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RESEARCH ARTICLE

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Influences of leaf litter replacement on soil biochemical characteristics of main planted forests in Qinling Mountains of China

Abstract Long-term continuous growth of the same tree species in planted pure forest will lead to soil polarization and degradation. Mixed forestation or litter replacement between different needle- and broad-leaved forests are effective measures, except fertilization, to control soil polarization according to the mutual compensation principle of different tree species. Through a two-year leaf litter replacement experiment in 4 typical planted pure forests of *Larix kaempferi*, *Pinus tabulaeformis*, *Catalpa fargesii* and *Quercus aliena* var. *acuteserrata* in Qinling Mountains of China, influences of leaf litter replacement on soil biochemical characteristics and their interspecific relationships were studied and main conclusions were reached as follows. (1) Annual leaf litter decomposition rate of broad-leaved forests was 33.70% higher than those of needle-leaved forests and increased by 8.35%–12.15% when needle-leaved litter was replaced with broad-leaved forests, whereas it decreased by 5.38% – 9.49% when broad-leaved litter was replaced with needle-leaved forests. (2) Leaf litter replacement between needle- and broad-leaved forests popularly raised the contents of organic C, available N, P and K in soil, whose content increments in the needle-leaved forests (8.70%–35.84%) were obviously more than those in the broad-leaved forests (3.73%–10.44%), and in the former, the content increments after replacement with the litter of *Catalpa fargesii* (24.63%–35.84%) were more than those after replacement with the litter of *Quercus aliena* var. *acuteserrata* (8.70% – 28.15%). Furthermore, the litter replacement was found to make the soil pH of needle-leaved forests developed from light-acid to neutral. (3) Litter replacement of the needle-leaved forests with the broad-leaved litter popularly raised enzyme activities, amounts of microorganisms and contents of micro-biomass C and N in soil, the increments of which after replacement with the litter of *Catalpa fargesii* were also more than those after replacement with the litter of *Quercus aliena* var. *acuteserrata*; while the litter replacement of broad-leaved forests with needle-leaved litter resulted differently depending upon the tree species. Among them, the soil enzyme activities and contents of micro-biomass C and N in the forest of *Quercus aliena* var. *acuteserrata* raised while they lowered in the forest of *Catalpa fargesii*.

Keywords planted forest, soil degradation, litter replacement, litter decomposition, biochemical properties of soil, interspecific relationship

1 Introduction

Because of the specialization of biological and ecological properties, selections of nutrient absorption and particularity of environmental effects of tree species in planted pure forests, the soil will deviate from its original equilibrium status and gradually develop toward an unbalanced or extreme condition, which is called soil polarization. Soil polarization will result in decline of forest growth and soil degradation, particularly as trees are getting older or during regeneration after harvest (Liu et al., 2007; Zhu and Li, 2007). Due to its serious influences or even its limit in the sustainable development of forestry, large researches have been carried out to investigate soil degradation in the planted pure forests (Cui, 1996; Ma and Huang, 1997; Wang et al., 2005; He et al., 2006) and many

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countermeasures such as fertilization, renewal of tree species and forestation with different tree species have been proposed (Vitousek and Matson, 1985; Cao and Luo, 1994; Keeves, 1996; Xiao et al., 2002; Xue et al., 2003, 2005; Pang et al., 2004). Among them, fertilization is limited in practical application because of its higher cost (suitable only for culturing the quick grown and intensively-managed forest). Renewal of tree species and mix-forestation are fundamental approaches to control soil degradation of planted pure forests, but they can not meet the urgent needs of forestry production which is featured currently with high time-consumption and low efficiency.

Leaf litters of different tree species will produce different influences on forest soil due to their different substrate qualities and decomposition rates (Dilly and Munch, 1996; Berg, 2000; Vance and Chapin, 2001; Kourtev et al., 2002). So, replacement of litters between needle- and broad-leaved forests (i.e. replacing the litter near tree roots of target forest with the litter of other tree species) will alleviate the soil degradation of planted pure forest in a short period of time. Moreover, because litter can be more easily gathered nearby (such as from road trees or in vacant field and surrounding forests) and the costs are often lower, litter replacement may be one of the available approaches to solve the problem of soil degradation. Therefore, the objectives of our research were to study the influences of litter replacement on soil biochemical properties and explore the feasibility of this approach through litter replacement experiments between needle- and broad-leaved forests. And in the meantime, we discussed the interspecific relationships so as to provide important references for selection of tree species in forest renewal and mix-forestation.

2 Materials and methods

2.1 Site description

The study area is located in the Angou watershed of Zhouzhi County, a branch of the upper reach of Heihe River in Shaanxi Province of China (107°45′E, 33°45′N), which belongs to the north slope of mid-section of Qinling Mountain and warm-temperate bioclimatic zone. The annual precipitation is 900 mm, on the average, in this area and the soil is of the mountain braw type. Natural forests are dominated by *Quercus* trees and the planted forests are mainly composed of *Larix kaempferi*, *Pinus tabulaeformis*, *Catalpa fargesii*, *Quercus aliena* var. *acuteserrata* and *Castanea mollissima*. Four typical plantations of artificial pure forests were selected as the objectives of our study, and their growth as well as site conditions are shown in Table 1.

2.2 Experimental design

In mid-May of 2005, four typical plantations of *Larix kaempferi*, *Pinus tabulaeformis*, *Catalpa fargesii*, and *Quercus aliena* var. *acuteserrata* were selected after a wide survey and 3 groups (replicates) of 3 standard plots of 2 m × 3 m with the same site conditions were established in each plantation along the contour. Among the 3 standard plots in each group, the middle one was taken as control (ck), with a 0.5-m space between one another. After taking away all the litter in 6 uncontrolled plots for every plantation, the litter substitute from other forests (different needle- and broad-leaved tree species) was brought in, with which the plots were evenly covered. The biomass and depth of litter coverage were doubled to its source forests (weighted accurately with portable electronic weighing-scale).

2.3 Experiments of litter decomposition

Yearly, right fallen leaves were gathered and fully dried at 60°C after being rapidly cleaned with water and then a few weighted leaves were put into litter bags of 20 cm × 30 cm sewn with indecomposable nylon nets of 0.5 mm mesh size (15 g per bag for *Larix kaempferi* and *Pinus tabulaeformis*, 10 g per bag for *Catalpa fargesii* and *Quercus aliena* var. *acuteserrata*) which were subsequently laid on the surface of soil in each plot and fixed with clips (the litter in the bags was the same with that of plots after replacement). In total, 36 litterbags were laid in every type of plot.

2.4 Retrieval of litter bags and soil sampling

Since the beginning of the litter decomposition experiment in mid-May of 2005, litterbags were retrieved every 2 months from every type of plot until mid-July of 2007 (a total of 6 times, with 6 litterbags each time). After being rapidly cleaned with water in a nylon sieve of 0.5 mm mesh size, the litter residue was dried at 60°C and then weighed. According to the original and residue weight of litter, the ratio of decomposition was calculated.

When the last 6 litter bags were retrieved from every

Table 1 Experimental forests

forest	age/yr	density/(tree · hm^{-2})	elevation/m	aspect/°	slope/°	BHD/cm	height/m
L. kaempferi	25	1750	1270	NE45	18	13.16	13.4
P. tabulaeformis	22	3056	1300	NE60	10	10.90	11.0
C. fargesii	18	1867	1370	SW50	12	11.40	13.5
Q. aliena var. *acuteserrata*	16	1500	1440	SW70	27	6.63	7.7

type of plot in mid-July of 2007, the soil at a depth of 0–10 cm in every plot of the 3 replicates of the same type was sampled with 5-point-mixing method and then remixed with the soil samples from the other two plots and brought into the laboratory for chemical determination after picking out miscellaneous objects such as leaves, roots and stones.

2.5 Chemical determination of soil

The methods of chemical determination were as follows. Soil organic-carbon (Org-C) was determined with Total Organic Carbon Analyzer (Toc-$V_{CPH/CPN}$). Total nitrogen (N) was determined with semi-minimal Kai's methods—digesting soil samples with H_2SO_4, followed by distillation. pH value was determined with acidity meter (PHS-2). Micro biomass-carbon (MB-C) and nitrogen (MB-N) were determined with suffocating chloroform and K_2SO_4 extract (Lu, 1999). Enzyme activity of urease was determined with the method of Hoffmann and Teicher (Zhou, 1980; Guan, 1986) according to the amount of NH_4-N released through hydrolyzing with urea 3 h after incubation of soil (mg·g^{-1}). Enzyme activity of sucrase was determined using the method of Hoffmann and Seegerer (Zhou, 1980; Guan, 1986) based on the amount of 0.2 mol·L^{-1} $Na_2S_2O_3$ titrated 24 h after incubation. Enzyme activity of catalase was determined with the method of Johnson and Temple (Zhou, 1980; Guan, 1986) based on the amount of 0.1 mol·L^{-1} $KMnO_4$ titrated (mL·g^{-1}). The amount of micro-organisms was determined with spread-plate technique (Nanjing Institute of Soil Science, Chinese Academy of Sciences, 1985).

All the above properties were measured with 3 replicates (measurement error $< 5\%$). Excel 2003 and SPSS 13.0 were applied in data processing and LSD Multiple-Testing Procedure was applied in the significance test between different treatments.

3 Results and discussion

3.1 Influences of leaf litter replacement on its decomposition

Litter decomposition rate is influenced by forest environment including microclimate (Li et al., 2007), soil physiochemical properties (Sun et al., 2007) and micro-organisms (Li et al., 2007) apart from the substrate quality of itself (Yang et al., 2007). So, litter decomposition rate will change certainly when it is replaced to other forestlands (Wang et al., 2007). The dynamics of litter decomposition can be described with a revised exponential model as $R = X/X_0 = a\,e^{-kt}$ (Liu et al., 2006), where R is the ratio of litter residue to its original mass; X_0 and X are residues of litter at the beginning and time t respectively; a and k are constants. According to the model, average annual decomposition rate of litter can be calculated with $d = 1 - ae^{-k}$. The litter decomposition models and annual litter decomposition rates in different litter replacement plots are shown in Table 2.

Table 2 shows that annual decomposition rates of litter in its source forestlands were broad-leaved > needle-leaved, in detail, *Q. aliena* var. *acuteserrata* > *C. Fargesii* > *L. kaempferi* > *P. tabulaeformis*. When needle-leaved litter was replaced with broad-leaved forestland, the annual decomposition rate increased obviously; particularly, the increment of litter decomposition rate of *L. kaempferi* was higher than that of *P. tabulaeformis*, and the increment of litter decomposition rate when replaced with forestland of *Q. aliena* var. *acuteserrata* was higher than that when replaced with forestland of *C. fargesii*, indicating that the forestland of *Q. aliena* var. *acuteserrata* was more beneficial to the needle-leaved litter decomposition than that of *C. fargesii*. Oppositely, when the broad-leaved litter was replaced with needle-leaved forestland, the annual

Table 2 Influences of leaf litter replacement on its decomposition rate

type of litter	plot	decomposition model $\ln R = \ln a - kt$	correlation r	coefficients		annual decay rates	
				a	k	d	Δ%
L. kaempferi	L→C	$\ln R = 4.3445 - 0.2572\ t$	−0.9713	0.7705	0.2572	0.4042	10.28
	L→Q	$\ln R = 4.4401 - 0.3644\ t$	−0.9809	0.8478	0.3644	0.4111	12.15
	L_{ck}	$\ln R = 4.3868 - 0.2382\ t$	−0.9617	0.8038	0.2382	0.3666	–
P. tabulaeformis	P→C	$\ln R = 4.3905 - 0.2401t$	−0.9612	0.8068	0.2401	0.3654	8.35
	P→Q	$\ln R = 4.4295 - 0.2861\ t$	−0.9910	0.8389	0.2861	0.3698	9.66
	P_{ck}	$\ln R = 4.4240 - 0.2302\ t$	−0.9997	0.8343	0.2302	0.3373	–
C. fargesii	C→L	$\ln R = 4.4017 - 0.3105\ t$	−0.9724	0.8159	0.3105	0.4019	−5.38
	C→P	$\ln \mathrm{R} = 4.3936 - 0.2755\ t$	−0.9115	0.8093	0.2755	0.3856	−9.22
	C_{ck}	$\ln R = 4.3860 - 0.3338\ t$	−0.9747	0.8032	0.3338	0.4248	–
Q. aliena var. *acuteserrata*	Q→L	$\ln \mathrm{R} = 4.2535 - 0.3046\ t$	−0.9297	0.7035	0.3046	0.4812	−6.78
	Q→P	$\ln R = 4.2545 - 0.2790\ t$	−0.9254	0.7042	0.279	0.4672	−9.49
	Q_{ck}	$\ln R = 4.2495 - 0.3705\ t$	−0.9811	0.7007	0.3705	0.5162	–

Note: L, P, C and Q represent *L. Kaempferi*, *P. tabulaeformis*, *C. fargesii* and *Q. aliena* var. *acuteserrata*, respectively. L→C means leaf litter of L is relocated to forestland of C, with the same as below. ck means control and Δ% means percent of increment in comparison with ck.

decomposition rate decreased obviously; specifically, the decrement of litter decomposition rate of *C. fargesii* was found near to that of *Q. aliena* var. *acuteserrata*, but the decrement of litter decomposition rate when replaced with forestland of *P. tabulaeformis* was higher than that when replaced with the forestland of *L. kaempferi*, indicating that the forestland of *P. tabulaeformis* was more restrained to the broad-leaved litter decomposition than that of *L. kaempferi*.

3.2 Influences of leaf litter replacement on pH and nutrients content of soil

Different litters had different influences on soil properties due to their different substrate qualities and decomposition rates (Sariyildiz et al., 2005). When litter was replaced from one forestland of tree species to another, it changed the chemical properties of soil of the target forestland while its decomposition rate changed. According to determination results (Table 3), it showed that when forestlands of *L. kaempferi* and *P. tabulaeformis* were recovered by the litter of *C. fargesii* and *Q. aliena* var. *acuteserrata*, the values of soil pH in both forestlands increased, which indicated that the soil developed from partial-acid to neutrol. In addition, all contents of org-C, available N, P and K increased to a different extent. In detail, the increment of the nutrients in the forestland of *P. tabulaeformis* was higher than that of *L. kaempferi*, with higher increment when recovered with the litter of *C. fargesii* than that with litter of *Q. aliena* var. *acuteserrata*.

Meanwhile, when the forestlands of *C. fargesii* and *Q. aliena* var. *acuteserrata* were recovered by the litter of *L. kaempferi* and *P. tabulaeformis*, the values of soil pH in both forestlands decreased, indicating that the soil developed toward partial-acid. In addition, all contents of org-C, available N, P and K increased to a little extent. In particular, the increment of the nutrients in forestland of *Q. aliena* var. *acuteserrata* was higher than that of *C. fargesii*, and the increment when recovered with the litter of *P. tabulaeformis* was higher than that of *L. kaempferi*.

3.3 Influences of leaf litter replacement on enzyme activities of soil

Enzyme activities are very important parameters to measure the biochemical characteristics of soil, because they affect the present status of numerous nutrients as well as the processes of transferring and recycling (Michael and Sten, 2004). The litter replacement is supposed to alter the biological properties of forest soil when its chemical properties changed, which will lead to the variation of enzyme activities. According to the determination results (Table 4), it was shown that when forestlands of *L. kaempferi* and *P. tabulaeformis* were recovered by the litter of *C. fargesii* and *Q. aliena* var. *acuteserrata*, all urease, sucrase and catalase of soil increased to some extent, of which the urease increased the enzyme activity the most, followed by sucrase and catalase. The increment in the forestland of *P. tabulaeformis* was higher than that in the forestland of *L. kaempferi*. Additionally, the increment when recovered with the litter of *C. fargesii* was higher than that of *Q. aliena* var. *acuteserrata*.

When the forestlands of *C. fargesii* and *Q. aliena* var. *acuteserrata* were recovered by the litter of *L. kaempferi* and *P. tabulaeformis*, different forestlands reacted very differently. In detail, the enzyme activities of soil in the forestland of *C. fargesii* decreased totally, whereas those in the forestland of *Q. aliena* var. *acuteserrata* increased totally. In the forestland of *C. fargesii*, the increment when recovered with *L. kaempferi* was higher than that recovered with *P. tabulaeformis*. In the forestland of *Q. aliena* var. *acuteserrata*, the increment when recovered with

Table 3 Influences of leaf litter replacement on pH and content of nutrients in soil

forest	plot	pH		org-C/(g·kg^{-1})		available N/(mg·kg^{-1})		available P/(mg·kg^{-1})		available K/(mg·kg^{-1})	
		P	Δ%	P	Δ%	P	Δ%	P	Δ%	P	Δ%
L. kaempferi	C→L	6.25	6.11	2.86	31.92	50.25	24.63	4.33	26.87	130.15	28.99
	Q→L	6.17	4.75	2.75	26.85	44.67	10.79	3.71	8.70	112.34	11.34
	L$_{ck}$	5.89	–	2.17	–	40.32	–	3.41	–	100.90	–
P. tabulaeformis	C→P	6.18	7.11	3.18	35.84	51.45	27.60	6.85	28.93	133.38	30.61
	Q→P	5.98	3.64	3.00	28.15	46.03	14.16	5.92	11.42	116.20	13.79
	P$_{ck}$	5.77	–	2.34	–	40.32	–	5.31	–	102.12	–
C. fargesii	L→C	6.54	−3.68	4.14	3.84	60.67	3.18	6.95	3.73	109.21	4.86
	P→C	6.37	−6.19	4.37	9.61	63.89	8.66	7.32	9.25	116.37	11.73
	C$_{ck}$	6.79	–	3.99	–	58.80	–	6.70	–	104.15	–
Q.aliena var. *acuteserrata*	L→Q	6.10	−2.71	3.98	4.90	54.75	6.27	6.08	5.01	117.28	5.97
	P→Q	5.92	−5.58	4.19	10.44	56.23	9.14	6.35	9.67	122.07	10.30
	Q$_{ck}$	6.27	–	3.79	–	51.52	–	5.79	–	110.67	–

Note: P represents practical value of determination and Δ% represents percent of increment in comparison with ck. The same for the following tables.

P. tabulaeformis was higher than that recovered with *L. kaempferi*.

3.4 Influences of leaf litter replacement on microbiomes of soil

Microbiomes are the most active biological factors in soil and their types and quantities may directly influence litter decomposition rates, processes of nutrients transformation and their availabilities to trees. So, much attention should be paid to the influences of litter replacement on soil microbiomes (Allen and Schlesinge, 2004). According to the determination (Table 4 and Table 5), it is shown that when the forestlands of *L. kaempferi* and *P. tabulaeformis* were recovered by litter of *C. fargesii* and *Q. aliena* var. *acuteserrata*, both the amount of microbiomes and the content of M-C and M-N in soil increased to some extent, in which, the increment of bacteria was the most, followed by actinomyce and fungi. The increment of M-C and M-N in the forestland of *P. tabulaeformis* was higher than that of *L. kaempferi*. The increment of M-C and M-N was higher when recovered with the litter of *C. fargesii*, than that of *Q. aliena* var. *acuteserrata*.

Oppositely, when the forestlands of *C. fargesii* and *Q. aliena* var. *acuteserrata* were recovered by the litter of *L. kaempferi* and *P. tabulaeformis*, different forestlands had significantly different responses to it. In detail, the content of M-C and M-N of soil in the forest of *C. fargesii* decreased, whereas that in the forest of *Q. aliena* var. *acuteserrata* increased. Additionally, the ammout of bacteria, fungi and actinomyce in the forestland of *C. fargesii* decreased totally, whereas, in the forestland of *Q. aliena* var. *Acuteserrata*, both bacteria and actinomyce decreased while fungi increased.

Table 4 Influences of leaf litter replacement on soil enzyme activities and micro-biomass C and N

forest	plot	urease/($mg\cdot g^{-1}$)		sucrase/($mL\cdot g^{-1}$)		catalase/($mL\cdot g^{-1}$)		MB-C/($mg\cdot kg^{-1}$)		MB-N/($mg\cdot kg^{-1}$)	
		P	Δ%	P	Δ%	P	Δ%	P	Δ%	P	Δ%
L. kaempferi	C→L	8.13	32.88	5.62	17.29	1.78	4.31	715.8	24.57	106.6	22.00
	Q→L	7.68	25.55	5.21	8.91	1.74	1.96	655.5	14.06	99.6	13.91
	L_{ck}	6.12	–	4.79	–	1.70	–	574.7	–	87.4	–
P. tabulaeformis	C→P	8.63	36.36	6.08	20.63	1.81	7.40	597.23	29.41	88.6	28.59
	Q→P	7.98	26.14	5.66	12.30	1.76	4.42	546.3	18.37	79.7	15.72
	P_{ck}	6.33	–	5.04	–	1.68	–	461.5	–	68.9	–
C. fargesii	L→C	6.55	−15.29	3.91	−27.94	1.49	−7.71	867.3	−12.84	142.2	−11.38
	P→C	7.21	−6.79	4.80	−11.48	1.52	−5.72	917.6	−7.78	150.3	−6.36
	C_{ck}	7.73	–	5.42	–	1.61	–	995.1	–	160.5	–
Q. aliena var. *acuteserrata*	L→Q	7.36	12.46	4.68	8.84	1.66	2.24	1227.0	10.95	190.2	10.06
	P→Q	7.75	18.45	4.78	11.12	1.69	4.50	1302.9	17.81	201.8	16.77
	Q_{ck}	6.54	–	4.30	–	1.62	–	1105.9	–	172.8	–

Table 5 Influences of leaf litter replacement on the amount of microbiomes

forest	plot	bacteria/($10^7\cdot g^{-1}$)		fungi/($10^4\cdot g^{-1}$)		actinomyce/($10^5\cdot g^{-1}$)		microorganisms/($10^7\cdot g^{-1}$)	
		P	Δ%	P	Δ%	P	Δ%	P	Δ%
L. kaempferi	C→L	4.68	152.97	17.17	11.13	7.74	67.17	4.77	149.75
	Q→L	4.83	161.08	16.09	4.14	6.77	46.22	4.91	157.03
	L_{ck}	1.85	–	15.45	–	4.63	–	1.91	–
P. tabulaeformis	C→P	3.27	202.78	4.76	24.28	14.23	81.04	3.42	193.96
	Q→P	2.64	144.44	4.37	14.10	12.64	60.81	2.77	138.36
	P_{ck}	1.08	–	3.83	–	7.86	–	1.16	–
C. fargesii	L→C	2.95	−17.37	14.36	−11.03	8.07	−43.53	3.05	−18.34
	P→C	3.25	−8.96	14.98	−7.19	10.18	−28.76	3.37	−9.71
	C_{ck}	3.57	–	16.14	–	14.29	–	3.73	–
Q. aliena var. *acuteserrata*	L→Q	3.23	−15.22	20.14	31.55	12.38	−33.12	3.37	−15.87
	P→Q	3.65	−4.20	22.09	44.28	16.15	−12.75	3.83	−4.41
	Q_{ck}	3.81	–	15.31	–	18.51	–	4.01	–

4 Conclusions

The annual decomposition rate of leaf litter was ranked from broad-leaved litter > needle-leaved litter. When the needle-leaved litter was replaced with the broad-leaved forestland, the annual decomposition rate increased obviously and the forestland of *Q. aliena* var. *acuteserrata* was found more beneficial to the needle-leaved litter decomposition than that of *C. fargesii*. However, when the broad-leaved litter was replaced with the needle-leaved forestland, the annual decomposition rate decreased and the forestland of *P. tabulaeformis* was more restrained to the broad-leaved litter decomposition than that of *L. kaempferi*.

Leaf litter replacement between needle-leaved and broad-leaved forestlands totally raised the nutrient contents of org-C, available N, P and K in soil to a different extent, and their effect to the needle-leaved forestland was very significant than that for the broad-leaved forestland, with better effect when recovered with the litter of *C. fargesii* than that of *Q. aliena* var. *acuteserrata*. In additon, the broad-leaved litter replacement could make the soil of needle-leaved forest develop from partial-acid to neutral, whereas the needle-leaved litter replacement could make the soil of broad-leaved forest develop from neutral to partial-acid.

The enzyme activities, amounts of microbiomes and contents of M-C and M-N of soil increased when the needle-leaved forestland was recovered with the broad-leaved litter, in which the litter of *C. fargesii* was better than that of *Q. aliena* var. *acuteserrata*. However, they varied with different tree species when the broad-leaved forestland was recovered with the needle-leaved litter; in particular, they increased in the forestland of *Q. aliena* var. *acuteserrata*, but decreased in the forestland of *C. fargesii*.

5 Suggestions

Many researches have shown that soil polarization and degradation in planted needle-leaved forests are more serious than those in broad-leaved forests, which is mostly related to the substrate qualities of needle-leaved litter. Therefore, controlling the soil degradation in planted needle-leaved forests is the primary task in the present management of planted forests. Applying the broad-leaved litter replacement to control the soil degradation in needle-leaved forests is an attempt, but much attention should be paid to its practices. Firstly, gathering of needle-leaved litter should not be harmful to the source forestland, which can be avoided through gathering the litter of roadside trees and the litter in vacant field or surroundings of the forestland. Secondly, due to the quantity limitation of gathered litter, the replacement should be carried out near the tree roots. Equally, in the area poor with litter of forests but rich in weeds, the hay of the weeds can be adopted as the substitute for litter, which still needs more experiments to test and verify its feasibility.

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