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Impacts of Close-to-nature Management Technology on the Korean Pine Soil Chemical Properties in Northeast China

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Abstract

Based on the guiding ideology of "Close-to-nature forestry", the soil chemical properties of Korean pine (*Pinus koraiensis*) plantation forest which was early done by canopy gap control were analyzed of Liangshui nature reserve in northeastern China. The results indicated that the nurture of forestry crevice diaphanous tended to improve the soil nutrient contents and significant differences of soil nutrients existed among different levels of soil for the same forest type of Korean pine. At $0<H\leq20$ cm layer, the content of available nitrogen, available phosphorus, available potassium, total nitrogen and total phosphorus in artificial pure Korean pine forest are 640.28 mg · kg^{-1}, 7.54 mg · kg^{-1}, 275.91 mg · kg^{-1}, 1.114% and 0.075%, they all higher than the other kinds of forests and for average 1.1 times, 1.4 times, 1.3 times, 1.6 times and 1.2 times. From the layer of $0<H\leq20$ cm to 20 cm$<H\leq40$ cm, soil nutrient indicators showed various degrees of decreasing in which organic matter had the greatest decline, decreasing by 170.64% while PH had the lowest decline, decreasing by 4.66%.

Key Words: Korean pine, close-to-nature forestry, the nurture of canopy gap control, soil chemical properties, soil microelement

Introduction

"Close-to-nature forestry" was popular in continental Europe during the 1980s and 1990s, especially in Central Europe (Germany, Austria, and Sweden). "Close-to-nature forestry" management ideas can be expressed as "A forestry activity which was under the premise of ensuring that the forest structure self-preservation ability and following the natural conditions ", It is a business mode which compatible with forestry production and nature conservation (Shao 1991; 1995) . The background of "Close-to-nature forestry", in addition to the increased focus on environmental protection requirements, brought from century operating plantations on various abuses (does not apply to the right tree, simple structure, less stable, reduced biodiversity, declining soil fertility, poor environmental benefits) were also important contributing factors (Felton et al. 2006; Muscolo et al. 2007). "Close-to-nature forestry theory" was published by Gayer in 1898, He pointed out: "the forest production secret is that all play a role in the harmonious strength inside of the forest". Moeller proposed the continuous forest management in 1922. Krutzsch and

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WeikeMoeller put forward the continuous forest based on the adaptation of natural forest management mode in 1950. "Close-to-nature forestry" business law incoming China in the early 90's last century, many scholars study on "close-to-nature forestry" theory and its practice in China have done a great deal of discussion on the feasibility of application (Wu et al. 2000; Zhang and Lin 2000; Feng et al. 2006). Through practical experience on close-to-nature forestry forest management practices in Germany, the suitable method of forest management in the region was found out with Inner Mongolia Greater Khingan Range forest condition (Gao et al. 2000). "Close-to-nature forestry" mode of operation was used in Chinese fir plantation management (Zhang et al. 2001). "Close-to-nature forestry" theory as the instruction, the Fujian natural broad-leaved forest was proposed in the mid-subtropical zone ideal structure index and Standard (Huang et al. 2003).

The soil and the forest are close, the updates, growth, forest type, structure and productivity of forest are affected by soil factors constraining. Forest soil resource is crucial to the sustainable management of forests and the environment material analysis of forest soil can provide a basis for the operation and management of forest resources (Mishraa et al. 2003; Pedersen and Howard 2004; Hardy and Sonké 2004; Salas et al. 2006). This paper compared the soil chemical nature of early done canopy gap control experimental of Korean pine (*Pinus koraiensis*) plantation, Korean pine natural, Korean pine artificial pure forest, and Korean pine plantation and Broadleaf mixed forest, aimed at revealed to the effect of "near-to- natural forestry" for guiding ideology of canopy gap control tending on soil chemical nature, it will provide support and guarantee to the business management of Korean pine forest in future.

Materials and Methods

Study site

Data for this study were collected from Liangshui Natural Reserve in northeastern China, which is the largest and well-protected natural distributive region of the broad-leaved-Korean pine ecosystem, it is dominated by Korean pine and accompany with many warm-and cold-broad-leaved species. Liangshui Natural Reserve is located in Yichun City of Heilongjiang province, on the mid-north of Xiaoxing' an Mountains, Northeast China, its location is $47^{o}07'39''$-$47^{o}14'22''$N, $128^{o}48'30''$-$128^{o}55'50''$E. The annual precipitation in it is -0.3°C and the mean temperature range from -6.6°C in January to 7.5°C in July. The annual precipitation is 600-700 mm with the evaporation of 805 mm and about 60% concentrates in June, July and August. The annual mean relative humidity is 78%.

The forest resource inventory of Liangshui Natural Reserve in 1999 indicated that the total area was 6,394 ha. Forest coverage is up to 91.2%. The zonal climax community is the broadleaved-Korean pine forest.

Dark brown soil is the zonal soil in this area and it accounts for about 85% of the forestry land. The hidden territory soil (azonal soil) is the meadow soil, the bog soil, and the turf soil. The mountainous region dark brown soil belongs to the eluviate order of soil, is soil which grow under the temperate zone moist area conifer and broadleaf mixed forest. The forming process is the process of humus accumulate and weak acid eluviate The positive ion substitution quantity is high, by Ca^{2+} and Mg^{2+} Primarily. The dark brown soil parent material in this local is the residuals and the slope sediment of granite and the gneiss.

Studies local forest land survey

This research select sample plots of the Liangshui National Nature Reserve in Xiaoxing' an mountains in Northeastern China, selected forest soils are dark brown, respectively selected as the plots of canopy gap control, the same site conditions of Korean pine natural forest, Korean pine artificial pure forest and Korean pine artificial needle broad mixed forest each of the block, setting the standard sample, the standard woodland profile the following Table 1.

Data collection

Different forest types of Korean pine standards were set separately, the area of the standard sample plot decides according to the actual situation of forest land, choose 4 spot digs to takes the soil profile in each standard stochastic, each soil profile takes two layers (layer A: 0-20 cm, layer B: 20-40 cm), take soil from layer A and layer B in 4 spot digs separately, mixes uniformly, brings back to the laboratory to use in the chemical foundation nutrient and trace elements analysis.

Table 1. Forest situation in Liangshui Natural Reserve, Northeast China

Forest types	Sample plot				
	Area (ha)	Age	$\overline{Dg}$ (cm)	$\overline{H}$ (m)	Species composition (by volume)
Forest gap light transmission test plots	0.09	53	11.6	10.8	4 *Populus davidiana*, 2 *Pinus koraiensis*, 2 *Betula platyphylla*, 1 *Ulmus laciniata*, 1 *Salix babylonica*
Natural forest of Korean pine	0.08	129	17.2	12.3	6 *Pinus koraiensis*, 1 *Ulmus laciniata*, 1 *Acer mono*, 1 *Betula costata*, 1 *Acer mono*
Korean pine artificial forest	0.06	53	12	11.1	7 *Pinus koraiensis*, 1 *Populus davidiana*, 1 *Betula costata*, 1 *Betula platyphylla*
Artificial Korean pine needle-leaved trees	0.06	54	12.2	10.6	7 *Betula platyphylla*, 1 *Pinus koraiensis*, 1 *Populus davidiana*, 1 *Ulmus laciniata*

Analysis project and method

Do three repeat of each standard soil which was retrieve from field investigation, sample data was measured average as the final value. Foundation nutrient main analysis soil pH value, organic matter, available nitrogen (available N), available phosphorus (available P), available potassium (available K), total nitrogen (total N), and total phosphorus (total P); trace elements main analysis the mass fraction of copper (Cu), zinc (Zn), iron (Fe) and manganic (Mn). The soil nutrient analysis method is: The pH value adopt the electric potential measuring method that the water used and the soil ratio of 2.5:1, the organic matter uses the method of bichromate potassium capacity, the available nitrogen uses the method of alkaline hydrolysis — diffusion process, The available phosphorus adopt the molybdenum stibium anti color method with the hydrochloric acid and sulfur acid pickling, the available potassium soaks with the ammonium acetate raises flame photometer, the total nitrogen uses semimicro fixation of nitrogen, the total phosphorus uses method of sulfuric acid — perchloric acid to dissolve the molybdenum stibium anti color; spectrophotometer determination of trace elements are atoms (Soil physical and chemical analysis test instruction 2002).

Statistics can be viewed as the prescription for making the quantitative learning process effective. The paper selects correlation matrices of Statistica7.0 statistical software for data correlation analysis, statistical the correlation coefficient of which importance $p < 0.05$. The greater the absolute value of the correlation coefficient, the higher the correlation between the parameters.

Results and Discussion

Korean pine forest soil nutrients under different operating conditions

Table 2 is the research result and the soil various nutrient determination value and mean value in different level for the sample plot of canopy gap control, Korean pine natural forest, Korean pine artificial pure forest and Korean pine broad-leaved mixed forest in the same conditions. We can see from Table 2, the sample plot of canopy gap control based nutrient determination value significantly higher than the other forest types, and various nutrients as the level change has also shown a certain amount of variation.

It can be seen from table 2, under various operating conditions the soil pH value other than the sample plot of canopy gap control, other differences are not significant, are all slightly acidic soil, the pH value in layer A of order: the sample plot of canopy gap control > Korean pine natural forest > Korean pine broad-leaved mixed forest > Korean pine artificial pure forest, acidic soil growing. The layer B soil pH value difference is not significant. The layer A pH value of the sample plot of canopy gap control is supreme, this is human tending of results, pH value indicates soil in the activity acid of size, activity acid directly effect forest of growth and nutrient of effectiveness, human tending measures in must degree increased has soil of ventilation sexual, enhanced has soil oxidation restored of capacity, to improve has soil of pH value, and for Korean pine artificial pure forest and Korean pine broad-leaved mixed forest, due to long time no human tending, soil of ventilation sexual declined, soil acidity and acid soils of natural forests of Korean pine is

Table 2. Korean pine under different management conditions soil nutrients

Forest types	Layer (cm)	pH value	Organic matter (%)	Available N (mg・kg^{-1})	Available P (mg・kg^{-1})	Available K (mg・kg^{-1})	Total N (%)	Total P (%)
The sample plot of canopy gap control	0-20 cm	6.10±0.055*^{a}	30.22±2.27^{a}	640.28±32.78	7.54±0.610^{a}	275.91±7.35^{a}	1.114±0.015^{a}	0.075±0.002^{a}
Korean pine natural forest		5.78±0.151^{b}	14.42±0.25^{b}	607.28±44.42	3.58±0.604^{b}	213.62±1.54^{b}	0.740±0.027^{b}	0.058±0.001^{b}
Korean pine artificial pure forest		5.73±0.017^{b}	12.39±0.45^{b}	531.80±44.36	3.18 ±0.41^{a}	184.67±4.08^{c}	0.215±0.018^{b}	0.053±0.001^{b}
Korean pine broad-leaved mixed forest		5.75±0.031^{b}	16.30±1.46^{c}	467.41±167.32	6.67±0.398^{b}	180.88±1.59^{c}	0.753±0.011^{c}	0.059±0.002^{c}
Average value		5.84	19.08	561.69	5.24	213.77	0.706	0.061
The sample plot of canopy gap control	20-40 cm	5.61±0.15^{a}	8.54±0.6^{a}	324.48±49.72	2.75±2.75^{a}	133.03±7.00^{a}	0.292±0.021^{a}	0.049±0.002^{a}
Korean pine natural forest		5.64±0.061^{a}	4.00±0.78^{b}	319.88±85.71	6.46±6.45^{b}	60.68±1.52^{b}	0.314±0.03^{a}	0.044±0.001^{b}
Korean pine artificial pure forest		5.63±0.106^{b}	8.23±0.79^{a}	295.99±1.74	2.47±2.47^{c}	65.05±1.51^{c}	0.642±0.02^{a}	0.043±0.002^{b}
Korean pine broad-leaved mixed forest		5.43±0.032^{c}	7.41±0.461^{a}	278.00±18.82	4.91±4.91^{a}	72.22±2.66^{c}	0.328±0.006^{b}	0.045±0.002^{b}
Average value		5.58	7.05	304.59	4.15	82.75	0.394	0.045

*In the table the value is arithmetic mean value and standard deviation of the 4 sample spots.
^{a,b,c,d}indicated measured the factor has remarkable difference in 0.05 level.

not too much difference.

One of the solid parts of the organic matter in the soil is important, it not only affects the physical and chemical properties of soil and soil fertility plays a very important role in the development (You and Jiang 2005). The sample plot of canopy gap control of the highest organic matter content, 30.22% and 8.54% in layer 0-20 cm and 20-40 cm respectively, Korean pine natural control forest minimum, reduced 14.42% and 4.00%, layer A of organic matter content in order of largest to smallest are: the sample plot of canopy gap control > Korean pine artificial broadleaf mixed forest > Korean pine artificial pure forest > Korean pine natural forest, layer B of organic matter content in order of largest to smallest are: the sample plot of canopy gap control > Korean pine artificial pure forest > Korean pine artificial broadleaf mixed forest > Korean pine natural forest. Visible human productive activity and tending the soil organic matter has a certain influence, mixed forest planted in Korean pine plantations can increase soil organic matter content, and tending of forest gap light on the content of soil organic matter has a certain effect.

Soil nutrients are forest tree growth and development of material base. In layer 0-20 cm, the sample plot of canopy gap control of available nitrogen, and available phosphorus, and available potassium, and total nitrogen and total phosphorus of content respectively for 640.28 mg・kg^{-1}, 7.54 mg・kg^{-1}, 275.91 mg・kg^{-1}, 1.114% and 0.075%, Compared with other stand is the highest, and for average of 1.1, and 1.4, and 1.3, and 1.6 and 1.2 times, Korean pine artificial pure forest of each index basically is the lowest. This is because the effect makes Korean pine trees high, diameter growth in time and space formed a “first high diameter” process, enhanced the competition between forest and vegetation of diversity undergrowth, improve the soil fertility function, make the soil nutrient content increased, and trees high, diameter growth in time and space formed a “synchronization” change process, lack of competition between the trees, soil fertility, nutrient content reduce function decline. In the 20-40 cm layer, the sample plot of canopy gap control in addition to available phosphorus and total nitrogen content lower than other forest particularly, the rest of the index is higher than other stand, available phosphorus less than the average of 1.4 mg/kg, total nitrogen 0.102 under less than average, The phenomenon may be because of the canopy gap control tending to the influence of the upper soil is larger, and to lower the influence of soil and is not so obvious.

Soil foundation nutrient comparison in different layers

Table 2 is mean value of soil various foundations nutrient in layer A and layer B compares. We can see from the Fig. 1 that based on indicators of nutrient averages decreased with increasing soil depth. From the layer 0-20 cm to the layer 20-40 cm, available phosphorus drops from 5.24 mg・kg^{-1} to 4.15 mg・kg^{-1}, dropped 26.27%; Total phosphorus drops from 0.061 to 0.045%, dropped 35.56%; hydrolysis nitrogen drops from 561.69 mg・kg^{-1} to 304.59 mg・kg^{-1}, dropped 84.41%; total nitrogen drops from 0.706% to 0.394%,dropped 79.19%; available potassium drops from 213.77 mg・kg^{-1} to 82.75 mg・kg^{-1} ,dropped 158.33%; PH values drops from 5.84 to 5.58, dropped 4.66; organic matter drops from 19.08% to 7.05%, dropped 170.64%. It proved that the deepening of the soil layer, soil nutrient indicators show different degrees of downward trend, in which organic matter is the biggest decline, dropped 170.64%, the PH value is the smallest decline, dropped 4.66%. Obviously, the soil layer is deeper, the soil nutrient content is less, the soil is more barren.

Soil trace elements comparison under different operating conditions

The content of trace elements in soils is low, but it is indispensable part of soil nutrients, its content and distribution on tree growth plays a very important role.

The content of copper in every forest is relatively low. In the layer 0-20 cm, the highest content of copper is the pervious to light experimental field, followed by the Korean pine natural forest, arrange in order: the pervious to light experimental field＞Korean pine natural forest＞Korean pine artificial pure forest＞Korean pine artificial broadleaf mixed forest; But in the layer 20-40 cm, the pervious to light experimental field of copper is the lowest, highest is the Korean pine natural forest, arrange in order: Korean pine forest natural control＞Korean pine artificial broadleaf mixed forest＞Korean pine artificial pure forest＞the pervious to light experimental field. Because organic matter, PH value, minerals in soil and other factors will affect the effectiveness of copper in soils, therefore, with the deepening of the soil, changes of various forest types were not a regular, but elevated or content or less (Fig. 1).

Zinc in forest layer 0-20 cm of the order consistent with the copper, but in layer 20-40 cm it became: Korean pine forest natural control＞the pervious to light experimental field＞Korean pine artificial pure forest＞Korean pine artificial broadleaf mixed forest, the effectiveness of zinc is also affected by organic matter, PH value, minerals and other

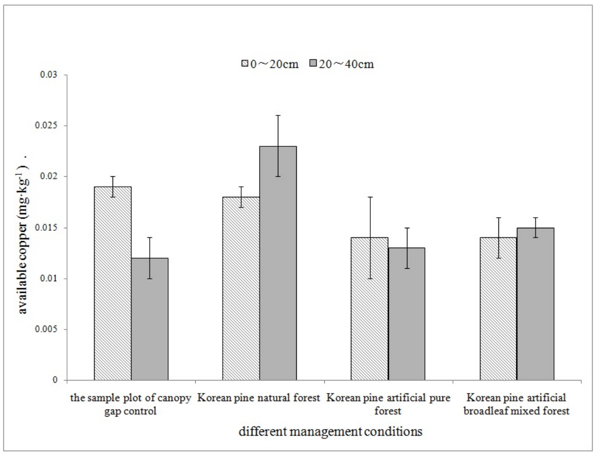

Fig. 1. Available copper of Korean pine under different management effective.

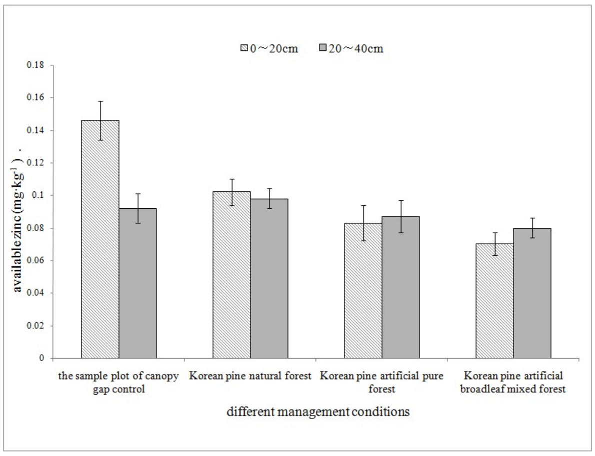

Fig. 2. Available zinc of Korean pine under different management effective.

factors, as well as, high organic matter content are responsible for complexes of zinc generates insoluble complexes, thereby reducing the effectiveness of zinc (Fig. 2).

Content of iron in the stands are relatively high in comparison with other trace elements, and in the stands are shown by the content of layer A to layer B was gradually increasing. In the layer 0-20 cm, effective order of iron in the stands: Korean pine artificial broadleaf mixed forest > Korean pine forest natural control > Korean pine artificial pure forest > the pervious to light experimental field; the layer 20-40 cm, valid order of iron are: natural control of Korean pine forest > Korean pine artificial broadleaf mixed forest > the pervious to light experimental field > Korean pine artificial pure forest. Fe in the soil is Fe^{2+} and Fe^{3+}, Fe^{2+} which is a valid rail, mobility strong, layer 0-20 cm, the pervious to light experimental field of effective low iron content may be artificially raising measures related to human activities contribute to flow, thereby reducing the effective content of iron (Fig. 3).

The content of Manganese by layer A and layer B also took on a regular, but contrary to the rail, effective in manganese in the stands are shown by layer A to layer B content gradually decreasing. In the layer 0-20 cm and layer 20-40 cm, the order of manganese in the forest is: Korean pine forest natural control > the pervious to light experimental field > Korean pine artificial broadleaf mixed forest > Korean pine artificial pure forest. Visible, effective for manganese in Korean pine forest natural control is the highest (Fig. 4).

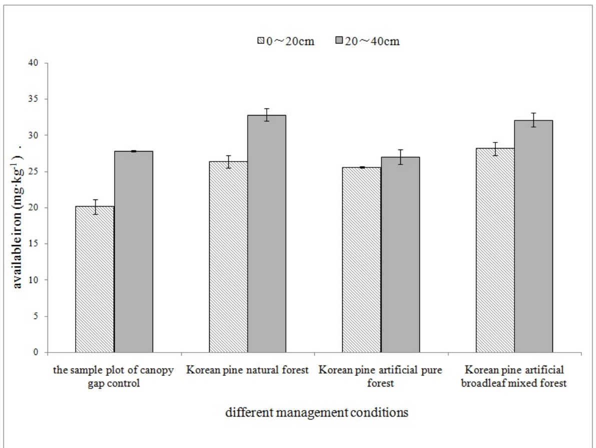

Fig. 3. Available iron of Korean pine under different management effective.

Conclusion

Tending of the canopy gap control improves the nutrient content of the soil, it make the nutrient content higher than the Korean pine natural forest, Korean pine artificial pure forest and Korean pine artificial broadleaf mixed forest under the same site conditions, this increase is particularly manifested in the layer 0-20 cm of Korean pine, it provides the necessary nutrients to the tree's growth and updated. Soil pH, organic matter and available nitrogen, available phosphorus and available potassium, hydrolysis of nitrogen and phosphorus in average decreased with increasing of soil depth level, it proved that the soil layer is deeper, the soil nutrient content is less, the soil is more barren. Therefore, in the future management of Korean pine forest should pay more attention on the soil surface nutrient use.

Due to the Korean pine natural forest consisting of a single, makes the lack of competition between trees, understory vegetation coverage is low, soil nutrient content lower than other forest types. "Close-to-nature" management to create high soil nutrients in Korean pine and Korean pine artificial broadleaf mixed forest, forest-friendly growth, if we take full advantage of gap effect, it will provide a new channel for the mode of operation of Korean pine.

Despite the important factors that affect the nutrient content of soil organic matter, but it was unable to fully reveal the chemical properties of soils, soil chemistry is very complex in nature, human activities and the effects of other

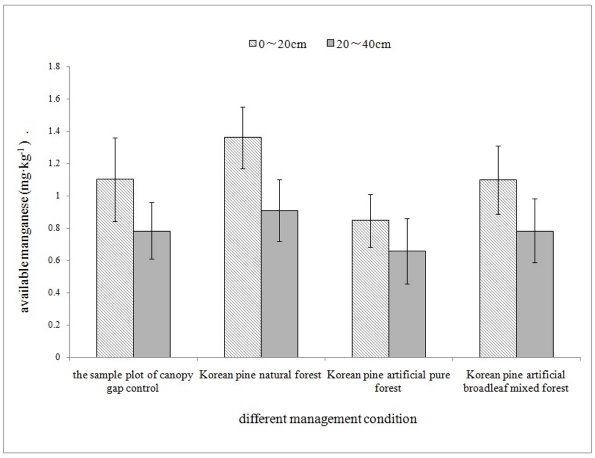

Fig. 4. Available manganese of Korean pine under different management effective.

factors are also factors that cannot be ignored.

In addition to effective iron of soil, other elements are low in the sample plot of canopy gap control, Korean pine natural forest, Korean pine artificial pure forest and Korean pine artificial broadleaf mixed forest, and at different layers and different forest types are no rules to follow, visible soil trace elements in soil nutrients are not easy to grasp part of the study to be further in the future.

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