inner Mongolia Autonomous Region has a rich variety of plant species and a complex geographical environment, it is one of the provinces with the most serious desertification in China (Wang, 2016). Research on vegetation restoration can not only improve the functions of fragile ecosystems, but also be particularly important for maintaining the ecological barrier in northern China (Han et al., 2009). Research has shown that the most effective measure for desertification prevention and control is the restoration and reconstruction of vegetation communities. The main vegetation type in arid and semi-arid areas is sandy shrubs, among which *Salix psammophila* is often used as a pioneer tree species for wind and sand fixation, soil and water conservation, and vegetation restoration due to its drought resistance and strong sprouting characteristics (Fan et al., 2018). *S. psammophila*, also known as *Salix mongolica* belongs to the family Salicaceae. It is a deciduous upright shrub or small tree with a height of generally 3-4 m and can reach up to 8 m. It is an important tree species for improving ecological environment, windbreak and sand fixation, and industrial raw material forests in desertification areas (De et al., 2021). However, as the growth years increase, the growth of *S. psammophila* will gradually decrease, mainly manifested as slow or stagnant tree growth, dead branches, and low seed setting rate. The quality of the forest stand will seriously decline, and the ability to prevent wind and sand will weaken, leading to the growth of understory vegetation will be affected. Therefore, nurturing and managing the artificial *S. psammophila* forests in the Hangjin Banner of Ordos to achieve sustainable development of windbreak and sand fixation forests is an urgent issue that needs to be addressed.

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Stumping is a nurturing measure that involves cutting the aboveground part of a plant to a certain height to stimulate the growth of sprouting branches. It can better promote the growth and development of the plant itself (Tai et al., 2021; Maschinski et al., 1989). At the same time, due to the destruction of aboveground tissues, the proportion of root and crown in sprouting plants is imbalanced, leading to compensatory growth of the plants at this time (Mardem et al., 2018). Due to the strong compensatory growth characteristics of desert plants, the aboveground biomass of the local area can quickly recover after being damaged by stumping (Zhang, 2023). So stumping is one of the most commonly used methods for regeneration and rejuvenation of sandy shrubs. stumping can not only solve the problem of vegetation decline, but also have a significant impact on the structural characteristics of plant communities and soil physicochemical properties (Cai et al., 2022). At the same time, the branches cut from stumping can be processed into high-quality feed, which can alleviate the problem of insufficient feed in animal husbandry in winter (Wang et al., 2021). Stumping relieves the apical advantage of plants and has a certain impact on their branching ability (Liu et al., 2019; Hobbs et al., 1985). Stumping is beneficial for stimulating the development of the spatial pattern of shrubs, complicating the configuration of shrub branches, changing the habitat within the forest, increasing vegetation diversity, and improving soil moisture and quality to a certain extent (Jia et al., 2020). However, current research mainly focuses on the aspects of stumping equipment, stumping methods, and stumping time, and there is no systematic study on the impact of different stumping intervals on the habitat of *S. psammophila* plantations in Inner Mongolia Autonomous Region (Zhou et al., 2017).

Therefore, by observing and calculating the vegetation growth characteristics and soil physicochemical properties related indicators of *S. psammophila* plantations, the actual level of ecological environment and wind and sand fixation function in the region can be obtained. This can provide important theoretical support and technical guidance for ecological restoration construction in Inner Mongolia and subsequent artificial forest nurturing in other arid areas.

Materials and methods

General situation of the research area

The experimental area is located in the southeast of Xini Town, Hangjin Banner, Ordos City, Inner Mongolia Autonomous Region, China, 40 km away from the town. The town is located at 108° 44’ E and 39° 49’ N, in the handshake zone between the Kubuqi Desert and the Mu Us Desert. It belongs to a typical continental climate of the semi-arid plateau in the temperate zone. The terrain is high in the south and low in the north, with a predominantly undulating plateau and an average elevation of 1389 m. There is less snow in winter and less rain in summer, with a dry climate and a large temperature difference between day and night. The vegetation is mainly composed of drought and mid drought plants (see *Table 1* and *Fig. 1* for details).

Sample site setting

The *S. psammophila* forest in the experimental area is an artificial forest created by the Grain for Green Project in the 1960s and 1970s. The forest is approximately 70 years old and is continuously nurtured and updated in the later stage, distributed in a strip shape. In April 2023, four *S. psammophila* artificial forests with basically the same altitude, slope,

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aspect, and position were selected in the vicinity of Amenqirige Village, Xini Town, Hangjin Banner, Ordos. The four artificial forests were stumped in October 2022, October 2021, October 2020, and October 2018 (marked as P1, P2, P3, and CK for the interval between leveling until 2023), with a height of 0 cm. The sample plot is set to a square size of 50 m × 50 m, with an average spacing of 9 m between *S. psammophila* belts and an average spacing of 2 m between plants (refer to *Fig. 2* for details).

Table 1. *Basic overview of the study area*

Sample site location	108° 44’ E, 39° 49’ N
Altitude	1389 m
Slope	South high and north low
Sample plot size	50 m × 50 m

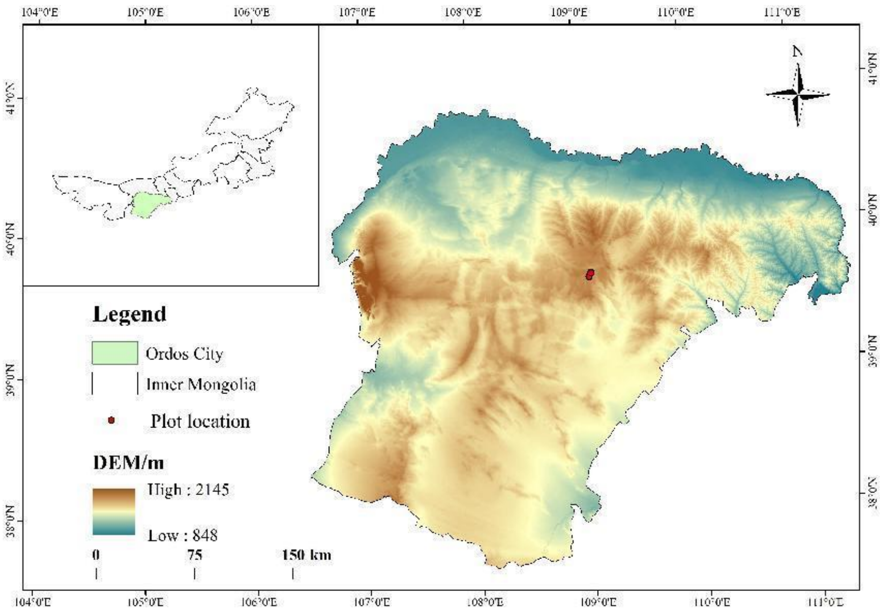

Figure 1. *The study area and the sampling sites*

Figure 2. *Map of habitat conditions in the sample plot*

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Measurement items and methods

Vegetation characteristics

In September 2023, five 1 × 1 m herbaceous plots were evenly distributed in each plot, and the plant categories, number of plants of the same species, coverage, and aboveground biomass of plants in the plots were investigated. The Margale index, Shannon Wiener index, Simpson index, and Pielou index were calculated (Wang, 2014).

In October 2023, a survey was conducted on the growth of *S. psammophila* in the *S. psammophila* sample plot, including plant height, basal diameter, crown width, branch moisture content, and biomass. The height, basal diameter, and crown width of *S. psammophila* were measured directly, while the moisture content of the branches was measured by drying method. The biomass was measured using the standard branch method.

Soil factors

From April to October 2023, the “S” five point sampling method will be adopted, that is, five locations will be selected at the four vertices of the sample plot and the center of the sample plot in different stubble intervals, and the soil will be taken by digging a pit with a shovel. The depth of the pit is 1 m, and the soil samples of 0~20 cm, 20~40 cm, 40~60 cm, 60~80 cm, and 80~100 cm deep soil layers will be collected respectively, three times for each layer. Uniformly mix the soil from 5 sampling points at the same soil depth into a sealed bag and number it. After removing animal and plant residues in the laboratory, soil mechanical composition, soil nutrient content, and soil moisture content were measured.

The organic matter content in soil nutrients was determined using the potassium dichromate volumetric method-external heating method, the total phosphorus content in soil was determined using a flow analyzer (Li et al., 2020), the total nitrogen content in soil was determined using the Kjeldahl nitrogen determination method, the Alkaline hydrolysis of nitrogen was determined using the alkaline diffusion method, and the soil pH was determined using the pH meter potential method. According to the Chinese soil particle size classification standard, the soil mechanical composition is divided into coarse sand (>0.5 mm) 35 mesh, medium sand (0.25-0.5 mm) 65 mesh, fine sand (0.05-0.5 mm) 300 mesh, and Silty sand (<0.05 mm). The soil particle size is determined using the sieving method. Select soil samples with a depth of 0-100 cm, layer by layer every 20 cm, take 3 replicates, and use traditional drying method to determine the fresh soil moisture content and air dried soil moisture content of each soil layer.

Data analysis

On the basis of completing relevant data collection, this article uses SPSS20.0 software to process and calculate vegetation and soil data of *S. psammophila* plantations with different stumping intervals, including basic statistical analysis, analysis of variance, and correlation analysis. The data in the chart are all mean ± standard deviation.

Results and analysis

Growth characteristics of S. psammophila at different intervals of stumping

From *Figure 3*, it can be seen that the rejuvenation and renewal effect of S. psammophila after stumping treatment is significant. The height, crown width and basal

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diameter of S. psammophila after stumping increased with the increase of the interval between stumping, but there was no significant difference in branch water content among the treatments. The plant height of CK is 1.36, 1.27, and 1.01 times that of P1, P2, and P3, and the crown width is 2.04, 1.98, and 1.30 times that of P1, P2, and P3. The basal diameter of CK is 1.74, 1.26, and 1.07 times that of P1, P2, and P3. The difference in biomass between P1 and P3 is significantly higher than that between CK and P3, and there is no significant difference in biomass difference between P3 and CK, indicating that the first two years after stumping are the rapid growth period of S. psammophila, and the growth rate decreases compared to the previous two years after 3 years. Therefore, it can be considered to carry out flat cropping treatment for 3 years, which can yield good results.

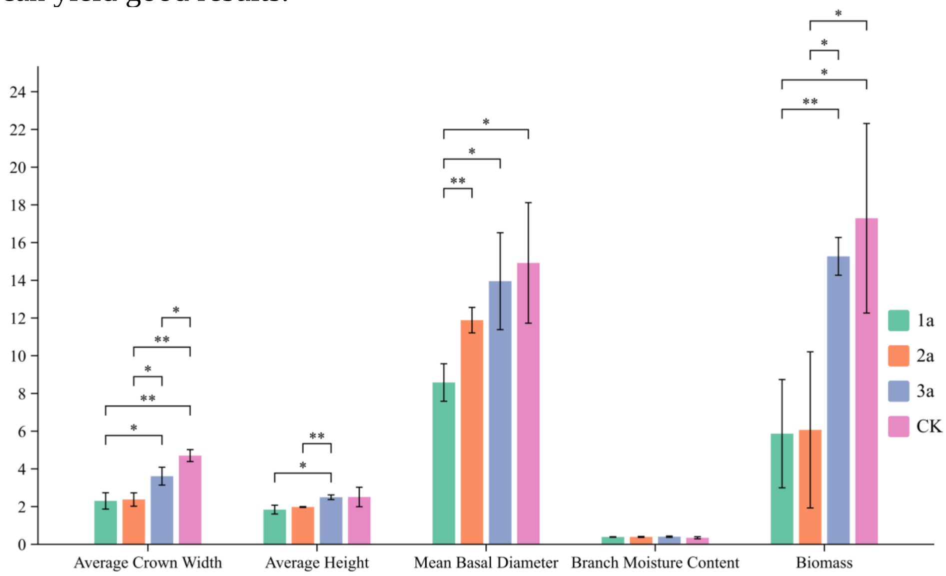

Figure 3. *Differences in growth characteristics of S. psammophila during different intervals of stumping*

Characteristics of understory plant composition in S. psammophila forests at different intervals of stumping

The composition of plant life forms under the *S. psammophila* forest at different intervals of stumping is shown in *Table 2*. There are a total of 13 plant species present in the sample plot, belonging to 5 families and 12 genera. The proportion of perennial herbaceous species reached the highest at 53.8%, followed by annual herbaceous plants at 30.8%, and finally semi shrubs at 15.4%. The number of P1 and CK species is higher than P3 and much higher than P2. The proportion of annual herbaceous plants in the flat crop P3 plot is higher than that in CK, and then higher than that in 1 year. The number of species shows an increasing trend within 1-3 years after stumping. After 3 years, there will be a slight decline.

Characteristics of understory plant community

The characteristics of the forest plant community are shown in *Table 3*. The coverage of P3 plot is the highest, reaching 76.33%, followed by CK, P2, and P1. The biomass is also the highest in the P3 plot, reaching 212.85 g/m^2. There is not much difference in P1, P2, P3 and CK. In the short term, as the interval between stumping increases, the

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coverage of understory herbaceous plants and aboveground biomass gradually increase. stumping increases the biomass of understory herbaceous plants, which is beneficial for their growth. The vegetation density P1 is the highest, possibly because the relatively exposed surface and the increase in relative nutrient content are more suitable for the settlement and growth of 1-year-old herbaceous plants. The species richness index shows a trend of first decreasing and then continuously increasing, with significant differences between CK and P1, P2 ($p < 0.05$). The species diversity index shows a gradually increasing trend, but there is no significant difference among the treatments. The ecological dominance index showed an upward trend in the first three years after stumping, and the change was not significant after P3, indicating that it may have reached relative stability in P3. The species evenness index showed no significant change pattern, indicating that the impact of different intercropping intervals on it was relatively small.

Table 2. *Composition of interstand plant life forms in S. psammophila during different intervals of stumping*

Treatment	Total number of species	Semi-shrubs		Perennial plant		Annual plant	
		Number of species	Proportion of species	Number of species	Proportion of species	Number of species	Proportion of species
P1	9	2	22.2%	4	44.4%	3	33.3%
P2	4	2	50%	2	50%		
P3	8	2	25%	1	12.5%	5	62.5%
CK	9	2	22.2%	2	22.2%	5	55.6%

Table 3. *Characteristics of interforest plant communities in S. psammophila during different intervals of stumping*

Treatment	Vegetation coverage (%)	Plant density (plant·m^{-2})	Aboveground biomass of herbaceous plant (g·m^{-2})	Richness	Shannon–Wiener	Simpson	Pielou
P1	55.33±5.9a	126.67±30.36a	77.83±12.83a	0.85±0.13ab	0.85±0.21a	0.43±0.13a	0.54±0.14a
P2	57.67±7.62a	73.33±4.67a	99.31±14.82a	0.54±0.15b	0.89±0.33a	0.48±0.19a	0.7±0.18a
P3	77±4.93a	88±14.42a	214.85±97.62a	0.91±0.14ab	0.98±0.09a	0.69±0.13a	0.62±0.05a
CK	61.33±1.26a	82.33±20.17a	69.79±32.79a	1.23±0.04a	1.46±0.22a	0.68±0.09a	0.66±0.06a

The data in the table is the mean ± standard deviation; Different lowercase letters in the same column indicate significant differences ($p < 0.05$) in the interval between different flat crops. Same below

Physical and chemical properties of S. psammophila soil at different cropping intervals

Mechanical composition of S. psammophila soil at different intervals of stumping

According to *Table 4,* it can be seen that the soil in the 0-100 cm soil of *S. psammophila* forest at different interval periods is mainly composed of coarse sand and medium sand, accounting for 71.54% to 81.74% of the total. There is a significant difference in the content of medium sand between P1 and P2, while there is no significant difference in soil mechanical composition in the remaining stumping *S. psammophila* forests ($p > 0.05$). Among them, P2 has the highest proportion of coarse sand content (0.40%). The proportion of medium sand content is highest in P1 (0.54%), and there is a significant difference ($p < 0.05$) between P1 and P2. The highest

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proportion of fine sand is P3 (0.24%), and the highest proportion of fine sand is CK (0.51%), indicating that the planting of Salix has played a role in refining soil particles.

Table 4. *Soil mechanical composition of S. psammophila forest during different intervals of stumping*

Treatment	Mechanical composition／%			
	Coarse sand (>0.5 mm)	**Medium sand (0.25–0.5 mm)**	**Fine sand (0.05–0.25 mm)**	**Silty sand (<0.05 mm)**
P1	0.26 ± 0.03a	0.54 ± 0.02a	0.17 ± 0.03a	0.04 ± 0.01a
P2	0.40 ± 0.05a	0.42 ± 0.02b	0.14 ± 0.04a	0.05 ± 0.01a
P3	0.24 ± 0.06a	0.48 ± 0.05ab	0.24 ± 0.04a	0.04 ± 0.01a
CK	0.28 ± 0.07a	0.47 ± 0.04ab	0.2 ± 0.04a	0.05 ± 0.01a

Spatial heterogeneity of soil moisture

From *Figure 4*, it can be seen that from April to October 2023, except for July when the moisture content of P3 was higher than that of CK, the moisture content of all other CK was at a leading level. As the growth years of *S. psammophila* increase, its ability to retain surface soil moisture will improve. At the same time, it can reduce the consumption of water, providing more favorable conditions for the growth of understory vegetation. Except for October, the moisture content of P1, P2, P3, and CK show a trend of first decreasing and then increasing with each month, with a turning point of increase from June to July. This is likely due to the fact that 4-6 belongs to the rapid growth period of *S. psammophila*, which increases the consumption of water and exacerbates soil moisture consumption. After June, as the water consumption during *S. psammophila* growth decreases and precipitation replenishes, soil moisture begins to rise. Among them, the soil moisture content in P3 rebounds significantly, indicating that *S. psammophila* has a better ability to fix and absorb water than other periods during its 3-year growth. The dormant period of soil moisture content is higher than the end of the growing season. In April and October, there was a significant difference in soil moisture content between P1, P2, and P3 ($p < 0.05$), and a very significant difference with CK ($p < 0.01$). There was no significant difference between P3 and CK. In May, there was a significant difference in soil moisture content between P1, P2, and P3 ($p < 0.05$). In June, there was a significant difference in soil moisture content between P1 and P2, P2 and P3 ($p < 0.01$), and a significant difference between them and CK ($p < 0.05$). There was no significant difference between P3 and CK. In June, there were extremely significant differences ($p < 0.01$) between P1, P2, P3, and CK, while there was no significant difference between P3 and CK. There was no significant difference between the treatments of 7, 8, and 9 months. This reason is likely due to the fact that after July, the growth of *S. psammophila* and aboveground vegetation reached a stable period, and the difference in soil moisture consumption was not significant.

As shown in *Figure 5*, the soil moisture content of P1 and P2 increases with the depth of the soil layer, while P3 and CK show a trend of first increasing, then decreasing, and then increasing. But all treatments have a higher moisture content in the 80-100 cm soil layer than in the 0-20 cm soil layer. Overall, the soil moisture content of each treatment in descending order is CK (5.37%) > P3 (5.33%) > P2 (3.89%) > P3 (3.49%).

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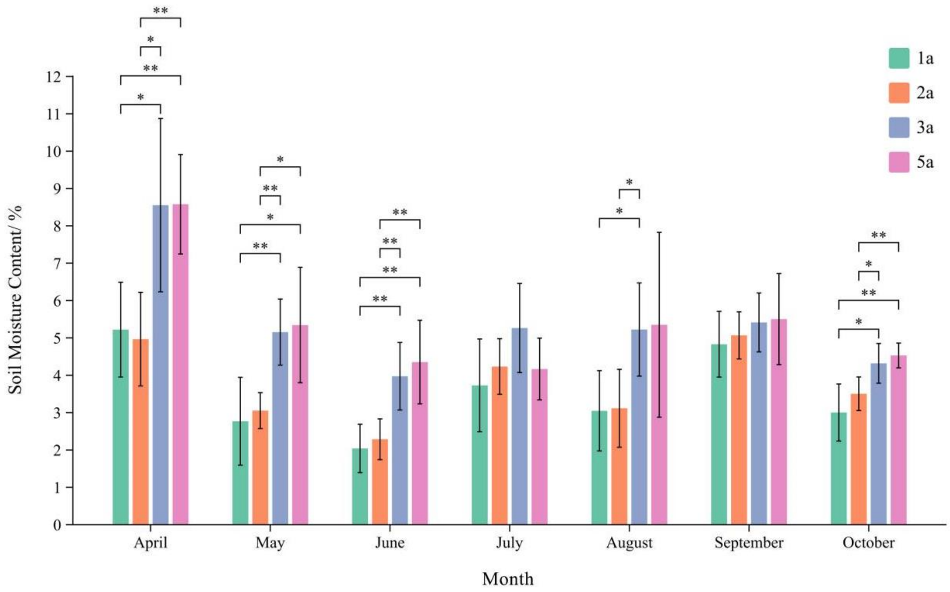

Figure 4. *Monthly changes in water content of S. psammophila during different intervals of stumping*

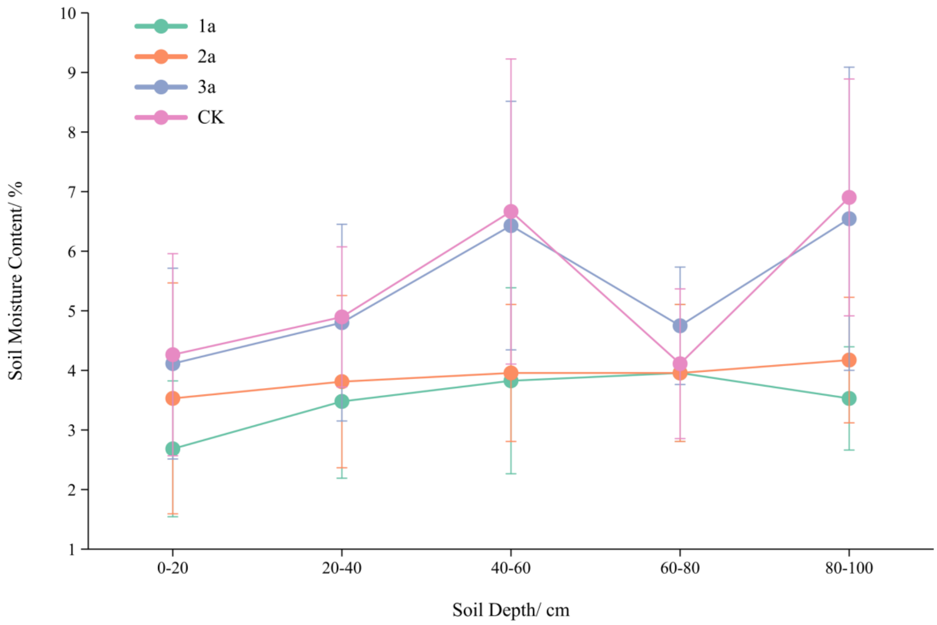

Figure 5. *Depth variation of soil moisture content in S. psammophila during different interval periods of stumping. The error bar in the figure refers to the standard deviation of the data*

Changes in soil nutrient content between S. psammophila forests at different intervals of stumping

From *Figure 6*, it can be seen that there are significant differences in soil nutrients in the understory of S. psammophila plantations treated with different stumping intervals from May to October 2023. Among them, different stumping intervals have little effect on the total phosphorus of the soil, and there is no significant difference between different stumping intervals. There was a significant difference ($p < 0.05$) in the available phosphorus content of soil between P1, P2, and CK *S. psammophila*. Overall, it showed an increase in the first three years of stumping, and a downward trend began to appear after three years. This indicates that long-term non stumping treatment will reduce the available phosphorus content in the soil. There is a significant difference in total nitrogen content between P2 and CK ($p < 0.05$). There is a significant difference ($p < 0.05$) in the alkaline nitrogen content between P1 and P2, while there is an extremely significant difference ($p < 0.01$) in the alkaline nitrogen content between P1 and P3, showing a trend of first increasing and then decreasing, reaching the highest level in 3 years. There is a significant difference in organic matter content between P1 and P2 ($p < 0.05$), and there is an extremely significant difference between P1 and P3 ($p < 0.01$), showing a trend of first increasing and then decreasing. There is a significant difference in total carbon content between P1 and P2 ($p < 0.05$), and an extremely significant difference between P1 and CK ($p < 0.01$). The total carbon content of *S. psammophila* increases with time, but there is no significant difference between P3 and CK, indicating that the total carbon content of the soil may reach a stable state after 3 years of growth. The soil pH index P2 showed significant differences compared to P1, P3, and CK ($p < 0.01$).

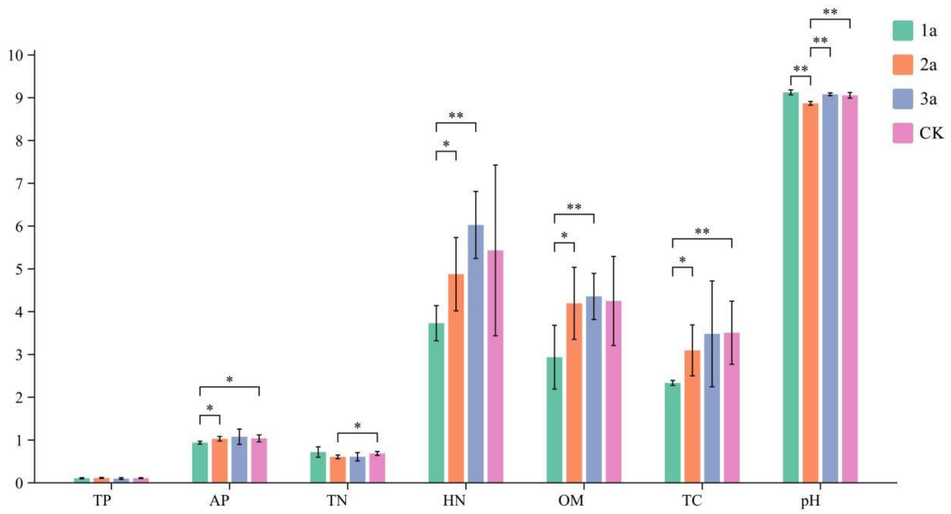

Figure 6. *Differences in soil nutrients of S. psammophila during different intervals of stumping*

From *Figure 7*, it can be seen that the total nitrogen, total carbon, total phosphorus, alkaline nitrogen, available phosphorus, and organic matter content of soil at different intervals of stumping all show a decreasing trend with the increase of soil depth. Overall, the nutrient content in the 0-40 cm deep soil layer is relatively high, and the accumulation of nutrients in different soil layers shows a significant transfer process from shallow soil to deep soil, indicating a significant surface aggregation phenomenon of soil nutrients.

Effects of environmental factors on soil nutrients of S. psammophila during different stumping intervals

Figure 8 shows the relationship between the growth indicators of *S. psammophila*, soil physicochemical properties, and herbaceous plant diversity. From the graph, it can be seen that the average crown width and average height of *S. psammophila* show a highly significant positive correlation ($p < 0.01$), and a highly significant negative correlation ($p < 0.01$) with soil phosphorus content. The average plant height showed a

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highly significant negative correlation with available phosphorus (AP) ($p < 0.01$), while Coarse Sand and total phosphorus (TP) showed a significant negative correlation ($p < 0.05$). There is a highly significant positive correlation ($p < 0.01$) between the biomass of *S. psammophila* and total nitrogen (TN), alkaline nitrogen (HN), organic carbon (TC), and species diversity index (Shannon). Soil bulk density was significantly negatively correlated with total phosphorus and available phosphorus ($p < 0.05$). The species evenness index has a certain negative correlation with various nutrient indicators in soil. There is a highly significant positive correlation ($p < 0.01$) between the ecological dominance index and soil nitrogen and organic carbon content.

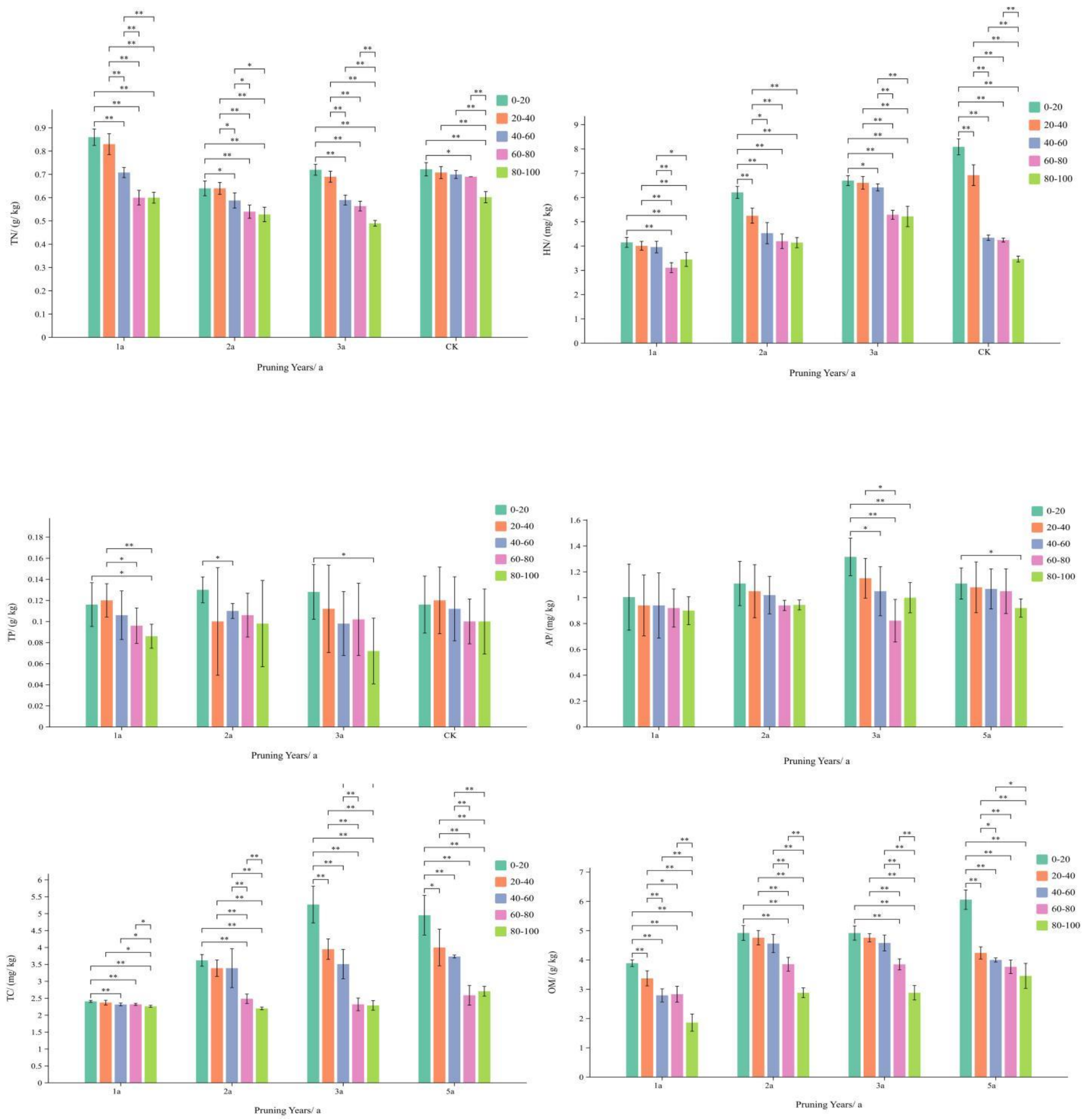

***Figure 7.** Differences in soil nutrients at different depths of soil layers*

Discussion

The impact of stumping on vegetation growth

Stumping can change the growth decline phenomenon of desert shrubs over time. After stumping, indicators such as height, crown width, basal diameter, and biomass of

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S. psammophila increase with the increase of the interval between stumping. The herbaceous plant community is an important component of shrub forests, playing a crucial role in promoting shrub productivity and nutrient cycling within the forest (Ma et al., 2015). The stumping increased the coverage and height of the understory grassland plant community of shrub, and significantly increased the species richness of the grassland community (Yu, 2016). In this study, the proportion of annual herbaceous plants in the P3 treatment plot was higher than that in the CK, and then higher than that in P1. The number of species shows an increasing trend within 3 years after crop cultivation. There will be a slight decline after 3 years. At the same time, the coverage, density, and aboveground biomass of understory herbaceous plants gradually increase with the increase of stumping intervals. This research result is consistent with the research results of Ma Zhanying and Guo Mengjia on sandy shrubs (Ma, 2020; Guo, 2021). This reason may be because stumping can change the water, light, and nutrient conditions in the sample plot, which has a positive promoting effect on the settlement and growth of understory herbaceous plants. Undergrowth herbaceous vegetation is an important component of artificial forest ecosystems, playing an important role in nutrient accumulation and material cycling, soil and water conservation, and maintaining biodiversity (Xu et al., 2019). In this study, it was found that the species Richness index, Shannon Wiener species diversity index, Simpson ecological dominance index, and Pielou species evenness index in the CK were 1.45, 1.72, 1, 59, and 1, 48 times higher than those in P1.

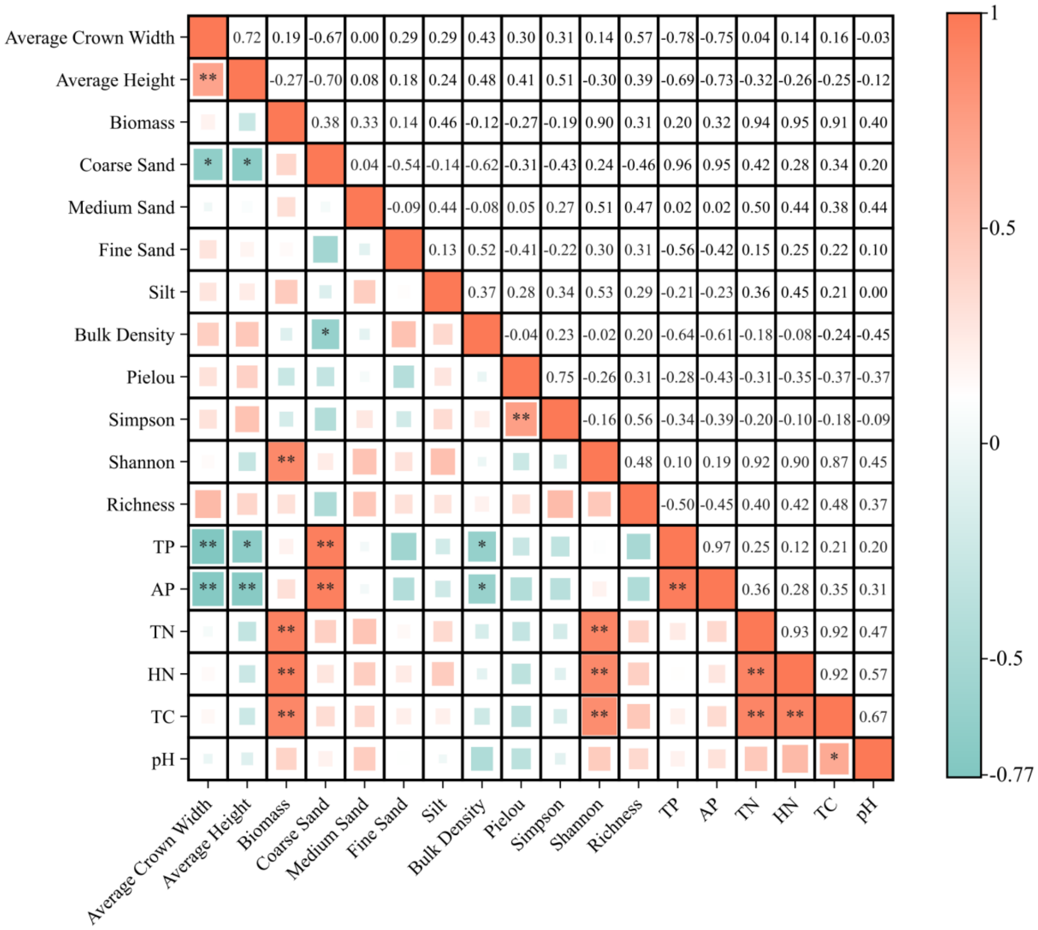

Figure 8. *Hotspot map of correlation between environmental factors and soil nutrients*

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The effect of stumping on soil physical properties

The stumping can have a positive impact on the changes in soil physical properties of artificial *S. psammophila* forests in desert grassland areas. Soil particle composition, as the most basic unit of soil structure composition, is an important soil physical property parameter. The content of each particle size component has a significant impact on the storage and movement of soil moisture, nutrients, air, and heat in the soil (Gao et al., 2019). At the same time, it will also have a certain impact on soil nutrient conversion (Wernerehl et al., 2015; Yang et al., 2021).

In this experiment, among the four types of *S. psammophila* plots with stumping years, the soil composition was mainly composed of medium sand, accounting for 41.93~53.57% of the total. At the same time, the proportion of coarse sand in P3 was the lowest, and the proportion of fine sand in P3 was the highest. The growth of *S. psammophila* and understory vegetation has a refining effect on the soil, reaching a stable state during the stumping of P3. In the CK group, the proportion of coarse sand in *S. psammophila* slightly increased, while the proportion of medium sand slightly decreased. The research conclusion is consistent with Bian Yingying's conclusion on artificial *Caragana korshinskii* forests in desert grassland areas (Bian et al., 2018). The impact of different types of sandy shrubs on soil structure composition is similar.

Soil moisture, as one of the most important limiting factors for plant growth, has a crucial impact on the entire growth and development cycle of plants, especially for the survival of plants in arid areas. The role of soil and water conservation is one of the important purposes of planting desert shrubs. This study found that the soil moisture content of the *S. psammophila* sample plot in Hangjin Banner, Ordos showed a general "W" shaped trend before April to October, with a decrease from April to June, an increase from June to July, a decrease from July to August, and a slight increase from August to October. However, the moisture content in October was lower than the initial content in April. This trend is similar to the conclusion that the moisture content from June to August is the lowest level of a year in the protective forest of Jilantai Salt Lake (Wei et al., 2023). The reason for the high moisture content in April is due to the adjustment of the entire dormancy period and the injection of snowmelt into the soil, which reaches the highest water level. May to July is the growing season of *S. psammophila*. The demand for soil moisture is significantly higher than that in the later stage of growth from August to October. June to August is the rainy season in the western region of Inner Mongolia, so there is a brief increase in soil moisture content in July. The temperature in August is higher, transpiration is stronger, and soil moisture loss is severe. With the decrease in temperature and the end of the *S. psammophila* growth season, the soil moisture content begins to rise after August.

The effect of stumping on soil nutrient composition

At the temporal level, the establishment of *S. psammophila* plantation has a significant promoting effect on the accumulation of soil nutrients. Soil organic matter is the center of plant nutrient cycling, mainly influenced by plant litter, plant roots, animal and microbial residues, and is an important factor in soil structure (Hai, 2023). The total nutrient status of the soil determines its potential nutrient supply capacity, and soil available nutrients are the direct source of essential basic elements for crop growth and development (Zhao et al., 2005). In this experiment, indicators such as AP, HN, OM, and TC reached their highest state at P3. This conclusion is consistent with Liu Lu's

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conclusion on the impact of *Hippophae rhamnoides* stumping on soil physical and chemical properties in sandstone areas. There may be two reasons for this: firstly, the growth of *S. psammophila* and understory vegetation within a certain period of time reduces the proportion of coarse sand in the soil, and increases the proportion of medium sand and fine sand. Small particle size sandy soils have significantly better retention and storage of water and nutrients than larger particle size soils. Secondly, through the release of root exudates, decomposition of aging tissues such as residual roots, and accumulation of litter, a favorable living environment is provided for the growth and development of microorganisms and other species. Soil microorganisms play an important role in the formation and evolution of soil fertility, the availability of soil nutrients, and the maintenance of a healthy relationship between vegetation and soil (Zhang et al., 2017).

In terms of soil depth, soil nutrients exhibit a significant surface aggregation phenomenon. This study found that the content of total nitrogen, total carbon, total phosphorus, alkaline nitrogen, available phosphorus, and organic matter in soil at different intervals of stumping showed a decreasing trend with increasing soil depth. This conclusion is roughly the same as Wang Jingya’s research on seabuckthorn (Wang et al., 2014). The reason may be that the decomposition of fallen leaves and plant residues produces a large amount of organic matter in the surface soil, which can improve soil structure and provide nutrients. And the surface soil is the main growth site for plants and microorganisms, so the biological activity is very high. These microorganisms can decompose organic matter and release nutrients, supporting plant growth, resulting in higher nutrient content than deep soil.

Through the analysis of the results of this experiment, it was found that the effects of stumping on the growth of sandy shrub vegetation and the physicochemical properties of underforest soil are similar. Therefore, some of the research results of this experiment can also be used as a reference for the study of stumping of other sandy tree species. However, the stumping interval is not fixed in the site of the sample, the investigation of vegetation characteristics and soil physicochemical properties of *S. psammophila* plantations in the experiment was not able to obtain complete data for continuous 1-5 years due to the cropping interval is not fixed. Therefore, the experimental results have certain limitations. Subsequent research can increase the types of experimental species and the number of years of stumping, in order to obtain more comprehensive results and conclusions, and provide more complete data and theoretical support for the stumping nurturing of *S. psammophila* in Hangjin Banner, Ordos, China.

Conclusion

(1) Stumping can improve the growth and decline of *S. psammophila*, promote the high growth and basal diameter growth of *S. psammophila*. As the interval between flat cropping increases, the diversity, richness, and coverage of early flowering plants under the *S. psammophila* forest significantly increase. Among them, there is no significant difference in multiple growth indicators between flat cropping for 3 years and CK, indicating that it is more suitable for flat cropping treatment at this time.

(2) Stumping can refine soil particles, thus enhancing the soil and water conservation ability of *S. psammophila*. After 3 years of stumping, the average moisture content of *S. psammophila* forest in 0-100 cm from April to October is 1.54 and 1.45 times that of 1-2 years.

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(3) Stumping is beneficial for soil nutrient accumulation. The content of organic carbon, total nitrogen, total phosphorus, alkaline nitrogen, and available phosphorus in the soil of *S. psammophila* with different stumping years is 2.34~3.51, 0.61~0.72, 0.1~0.11 g/kg, and 3.73~6.03, 0.94~1.08 mg/kg, respectively. The highest nutrient content is found in *S. psammophila* soil after 3 years of stumping.

(4) The average crown width, average plant height, biomass, soil fine sand content, soil bulk density, and Shannon biodiversity index are the main factors affecting soil nutrients.

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