The Water and Soil Conservative Function of Litter on Forestland

Wang Youmin and ***Weng Junhua***

Northwest science & technology university of agriculture & forestry, Yangling
Shaanxi, 712100，P. R. China
E-mail: wlhauto@263.net

Abstract: The research results on litter in forestland in China were preliminary summarized, include water holding ability of litter and its influence factors, effect of protecting soil from splash erosion, effect of restraining soil evaporation and retarding runoff velocity by forest litter, the anti-scourability of litter, so that to cooperate ecology construction which is developing at present in a large-scale in west China.
Keywords: litter, water holding ability, anti-scourability, soil conservation

Ecology construction is developing in a large scale in west China at present. A lot of protection forest has been established and play an important effect on hydrological ecology and soil conservation. But in some forestlands the litter was often used by people as fuel or stock food, so that the ecological effect of those forests was decreased. In order to bring to public's attention, it is necessary to discuss the important effect of litter on soil and water conservation.

1 Water holding ability of litter

Water absorbing ability of litter is decided by its thickness and property. Litter amount and its water holding ability in different region in China is as Tab.1. The biomass of the litter in the forestland is 10t/hm^2—60t/hm^2. The biomass of litter in the young forestland or thin forestland or in the forestland destroyed by people may be very low. A higher decomposition intensity is the reason having a lower biomass in mountain rain forest and semi-deciduous monsoon rain forest in Hainan island. Weight of litter absorbing water is twice or third as much as its dry weight, sometimes more than forth times in broad leaved forest. The water holding ability of litter is 1mm—5mm, and 10mm at most. The interception by litter is about 20mm—90mm a year.

Water absorption rate is difference with different ground-litter, for instance, the moss is 587%, the soft broad-leaved forest is 386%, the hard broad-leaved forest is 250%, the needle is 172% and the wilting twig of tree and shrub is 152%(Huang Lilong, 1994). The water absorption of moss is very much, so that the moss ground cover can intercept 40% amount of precipitation in Qilian Mountain (Che Kejun, 1994).

The water holding ability is different for the litter decomposed in varying degrees. The proportion of unhumified , half humified and humified layer in evergreen needle forest is 18.8%, 38.8% and 36.0% respectively, the proportion of their storage capacity of water is 18.8%, 56.8% and 24.4% respectively(Liu Lunhui,1990), which indicated that the water storage capacity of half humified layer is highest.

The effect of biomass of forest litter on water conservative ability is to a great extent. For instance, the biomass of litter in evergreen broad leave forest, evergreen needle forest and grass land is 24.7, 21.6 t/hm^2 and 9.1t/hm^2 respectively, and their storage capacity of water is 54.7, 46.6 and 16.3t/hm^2 respectively(Liu Lunhui, 1990), which indicated that the storage capacity of litter in broad leaved forest is higher than that of evergreen needle forest and grassland. The biomass of litter in *Cunninghamia lanceolata* and *Pinus massoniana* stand is 15.86t/hm^2 and 25.47t/hm^2 respectively, their water conservative ability is 4.09mm and 5.12mm respectively(Ma Xuehua,1994). But in *Phyllostaehys pubescens* stand, the biomass of living mulches is 5.09t/hm^2, and the litter is 2.134t/hm^2, the total water holding ability of those two parts is 0.6mm only(Zeng Qingbo,1994).

Table 1 Litter amount and its water conservative ability in different region in China

Region	Forest type	Amount t/hm^2	SW %	WHC* mm	GSI mm	PIP %	Ref.
Daxinganling	Pinus koraiensis Quercus mongolica	9.73 13.34	295.14 315.06	2.3 3.45			[1]
Nichuan, Shaanxi	PoPulus davidiana Pinus tabulaeformis	8.34 17.95	273.1 260.0	2.3 5.1	90.0 47.7	18.9 11.1	[2] [3]
Ziwuling, Gansu	Pinus sp, Quercusliaotung-ensis,Populusd avidiana, Butula platyphylla Ostryopsis davidiana Grass	32.9—62.5 23.2 3.88	6.5—9.99 1.323 0.142				[4]
Liupan Mountains Ningxia	Larix principis-rupprechtii Butula platyphylla Populusd avidiana Quercus liaotungensis	22.3 14.9 13.8 16.5	351.0 328.3 312.8 238.2	7.8 4.2 2.3 3.3	64.5 47.2 35.2 27.9	13.1 9.5 7.2 5.6	[5]
Qilian Mountains	Picea crossifolia Ssbina przewalskii Shrub forest	42.8 6.9 22.9		12.5 1.69 9.25		40	[6]
North Wei River	Robinia Pseudoacacia	13.2—14.2	288.7—541.3		23.4—52.6	3.7—15.3	[7]
Shandong	Platycladus orientalis Pinus tabulaeformis Platycladus orientalis mixed Robinia pseudoacacia Pinus tabulaeformis mixed Quercus acutissima	8.75 7.82 10.27 10.63	268.4 256.6 327.5 296.7	2.3 2.0 3.1 3.0			[8]
Qinling Shaanxi	Pinus armandii Pinus tabulaeformis Quercus aliena	25.8 22.9 18.6	314.8 303.6 414.2	4.85 3.85 4.13	86.2 93.6 83.9	11.3 12.7 11.0	[9]
West Sichuan	Abies sp	13.9—23.7		3.9—7.4			[10]
Jingxi	Cunninghamia lanceolata Pinus massoniana Phyllostachys pubescens	15.86 25.47 2.134		4.09 5.12 ＜0.6			[11] [12]
Hainan	Monsoon rain forest Mountain rain forest	5.1 9.4	208.9 328.4	1.1 3.3			[13]

SW: saturated water. WHC: water holding capacity, among them Qinling is available water. GSI: growth season interception, among them Nichan is annual interception. PIP: percent of interception to annual precipitation.

The relationship between annual interception of litter and the biomass of litter is non-linear correlation. When the biomass of litter increased from 500g/m^2 to 1,000g/m^2 and 1,500 g/m^2 in *Robinia Pseudoacacia* forest with canopy density 0.8, the interception of litter is increased from 23.5kg/(m^2 • a) to 36.51 kg/(m^2 • a) and 49.75 kg/(m^2 • a), in terms of percentage is only 55.4% and 112% increased. Which resulted from the characteristic of litter could permeate water while it absorb water(Wang Youmin, 1994).

1.1 The relationship between water holding ability and rainfall

The litter could absorb all rainfall in *Robinia pseudoacacia* forestland when the amount of litter is 500 g/m^2—625g/m^2 and the rainfall is less than 2.86mm. When rainfall is more than 2.86mm, the leakage water appeared underneath the litter, but the litter is not saturated yet. When rainfall is more than 45mm, the litter will be saturation. All fact above indicated that the amount of the water retaining of litter is increased slower than rainfall(Wang Youmin, 1994). The moss and litter layer in forest of Abies sp will absorb all rainfall in Miyalou mountains, Sichuan province, when rainfall is less than 5mm. The leakage water will appear underneath the litter when rainfall is more than 5mm. The amount of water retaining by

moss and litter will reach to maximum saturated value when rainfall approached 8mm. After that the water retaining began to drop(Ma Xuehua, 1989). So that, water conservative mechanism of litter should be studied deeply.

1.2 Relationship between water holding ability and topography

Degree of slope, aspect and elevation produce a great impact on moisture and thermal regime of surface soil. The evaporation capacity of litter on south slope is more than north slope, so water content of litter on south slope is lower than that on north slope, but the interception is higher. Water will move down along slope, which reducing the water content of litter. At the beginning of rain, water content of litter is low, the impact of slope is not evident. With the increasing of rainfall, the impact of slope on water content of litter is larger and larger. The proportion of saturated water retaining on slope of 30°, 25°, 20°,15° is 1∶1.05∶1.15∶1.28 respectively. The change of proportion is lower than the change of slope, which indicated that the water holding ability of litter is relative stability(Wang Youmin, 1994).

1.3 Estimate of interception by litter

The following regression equation reflect the relationship between interception W(g/m^2) in growth season by litter of *Robinia pseudoacacia* on south loess plateau and rainfall P(mm), canopy density C, slope gradient θ(°), and amount of litter M(g/m^2) (Wang Youmin, 1994).

$$W = 168.93 + 8.51 \ln P + 56.44(1/\ln C) - 539.6(1/\sin\theta) + 3.31M \quad (1)$$

Relationship between interception (I, mm) by litter of Pinus tabulaeformis and rainfall (P, mm) accord with power function (Liu Xiangdong, 1991).

$$I = 0.686\, P^{0.591} \quad (2)$$

2 Retarding effect of litter on evaporation

The effect of litter on retarding evaporation is relative to moisture of soil. It is not evident when the soil moisture is low. Having increased soil moisture and thickness of litter, the effect of litter on restraining evaporation of soil water is increased when the soil moisture is higher than 3/4 of the field capacity. The daily evaporation of soil (during five month in growth season), which is covered by 2cm and 5cm thickness of *Pinus tabulaeformis* litter, is reduced 13.5% and 27.1% respectively than that of the barren land when the soil moisture is 1/2 of field capacity, and is reduced 66.8 % and 77.4% when the soil moisture reaches to the field capacity (Zhao Hongyan, 1992[1]).If the soil moisture is w_0 in the beginning and w_t after time t, we could get $w_t = w_0 - Q_t$, here Q_t is evaporation in time t. The following equation was obtained: (Zhao Hongyan, 1992[2])

$$Q_t = [\, w_0 \cdot e^{kt} - w_0 + Q_0 \,] / e^{kt/l} \quad (3)$$

Here: Q_t—accumulative total evaporation of soil in observation time (g), k—proportional constant, Q_0—integral constant (g)； t—evaporation time (d), l—thickness of litter (cm).

It should be showed, effect of litter on retarding evaporation is restricted by soil moisture and temperature. The decrease of water in soil covered by litter approach that in the same soil without litter, when it is no rain for a long time and the soil is very drought. The difference of evaporation will be negligible whether the soil is covered by litter or not, when it is in low temperature.(Su Ninghu, 1988)

3 Effect of litter on retarding runoff velocity

3.1 Effect of litter on increasing roughness of soil surface

Roughness can reflect the resisting force received by sheet flow on slope. The value of roughness coefficient is inverse proportional to that of C in Chezy formula, so that the roughness coefficient will

impact on velocity of runoff on slope and eroding force, and the afflux time.

The roughness is increased along with the increasing of grass and litter. Roughness coefficient of *Pinus tabulaeformis* and *Robina pseudoacacia* forestland covered by litter is 4.1—4.7 times more than that of farmland(Zhang Hongjing,1995). The roughness coefficient *n* in different vegetation is difference in Granite area Sanxia region. The value of *n* is 0.2282 on mixed forestland of pine with oak, 0.1328 on shrub and grassland, 0.0723 on farmland, and is 0.0544 on barren land.(Zhang Hongjing, 1994[1]) Experiment in laboratory indicated that the relationship between roughness coefficient *n* and amount of litter and withered grass is exponential positive correlation. The impact of litter on roughness coefficient *n* exist a superior limit. If the unit charge is $\leqslant$94ml/(m • s), and the amount of litter reach to 25 t/hm^2—30t/hm^2, impact of litter amount on roughness coefficient *n* should be not present. (Zhang Hongjing, 1994[2])

Beside the amount and property of litter, the thickness of surface soil, soil mechanical composition and content of stone-chip in soil, and porosity of soil have impact on roughness coefficient *n*. The permeability coefficient is higher when the value of *n* is larger.(Zhang Hongjing, 1994[1])

3.2 Effect of litter on retarding runoff velocity

According to the measurement by Wu Changwen(1995), on the slope which slope-length is 60m, the afflux time is 30—40 minute on natural secondary forestland, 10—20 minute on man made forestland, 5.9 minute on barren land. Afflux time is 1.8—7.7 times on forestland than that of on barren land. It is evidently that the effect of litter on retarding runoff.

Effect of the forest litter on retarding runoff velocity is raised with increasing thickness of litters. and shortened along with the increasing of slope gradient and depth of runoff. When the depth of runoff is 1mm, slope gradient is 20°, thickness of litter is 0.5cm, compare the litter of pine with barren land, the runoff flowing out from 1m slope prolonged for 11.6 minute. When the thickness of litter is 3cm, the runoff flowing out prolonged for 15.3 minute(Liu Xiangdong,1991). After statistical analysis, in the forestland of *Populus davidiana* the relationship among time ΔT(s) which the litter prolonged runoff flowing out and thickness of the litter l (cm), slope gradient a (°), depth of runoff q (mm) is as follow:(Zhao Hongyan, 1994)

$$\Delta T = 50.283 l^{0.458} \cdot a^{-0.190} \cdot q^{-0.671} \tag{4}$$

Relationship among retarding runoff velocity ΔV(cm/s) of *Pinus tabulaeformis* litter and slope gradient a (°), depth of runoff q (mm), litter thickness l (cm) is positive correlation completely. Their regression equation is as follow:(Zhao Hongyan, 1991)

$$\Delta V = 17.2 a^{0.365} q^{0.346} l^{0.05} \tag{5}$$

4 Anti-erosionability of litter

4.1 Impact of litter on splash erosion

There is 76.44% or 97.5% decrease of splash erosion when 0.5cm or 1cm thickness of litter covered on the *Populus davidiana* forestland. There is 79.67% or 94% decrease of splash erosion when the *Pinus tabulaeformis* forestland is covered by 1cm or 1.5cm thickness of litter. The splash erosion can be eliminated when there is 2cm thickness of litter on the forestland (Han Bing, 1994).

4.2 Soil conservative ability and storage capacity of litter

According to the experiment, the scouring of discharge produced by 2.2 mm/min –3.6mm/min rain intensity can be resisted by 1cm thickness of litter (Wang Youke, 1991). The index of soil anti-scourability can be expressed by energy to erode 1gram of soil (J/g). When there is 1cm thickness of litter covered, on the forestland of *Pinus tabulaeformis*, *Populus davidiana*, *Hippophae rhamnoides*, *Robinia*

pseudoacacia and *Robinia pseudoacacia*, the ant-scourability is 0.113J/g, 0.1J/g, 0.03J/g, 0.018J/g respectively. When 1cm thickness of litter is covered on the forestlands of *Pinus tabulaeformis* and *Robinia pseudoacacia*, the anti-scourability is 28 and 4 times more than that on farmland. Soil erosion would be eliminated completely when there are 1cm-3cm thickness of litter on the forestland (Wang youke, 1993). Runoff on the forestland of *Populus davidiana* which no litter covered is 2.66 times more than that on the forestland which covered by litter, and soil erosion is 9.15 times more (Wu Qinxiao, 1992). So that, keeping the litter completely is fundamental measure for the soil and water conservation.

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