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Han, Jing-Long

School of Environment and Material Engineering, Yantai University

Jin, Fu-Shun

School of Environment and Material Engineering, Yantai University

Liu, Rui-Cui

School of Environment and Material Engineering, Yantai University

Liu, Ying-Xia

School of Environment and Material Engineering, Yantai University

他

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Variation and Controlling Factors of the Organic Matter Level in Soils after Conversion of Arable Land into Forest Land in Shandong Province of China

Jing-Long HAN¹, Fu-Shun JIN¹, Rui-Cui LIU¹, Ying-Xia LIU¹,
and Kazuhiko EGASHIRA*

Laboratory of Soil Science, Division of Soil Science and Plant Production,
Department of Plant Resources, Faculty of Agriculture,
Kyushu University, Fukuoka 812–8581, Japan
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The selected chemical properties were examined for soils after conversion of arable land into forest land in Shandong Province of China. Soils were collected at three locations, and they were different in the landform (flat land vs slope land), duration of tree growing (20 years vs 10 years), or species of tree (white birch vs apple tree). The pH ranged from 6.4 to 7.1 and the total nitrogen content was in a range of 0.51 to 1.10 g/kg. Their levels varied with the species of tree, and hence the pH and organic nitrogen content of soils were regarded to be controlled by the fertility management.

The organic matter content ranged from 11.6 to 28.7 g/kg. It was affected by the landform at the 1% significant level but was insignificantly affected by the duration of tree growing. The organic matter content varied with the human activity. It was significantly higher for the forest land without human activity and grown in the natural condition than for the forest land with human activity such as taking away of fallen leaves by farmers or growing of apple trees subjected to fertility management. Under the human activity, the organic matter content of soil was significantly higher for growing of apple trees than for taking away of fallen leaves.

INTRODUCTION

Global spread of destruction of environment is now becoming a threatening cause to survival, development and security of human society. Since environmental destruction means dysfunction of ecosystem, practices for keeping ecosystem alive is an urgent task imposed to a human being. Forest makes a central component in the land ecosystem, and recovery of forest is an essential work to conserve environment and to establish sustainable development in the global and local levels. It has been understood that environmental problems such as global warming, environmental pollution and loss of biodiversity are closely related with forest destruction. The large-scale deforestation with development of agricultural land due to population pressure have brought about destruction of natural forest, which in turn has caused malfunction of forest and lead to occurrence of soil loss and desertification.

In China, the eroded area reached 3,560,000 km² in 2002 and occupied 37.1% of the national land. Annually eroded soil amounts to 5 billion tons. The devastated area attained to 2,674,000 km² until 1999 with occupation of 27.9% of the national land. The desertified area is 1,743,100 km², equivalent to 18.2% of the national land. Desertification expands with the annual speed of 3,436 km². To conserve the deteriorated land, as stated in the above, and to recover the functional ecosystem, the Government issued the policy of conversion of

arable land into forest land.

Based on the above consideration, the purpose of the present study is the recovery of function of forest ecosystem by conversion of arable land into forest land. For this purpose, the soil organic matter status was examined for soils subjected to conversion of arable land into forest land in Shandong Province, China, with reference to landform, time after conversion, tree species, and management activity. Countermeasures were proposed to advance the appropriate and efficient practices of conversion of arable land into forest land.

BACKGROUND

Implementation of conversion of arable land into forest land

Recently, environmental destruction such as deforestation is increasing more and more in harmony with expansion of economy, resulting in the frequent occurrence of natural disasters. China was suffered from catastrophic flood in 1998, which brought about enormous economical and social loss. This event became an opportunity that people recognized more deeply the necessity of protection to natural disasters and that conversion of arable land into forest land was advanced more strongly. After inspection by the Prime Minister Zhu Rong Ji in 1999, three provinces of Si Chuan, Shan Xi and Gan Shu were designated as the representatives for promotion of conversion of arable land into forest land. Afterwards it has spread quickly through the country. Until 2002 conversion of arable land into forest land was implemented in 30 provinces, wards and cities including Xin Jiang production construction army corp, except Shanghai City, and 1,600 prefectures. At present, conversion of arable land into forest land was

¹ School of Environment and Material Engineering, Yantai University, Yantai City, Shandong Province, China
E-mail address of the top author: hanjinglong 8868@yahoo.co.jp

* Corresponding author (E-mail: kegashi@agr.kyushu-ac.jp)

changed from theory to practice in China, and it has been institutionalized and standardized more and more.

Policy progress of conversion of arable land into forest land in recent years

State Council issued "Notice of State Council for protection of forest resources and prohibition of land development by deforestation and unauthorized use of forest land" in 1998. Main regulations were as follows: person who permitted use of forest takes responsibility for it; person who destroyed forest recovers it; and forest land developed by deforestation is all returned to forest within the fixed time. Those regulations were carried out strictly at the respective places based on the detailed searching. State Council issued "Regulation of execution of Chinese Forest Law" in 2000. The following is main regulations: tree and grass should be planted at the slope land having a gradient over 25 degrees; arable land on the slope having a gradient over 25 degrees should be converted into forest land. "The Forest Plan issue [2000]111" was distributed by the National Forestry Department, National Planned Economy Committee and Financial Division. The main point of the issue was announcement on the formal start of the experimental trial on conversion of arable land into forest land in coverage of 174 prefectures of 13 provinces located in the upstream of the Changjiang and the upstream and middle-stream of the Huang He (Yellow River).

The conversion of arable land into forest land was formally integrated into the China National Economy and Social Development "15" Plans in the 4th Conference of the Ninth National People's Congress in 2001. The regulation on conversion of arable land into forest land was ruled in the 66th Standing Committee of

State Council in 2002. The principle points of the regulation are as follows: ① planning, task design, process design, and working plan of the year were ruled clearly; ② the whole process of conversion of arable land into forest land was regulated, including requisition for conversion of arable land into forest land, demand for management and protection, fund and food supply, inspection and validation and so on; ③ other safeguards for securing achievement of conversion of arable land into forest land; ④ pursuit of responsibility by law in violation of the regulation. Based on the above measures, executing plan, and economic and legal actions against conversion of arable land into forest land could be arranged

Economic measures by the country

In the country, food and financial supports are carried out without charge to farmers implementing conversion of arable land into forest land. The standard of the food support is as follows: in the Changjiang watershed and the southern region, food of 2,250 kg/year is provided per 1 hm of area converted into forest land; in the Huang He and the northern region, the food of 1,500 kg/year is provided per 1 hm of area converted into forest land. In the standard of the financial support, 300 yuan was provided per 1 hm of area converted into forest land. In addition, the duration of the food and financial supports was decided as 5 years to conversion into the commercial forest such as fruits and as 8 years to conversion into the ecological forest.

MATERIALS AND METHODS

Soil samples

Soil samples were collected in the regions of

Table 1. Site description and chemical properties of soils converted into forest land from arable land in Shangdong Province of China

Location	Sample No	Landform	Duration of tree growing (year)	Species of tree	pH	Organic matter	Total N
						(g/kg)	
Haiyang	S1	Flat land	20	White birch	7.0	28.7	0.67
	S2		20		7.1	26.8	0.63
	S3		20		7.0	27.8	0.66
	S4	Slope land	20		6.9	21.5	0.62
	S5		20		7.0	20.8	0.61
	S6		20		6.8	21.6	0.58
Wendeng	S7	Flat land	20	White birch	6.9	23.6	0.51
	S8		20		6.9	23.8	0.56
	S9		20		6.8	23.2	0.51
	S10		10		7.0	23.1	0.53
	S11		10		7.1	23.8	0.57
	S12		10		7.0	22.9	0.53
Qixia	S13	Flat land	20	White birch	6.8	12.8	0.54
	S14		20		6.8	11.6	0.51
	S15		20		7.0	13.7	0.59
	S16		20	6.5	18.8	1.10	
	S17		20	6.4	17.6	1.01	
	S18		20	6.4	17.2	0.97	

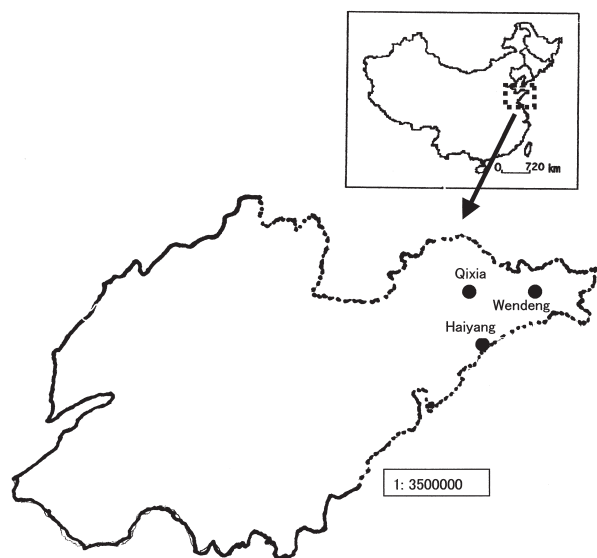


Fig. 1. Sampling locations of soils in Shandong Province of China.

Haiyang, Wendeng and Qixia in Shandong Province, China, at the first half of November 2005. One kg of samples was collected from the depth of 0 to 10 cm at six sites in each region. They were air-dried and subjected to analyses. Locations and site description of the three regions are shown in Fig. 1 and Table 1, respectively. In Qixia region, samples were collected from white birch forest land (S13 ~ S15) used for collection of fallen leaves as fuel and from apple orchard (S16 ~ S18), in order to clarify the effect of management activity of farmers on soils subjected to conversion of arable land into forest land.

Chemical analyses

Chemical properties of soils were analyzed by the soil standard methods (Committee for Soil Standard Methods for Analyses and Measurements (ed), 1986). The pH was measured in the suspension having a soil: water ratio of 1:2.5. The organic carbon content was determined by the Tyurin method and multiplied by the coefficient of 1.724 to give the organic matter content. The total nitrogen content was determined by the Kjeldahl method.

RESULTS AND DISCUSSION

Variation and controlling factors of the pH and total nitrogen content in soils converted into

forest land

Chemical properties of soils converted into forest land from arable land in Shandong Province of China are shown in Table 1. The pH of the total 18 samples ranged between 6.4 and 7.1. Among them, the samples collected from the apple orchard (S16 ~ S18) in Qixia region showed the slight acidic reaction with the values of 6.4 ~ 6.5, while the other samples were in the neutral condition. The samples collected in Haiyang and Wendeng regions were different in the landform (flat land vs slope land) and the duration of tree growing (20 and 10 years), respectively, but the pH was hardly changed between the different landforms or durations in each location. The samples collected in Qixia region have been affected by human activity with flat land in the landform and 20 years of duration of tree growing. The tree is white birch for samples S13 ~ S15, in which fallen leaves have been regularly taken away and used for fuel by farmers. However, the pH of samples S13 ~ S15 was in the same level as samples S1 ~ S12. In contrast to the samples S1 through S15 to which essentially no management practice for cultivation has been done, the tree is apple for the samples S16 ~ S18 and it has been subjected to management for cultivation. As a result, it is considered that presence or absence of management practice for cultivation has more or less strong impact on the soil reaction and that the relatively low pH of samples S16 ~ S18 is due to continuous management practice for cultivation.

The total N content of soils ranged from 0.51 to 1.10 g/kg as a whole. It was 0.97 to 1.10 g/kg for samples S16 ~ S18 and was somewhat higher than the values for the remaining samples. This is also considered to be due to management practice for cultivation of apple trees such as application of nitrogen fertilizer.

Variation and controlling factors of the organic matter content in soils converted into forest land

The organic matter content of soils ranged from 11.6 to 28.7 g/kg, as shown in Table 1. It was in a large variation, and the highest value of 28.7 g/kg of sample S1 was more than double of the lowest value of 11.6 g/kg of sample S14. Statistical analysis was attempted to examine the effects of landform, duration of tree growing, and human activity on the organic matter content. The results are shown in Tables 2 through 4.

Table 2 shows the result of F-test to examine the effect of landform on the organic matter content for soil samples in Haiyang region. A significant difference at

Table 2. F-test to examine the effect of landform on the organic matter content for soil samples in Haiyang region

Factor	DF	SS	MS	F	F _{0.01}	Level of significance*
Between sets	2	0.97	0.49	0.80	99.00	
During treatments	1	62.73	62.73	103.46	98.49	**
Error	2	1.21	0.61			
Total variation	5	64.91				

* **: significant at the 1% level.

Table 3. F-test to examine the effect of duration of tree growing on the organic matter content for soil samples in Wendeng region

Factor	DF	SS	MS	F	F _{0.05}	Level of significance*
Between sets	2	0.57	0.29	9.19	19.0	0
During treatments	1	0.11	0.11	3.55	18.5	0
Error	2	0.063	0.031			
Total variation	5	0.74				

* 0: insignificant.

Table 4. Duncan's multiple range test on the organic matter content for soil samples in Haiyang and Qixia regions

Tree species (Sample No)	Human effect	Average	Significance*
		(g/kg)	
White birch (S1 ~ S3)	without effect	27.8	A
White birch (S13 ~ S15)	with effect	12.7	C
Apple tree (S16 ~ S18)	with effect	17.9	B

* Different letters mean significance at the 1% level.

the 1% level was found in the organic matter content between flat land and slope land. The organic matter content was clearly higher for flat land than for slope land, probably meaning partial loss of soil organic matter by soil erosion in the slope land. Because the organic matter of soils was not determined before conversion of arable land into forest land, it is plausible that the organic matter content was originally lower for the slope land. Based on the above result, it is recommended that grass is first planted before tree planting in the slope land in recovering of function of forest land by conversion from arable land.

Table 3 shows the result of F-test to examine the effect of duration of tree growing on the organic matter content for soil samples in Wendeng region. It was indicated that there was no significant difference in the organic matter content between 20 and 10 years. In this context, measurement of the organic matter content is proposed to soils having the longer period after conversion into forest land.

Duncan's multiple range test was carried out to examine the effect of human activity on the organic matter content for three sets of samples S1 ~ S3 of Haiyang region, and both S13 ~ S15 and S16 ~ S18 of Qixia region. These three sets of soil samples have all the flat land in the landform but are different in the soil condition. Namely, trees are grown in the natural condition after planting at the sites of samples S1 ~ S3, fallen leaves of trees are taken away in autumn by nearby farmers at the sites of samples S13 ~ S15, and surface soil is plowed and chemical fertilizers are applied in the apple orchard at the sites of samples S16 ~ S18. The results of the statistical analysis are shown in Table 4.

It was indicated that a significant difference at the 1% level was found in the organic matter content between the set of samples S1~S3 and the sets of samples S13 ~ S15 and S16 ~ S18 and that the organic matter content was clearly higher for the former without

human activity than for the latter with human activity. Between the latter sets the organic matter content was significantly higher at the 1% level for samples S16 ~ S18 than for samples S13 ~ S15. Under the assumption that the organic matter level was the same before conversion of arable land into forest land, it is stated that great contribution of tree growing in the natural condition after conversion into forest land is expected to enrichment of organic matter in soil and that different human activities lead to different levels of organic matter in soil in correspondence with the type and intensity of human activity.

CONCLUSIONS AND PROPOSALS

In the implementation of conversion of arable land into forest land at the slope land, prevention of loss of organic matter from erosion by growing grass on the surface before tree planting leads to enrichment of organic matter in soil and eventually results in the recovery of ecological function of forest. At the flat land keeping forest in the natural condition contributes to enrichment of organic matter in soil and is essential for recovery of ecological function of forest. Political measures are desirable by the Government in substitution of other sources of fuel for fallen leaves at the area where farmers have used habitually fallen leaves as fuel. From the viewpoint of organic matter enrichment in soil natural forest is more effective than commercial forest such as orchard.

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