Soil Erosion of Young Forest Stands at the Slow-Slop Land and the Vegetation Coverage

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Abstract: In order to investigate water and soil erosion in young forest stand which was established on slow-slop land, and to find out the effects of vegetation coverage on soil and water erosion-control, methods as location investigating through setting up 1 000 m^2 runoff plot, combined with simulating rainfalls, were used to calculate and study the affects of vegetation coverage and biological ridge on soil erosion under the young chestnut stand. The results showed:

(1) When the annual precipitation was up to 1 638.2 mm, the annual erosion of read soil on slow-slop land without vegetation coverage was 6.4778 ton per 1 000 m^2.

(2) When rapes and peanuts were companion cropped successively and the rate of vegetation coverage area was of 24.2%, 31.5%, 44.9%, and 58.4% respectively under the forest stand, the annual soil erosion was reduced by 35.4%—57.55%, the runoff coefficient was decreased by 9.04%, and sediment discharge averagely reduced by 40.02%. With every 10% increase of crop coverage, the sediment discharge rate was decreased by 0.0019—0.0027.

(3) The biological ridge within the agro-forest area can reduce the sediment discharge significantly, compared with the control ridge(barren ridge); sediment discharge was decreased 17.02% with ridge of Lalanggrass (*Imperata cylindrical).* So in south China, to inter-plant or plant peanuts and rapes successively and to setup biological ridge with orange daylily and lalanggrass, are the good biological ways to prevent the soil erosion in the young forest stands at the slow slops.

Keywords: young forest stand at slow-slop, water and soil erosion, vegetation coverage, effects

Hill areas with high index of plantation in south China are the developed agriculture area, however the heavy population and small arable area of land has become a serious problem there. So more and more slow-slop land were reclaimed. Since the beginning of "the eighth five-year plan" the total reclaimed slop area was up to 176.67×10^4hm[1].All the newly terrace lands were reclaimed by local forest farmers and were planted with fruit trees, economical trees. The terrace lands were not even and without physical protection. So the reclaimed lands have become the new resource of sediments and sand of river system. To study the model for protecting water and soil at slow-slop lands is very important to the ecological construction.

1 General situation and research methods

1.1 General situation

The experimental land was located at Yinnan fruit and forest farm, Henyang basin of central Hunan, the lower reach of the first branch of Xiang River. It's topography is fragmentary, hills and valleys are distributed complicatedly. The altitude is from 63 to 117 meter; the soil is the terra rossa. The slop angle is about 11—15 degree, which is a typical low hill area. The climate belongs to the subtropical monsoon, and rainy and hot season start nearly at the same time. The total precipitation is 1 300—1 600 mm, which concentrates on April to July, and usually heavy and storm take place. Before the slop land was reclaimed, it was covered with thinning oil tea and mason pine, and then planted with chestnut, after being made into terrace land.

1.2 Methods

Setup of experimental runoff plot: pluvialmetric tube and automatic pluvialmetric instrument were fixed at the experimental area; 7 runoff plots covering 25 m×40 m were constructed at slops of 11—12 degree, which have similar conditions . In the runoff area, there are 2-year old chestnut trees. All the plots but number 2 (as a control) were companion planted different area with peanuts, rapes, or planted them successively. The peanuts were sowed in April 30th of 1997, and harvested on September 10th of the same year. While the rapes were sowed on November 10th of 1997, and harvested on May 1st of 1998. Inter-line planting controlled the planted areas. The exact planted areas at each plot are listed in Table 1.

Table 1 Planted area at each plot under forest

No.	1	2	3	4	5	6	7
Peanut	28.5	0.0	28.8	24.2	39.5	44.9	24.3
Rape	destroyed	0.0	37.2	28.5	51.4	58.4	31.5

Observation contents and methods: ① precipitation: By using of pluvial metric tube and automatic pluvial metric recorder, precipitation amount, raining duration, and raining period information were collected. ② runoff volume and sediment concentration: At 8 o'clock of every morning, runoff volume in the catchments was measured when it rain: to mix the water in catchments thoroughly, then sampled 500ml water, filtered and dryed that, and the sediment concentration was identified; ③ Crop coverage: 12-fixed observation sections (with 4 m^2 area) were established at each runoff plot, data of the area covered with crop's branches and leaves, the height, crown of each plant, and the total coverage were measured and recorded once half month. ④ Biomass and total coverage of crops: When the crops planted in the runoff plots were harvested, the total biomass, upper and under ground part biomass were recorded respectively. The procedure was: harvest, weigh and record fresh biomass, sample, dry, calculate the biomass of each part; record the height of seedling, and the total coverage.

Adjustment of the systematic error at runoff plot: The error was adjusted by using of the data collected from the simulated raining and forestland without crops.

Construction of biological ridge and its effect: By using of self-made precipitation instrument, through simulating, the sediment amount intercepted by biological ridge was measured. Simulate runoff area was measured in 2 m^2. The details are listed in Table 2.

Table 2 Basic information of measured runoff plots

Group	I		II		III	
No.	1	2	3	4	5	6
Slop angle	30	30	4	4	1	1
Bio-ridge	Imperata	ck	Imperata	ck	daylily	daylily
Area	2	2	2	2	2	2
Slop surface	Barren	barren	barren	barren	barren	peanut

Group	IV		V		VI				
No.	7	8	9	10	11	12	13	14	15
Slop angle	1	–2	1	28	25	20	2	3	3
Bio-ridge	ck	daylily	daylily	grass	grass	lichen	daylily	daylily	daylily
Area	2	2	2	2	2	2	2	2	2
Slop surface	peanut	peanut	peanut	barren	natural	natural	natural	natural	natural

Record of simulating rain at runoff plots: The rain was collected and measured with aluminum tube[2] (φ =11 cm), and each runoff plot had 3 tubes. The rain duration was recorded with stopwatch, and the rain intensity was limited to 1.1 mm/min. All the runoff was collected and measured with volumetric tube. The runoff was mixed thoroughly, then sampled 500 ml water, filtered, dried, weighed and calculated the amount of sand.

2 Results and discussion

2.1 Effects of companion cropped coverage under young forest stand on the annual soil erosion

The recorded data of crop coverage and amount of runoff, the exact sediment concentration in the runoff from May 4th of 1997 to May 4th of 1998 were listed in the Table 3. The table indicated that: ① In the 3rd year after the slop lands were prepared, when the annual precipitation was up to 1 638.2 mm, and the annual soil erosion under the young chestnut forest was up to 6.4778 t/1 000 m^2. ② To companion crop(whatever crop patterns were used) along the slop can reduce the sediment discharge effectively, and the annual soil erosion was decreased by 35.49% to 57.55% with the increase of coverage rate. ③ The total coverage rate at different plots resulted in quite different effect of soil protection. When plots covered with peanuts (the exact coverage rate was 44.9%) in summer and rapes (58.4%) in the spring, the sediment discharge was decreased by 57.55% compared with the control plot (without coverage), and the soil erosion of unit area was 2.7496 t/1 000 m^2; When the coverage rate of peanut was 24.2% and rape 31.5%, and the sediment discharge was 41.97% larger than that covered with 44.9% peanuts and 58.4% rapes, and the soil erosion of unit area was 3.9096 t/1 000 m^2. ④ Whichever companion cropping patterns were used, the sediment discharge was still comparatively large, in the third year after the slop lands were prepared. The sediment discharge amount was about 2.7496 t—4.1784 t/1 000 m^2, so the reclaimed slop lands was the majority resource of sediment. Even the 2 –season crop cover would not control the soil erosion at the plots to the permission range, but can reduce the discharge greatly and protect the soil perfectly. In order to limit the sediment discharge, other methods should be taken, besides the crop coverage, to increase the plant’s capacity for intercepting sediment.

2.2 The effect of plant coverage on the runoff coefficient and sediment discharge rate

The runoff coefficient and rate of sediment discharge are very important Indexes of reflecting the protect capacity of runoff area. The table showed that: ① the average runoff coefficient from the 6 companion cropping sites was 0.312, which was decreased by 9.04% compared with that in the control area. Through intercepting sediment by branches and leaves and fixing soil with roots, the crop can effectively improve the soil’s permeability and increase the water intercepting. Among the 6 sites, only number 4 runoff plot’s coefficient was decreased (because the high quality of tunnel around the site), the others’ change was little. ② The average rate of sediment discharge at the 6 sites planted with crops under the forest, was 0,00691, which was decreased by 40.02% than that from the control site. The range of change was from 0.00508 to 0.00814, and the ratio of the smallest sediment discharge to the biggest one was 60.02%. The lowest sediment discharge was 55.90% smaller than that from the control. The effect of crop cover under the young forest on reducing sediment discharge was much greater than on decreasing runoff coefficient. The sediment discharge was very sensitive to the change of crop coverage. And the crops under the young forest can improve effectively the resistant ability of the forestland.

Table 3 Water and soil erosion from May 4th of 1997 to May 4th of 1998

No.	Companion cropping ent discharge rate	total coverage	Annual runoff $M^3/1\ 000m^3$	runoff coefficient	soil erosion amount of erosion $t/1\ 000m^3$	Control(ck) +–%	sediment discharge rate	Rapes in winter and spring
1	Peanuts in summer and autumn rape in spring(destroyed)	28.5	513.44	0.313	4.1784	–35.49	0.00814	
2	Control	0	562.52	0.344	6.4778	100	0.01152	
3	Peanuts in summer and autumn	28.8	499.21	0.305	3.6372	–43.85	0.00729	37.4
4	Peanuts in summer And autumn	24.2	454.85	0.278	3.4759	–46.34	0.00764	28.5
5	Peanuts in summer And autumn	39.5	529.22	0.323	3.1647	–51.15	0.00598	51.4
6	Peanuts in summer And autumn	44.9	540.75	0.330	2.7496	–57.55	0.00508	58.4
7	Peanuts in summer And autumn	24.2	532.37	0.325	3.9036	–39.74	0.00733	31.5

Note: The annual precipitation was 1 638.2 mm quoted in the table

2.3 The effect of companion cropping pattern on the water and soil erosion

Peanuts and rapes were companion planted successively was the main pattern we selected. Rapes were sowed in October, which covered the lands in the spring of next year, and would be harvested in May of next year, while peanuts were sowed at the end of April. The rapes were sowed with wide space of line and small space between each plant. Before 10 to 15 days o harvesting rapes, peanuts were planted at inter-line. When the rapes were harvested, the peanuts had grown out for 7 to 10 days. After one month of growing out of the soil (about at the end of May), the coverage was up to 50%. The coverage increased with the growth of peanuts, from the end of June to the beginning of August, the coverage was up to 80%. This kind of companion cropping pattern can reduce the difference duration between the two species sowing time, which decreased the duration of nude land. At the experimental area, the rainy season is from April to July, the companion (or successive) cropping of peanuts and rapes covering the land surface in rainy season, can protect water and soil. When the exact planting area of peanuts and rapes were up to 45% and 58% respectively, the coverage increase every 10 %, the sediment discharge rate would decrease by 0.00190 to 0.0027. With the increase of coverage of peanuts the sediment discharge was decreased. The peanuts were good for protection of water and soil.

2.4 Biological ridges and the function of sediment intercepting

The biological ridge can intercept sediment physically, with the increase of precipitation, the runoff was formed, the runoff was blocked by the of ridge base. And the flow of runoff is slow down. The branches flowing with runoff would accumulate, and accumulate more and more. Through branches filter the suspending material and moving material contained in the runoff were greatly decreased, so that the sediment was intercepted, which reduce the surface erosion by runoff, and protect soil and intercept sand. The simulated calculated data were listed in Table 4.

Table 4 Effects of biological ridge on the runoff coefficient and sand concentration

Experiment No.	1	2	3	4	5	6	7	8
Precipitation	70.4	56.66	51.03	50.48	49.41	49.77	49.41	26.49
Runoff Coefficient	0.37	0.36	0.35	0.35	0.34	0.35	0.35	/
Runoff (mm)	26.05	20.4	17.96	1.67	17.59	17.42	17.29	
Sand concentration/kg	20.5	26.5	17.0	25.9	22.4	20.1	27.9	no flow
Experiment No.	9	10	11	12	13	14	15	Average
Precipitation	37.24	55.85	19.69	24.44	34.73	44.13	77.3	
Runoff Coefficient	0.34	0.4	0.34	0.34	0.35	0.36	0.37	0.331
Runoff (mm)	16.32	22.89	17.59	8.31	12.16	15.85	28.6	
Sand concentration/kg	22.1	24.0	28.1	21	22.0	20.00	2.02	21.17

Data listed in Table 4 showed that:① the sedument concentration in the simulated raining plots without biological ridge(number 2, 4, 7, 10, 11) was 26.48%, while the plots (number 1,3 5, 6, 9) with biological ridge, the sediment concentration was 20.42%, which was much lower than that without biology ridge. The runoff coefficient at the simulated raining plots without biological ridge was 0.36, and 0.35 for plots with biological ridge, which was 2.78% less than that in plots without biological ridge. So the function of biological ridge to reduce the sediment concentration is much greater than that to reduce runoff coefficient. ② Different kind of biological ridges and biological ridge at slop with different conditions have different sediment intercept capacity. At 20 to 30 degree slop with biological ridge, the sediment concentration in the runoff was 20.5 g/kg, while the slop at 2 to 4 degree with biological ridge, the sediment concentration was 17.0 g /kg, which reduced 2.44%, and 17.07 % respectively. At slops having similar conditions, the sediment concentration at the slops with lalanggrass, orange daylily, lichens, grass biological ridge and barren ridge were respectively 17.0 g/kg, 20.2 g/kg, 21.00 g/kg, 24.00 g/kg and 28.10 g/kg, so the difference is oblivious.

2.5 The effects of biological ridge on duration of starting runoff and soil erosion

Data from experimental plots of number 5, 6, 7, whose slop degree, soil's water concentration before raining, duration of starting runoff, rainfall amount were very close, were listed in Table 5. That showed: Compared the orange daylily ridge with the barren one, the duration of starting runoff was extent 93.08 %, the sediment production decreased by 13.06% averagely. So the biological ridge can extend the duration of start runoff, and decrease the soil erosion.

Table 5 Comparison of runoff, sediment characteristics in three experimental plots

No.	Terrance slop (degree)	water content%	rainfall volume (mm)	raining duration (min)	starting time of runoff(min)	runoff volume (kg)	sediment production	coeffi -cient
5 (orange daylily)	1	6.13	49.44	44	13.5	17.59	395	0.34
6 (orange daylily)	1	6.87	49.77	45	11.6	17.42	384	0.35
7 (barren)	1	6.88	49.41	44	6.5	17.29	448	0.35

3 Conclusion and analysis

(1) The reclaimed red soil slow-slop lands in south China is one of the important resource of sediment, when annual precipitation volume was up to 1 638.2 mm, the soil erosion at the slow- slop lands (in the third year after it was reclaimed) was 6.4778 t /1 000 m^2.

(2) When the planted area with peanuts and rapes under the young forest stands reached 24.2%—58.4% of total area, the annual soil erosion would be decreased by 35.49%—57.55%, and the sediment discharge reduced 40.2% averagely. The amount of annual erosion still change within 2.7496 t/1 000 m^2— 3 9036 t/1 000 m^2, with the change of crop coverage.

(3) When change of coverage area was from 24.2% to 58.4%, the sediment discharge would decreased by 0.0019—0.0027 with every 0.1 degree increase of coverage. The sediment discharge is sensitive to the coverage change.

(4) The biological ridge of terrace can intercept sediment effectively. Different degree slop with different biological ridge have different effect on the sediment intercepting. Orange daylily and lalanggrass ridges were the good models for protecting water and soil erosion at young forest stand , in South China.

Reference

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