A Study on Variation of Soil Microbial Activity Following Deforestation

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Abstract: Soil microbial activity is an indicator reflecting soil properties. Deforestation enhances soil loss and soil degradation. This paper concentrates to study on variation of soil organic matter, micro-biomass carbon, microbial population and soil enzyme at the up-slope, middle-slope and down-slope of hillslope in the Loess Plateau after forest vegetation destruction. The results showed that after seven years following deforestation, soil organic matter, soil micro-biomass carbon, microbial population, population of soil bacteria, actinomyces, fungi from 60cm depth of soil profile decreased at upslope, middle-slope and down-slope of hillslope, as compared to five years deforestation, especially in the 25cm depth of soil profile. Likewise, after seven years of forest vegetation destruction, surcease, neutral phosphatase also decreased, as compared to five years of deforestation. Due to micro-topography impact, soil organic matter, micro-biomass carbon, population of soil bacteria, actinomyces, fungi, and neutral phosphatase at shallow gully channel was greater that those at shallow gully slopes. The research results demonstrate that deforestation caused that soil microbial activity obviously decreased.
Keywords: vegetation destruction, soil microbial activity, the loess plateau

1 Introduction

Soil microbial activity is an indicator reflecting soil properties, soil microbial population and soil enzyme activity not only reflect soil fertility, but also reflect soil environmental conditions. The Ziwuling secondary forest area is sole forest region in the Loess Plateau. The numerous studies in this region have been made on soil erosion and eco-environmental change (Tang *et al*., 1993), soil erosion process following deforestation (Zheng *et al*., 1993), and soil erosion and soil nutrient loss (Bai *et al.*, 1993, Zheng *et al.*, 2000), soil microbial change before and after deforestation (Shi *et al*., 1998), and soil microbial population, soil biomass carbon before and after deforestation (Zhang *et al*., 1996 and 1998), with fruitful achieved. However, little attention has been paid to studying soil microbial activity and population, and soil enzyme activity following deforestation.

The objective of this paper is to study soil microbial population, soil enzyme activity in different slope locations of shallow gully detachment after conversion of woodland to cropland and discuss relationship between soil erosion and soil microbial activity.

2 Materials and methods

2.1 Study site description

The field study was conducted at Soil Erosion and Eco-environment Observatory, located on the eastern slopes of the Ziwuling secondary forest in the central Loess Plateau. The geographical location is latitude 33°50′—36°50′ N and longitude 107°30′—109°40′ E. Annual temperature is 6℃ to 10℃, precipitation 600 mm to 700 mm in which 60% falls from June to September. Landscape is hilly-gully landforms with an average gully density of 4.5 km per km^2. The soil surface in the forest is covered by litter 2 cm to 5 cm thick. The gray forest soil has an obvious organic horizon, well aggregated with a dense rooting system. However, leaching and illuvial horizons are not observed.

2.2 Soil sample collection

Soil samples were collected from a hillslope in the Soil Erosion and Eco-environment Observatory. Conversion of this hillslope from woodland to cropland was in 1990. According to different slope locations and micro-topography on the hillslope, soil samples collected from different slope locations of up-slope, middle-slope and down-slope, and shallow gully channels and shallow gully slope. The sampling date was in May 31, 1995 and May 25, 1997, respectively, that is five years and seven years following deforestation, respectivitly. Sampling depth was 60 cm, divided by four layers according to soil pedo-genesis horizon. Each fresh soil sample was stored in an aluminum container, which was disinfected. These soil samples were used to soil microbial population. The rest of soil samples were dried by air and used to analyze soil organic matter, soil microbial biomass , and soil enzyme.

2.3 Laboratory analysis

Bacteria was cultured by Beef-extract-proteose-agar medium, actinomyces by starch- ammonium-agar medium, both of them were measured by smearing-plate method. Fungi were cultured by Martin medium and inoculated by compound medium and diluted simple suspension.

Soil organic matter was analyzed by $K_2Cr_2O_7$ digestion and titration (Nanjing Institute of soil Science, 1978), soil microbial biomass carbon was measured by chloroform fumigation (Jenkinson, 1976 Re. Xu and Zheng, 1986). Soil sucrase was determined by titration，its activity was expressed by 1N $Na_2S_2O_3$ mg/(g • 24h). Urease was measured by photometric method，and its activity was expressed by NH_3-N mg/(g • 24h). Neutral phosphatase was analyzed by photometric method, it activity was expressed by phenol mg/(g • 24h) (Zhou, 1987, K.Alef., 1991).

3 Results and discussions

3.1 Variations of soil microbial activity in different slope locations following deforestation

3.1.1 Soil microbial population and enzyme activity

Soil microbe is a driving force for soil material transfer and cycle, rich in soil organic horizon. Table 1 showed that population of bacteria, fungi and actinomyces were decreased as soil profile depth increased. As compared to five years after deforestation, the three kind microbe of bacteria, fungi and actinomyces after seven years of deforestation obviously reduced in the 25 cm of soil profile, especially in 10 cm of soil profile. The reason was attributed to severe topsoil loss after vegetation destruction.

Table 1 Variation of soil microbe population distribution of soil profiles at different slope locations following deforestation

Slope locations	Soil depth (cm)	Bacteria ($\times10^6$/g)		Fungi ($\times10^3$/g)		Actinomyces ($\times10^5$/g)	
		5 years	7 years	5 years	7 years	5 years	7 years
Upslope	0—10	59.17	14.9	56.51	8.03	27.9	13.75
	10—24	37.11	5.69	34.44	7.47	24.4	13.87
	24—39	0.96	3.56	4.18	2.10	7.40	6.40
	39—60	0.29	2.14	1.21	3.53	4.70	5.14
Middle-slope	0—10	50.31	6.91	29.07	5.46	45.20	11.68
	10—25	62.80	3.63	18.82	4.79	31.00	13.60
	25—50	1.05	3.68	4.68	2.58	7.60	7.95
	50—60	0.69	5.20	0.79	3.49	6.50	4.83
Down-slope	0—7	199.2	91.79	39.11	5.44	47.4	5.15
	7—20	40.18	82.06	27.65	2.42	23.6	4.03
	20—40	3.22	44.84	4.63	2.43	9.00	1.72
	40—60	2.05	37.37	1.36	2.61	8.00	1.61

Soil bacteria on down-slope were higher than that on the up-slope and middle-slope. Distribution of soil fungi in the upslope was greater that that on the middle-slope and downslope. Soil actinomyces on middle-slope and down-slope was greater than that on the up-slope. Soil bacteria population exists in soil with single cell, easily adheres to soil particle, so it is easy to move with soil particle transport. Soil bacteria moved to down-slope demonstrated that eroded sediment occurred to deposit on down-slope while it was transport to down-slope. Because fungi and actinomyces have mycelium, both of them move to down-slope slowly, as compared to bacteria.

Soil enzyme activity and soil microbe were closely related to soil nutrient. Table 2 showed that soil sucrase, urease and neutral phosphatase decreased as years of deforestation and soil profile depth increased. Three kinds of soil enzymes distributed differently at different slope location due to their different behaviors. Soil sucrase activity was not obviously different at the upslope, middle-slope and down-slope after five and seven years of deforestation. However, soil urease and neutral phosphatase were obviously different at the upslope, middle-slope and down-slope. Soil urease had not obviously moved along slope length after five years of deforestation.

Table 2 Variations of soil enzymatic activities of soil profiles in different slope locations following deforestation

Slope location	Soil depth (cm)	Sucrase (0.1N $Na_2S_2O_3$ mg/(g • 24h))		Urease (NH_3-N mg/(g • 24h))		Neutral Phosphatase (phenol mg/(g • 24h))	
		5 years	7 years	5 years	7 years	5 years	7 years
Upslope	0—10	3.11	1.84	0.73	0.56	3.76	0.27
	10—24	1.30	0.52	0.61	0.30	1.14	0.087
	24—39	0.15	0.21	0.30	0.096	0	0.053
	39—60	0.18	0.13	0.28	0	0	0
Middle-slope	0—10	2.05	2.01	0.45	1.29	3.68	0.32
	10—25	0.61	0.26	0.25	0.46	1.98	0.12
	25—50	0.24	0.10	0.21	0.13	0.27	0.024
	50—60	0.17	0.13	0.13	0.047	0.16	0
Down-slope	0—7	2.10	1.80	0.37	0.71	4.14	0.024
	7—20	0.88	0.24	0.18	0.15	1.82	0.057
	20—40	0.56	0.17	0.12	0	1.52	0
	40—60	0.33	0.17	0.17	0.033	1.59	0.025

After seven years of deforestation, soil urease deposited along the slope length. Soil neutral phosphatase was not different at different slope locations after five years of deforestation. After seven years of deforestation, soil neutral phosphatase at down-slope obviously decreased. These results showed that effects of soil erosion on soil urease and neutral phosphatase were greater than that on soil sucrase.

3.1.2 Soil organic matter and soil microbial biomass

Soil organic matter is an indictor of soil fertility. Soil microbial biomass carbon (Bio-C) only takes a little part of soil carbon, but, Bio-C, which is the most active section of soil organic matter (Moor et al 2000, Yu et al 1999), not only reflects soil nutrient availability and soil microbial activity, but also reflects soil environmental condition. Table 3 showed that as compared to five years of deforestation, soil organic matter at up-slope and down-slope obviously reduced after seven years of deforestation, and soil organic matter at the middle-slope was not significantly different. It was seen from Table 3 that soil organic matter decreased with soil profile depth. Soil microbial biomass carbon had the same trend as the soil organic matter.

3.2 Effects of micro-topography of shallow gully on soil microbial activity

3.2.1 Soil microbial population and enzymatic activity

Table 4 showed that soil microbial population decreased as soil profile depth increased in shallow gully channel and at shallow gully slope. Three types of soil microbes in shallow gully channel were greater than at shallow gully slope. This reasons could be attributed to deeper soil organic matter horizon in shallow gully channel than that at shallow gully slope, and eroded sediment from shallow gully slope deposit in shallow gully channel (Zheng, Gao,2000)

Table 3 Variations of soil organic mater and microbial biomass carbon of soil profiles in different slope locations

Slope locations	Soil depth (cm)	Organic mater, g/kg		Microbial biomass carbon mg/kg	
		5 years	7 years	5 years	7 years
Upslope	0—10	22.40	17.45	1,058.8	370.38
	10—24	12.50	8.04	548.01	229.71
	24—39	3.68	5.55	333.29	94.53
	39—60	3.33	5.02	180.08	72.59
Middle-slope	0—10	18.40	17.29	687.3	758.18
	10—25	9.44	8.15	421.89	503.30
	25—50	5.60	6.21	214.72	289.07
	50—60	4.70	5.38	309.52	287.14
Down-slope	0—7	20.40	16.21	780.48	440.59
	7—20	10.80	6.57	425.93	175.94
	20—40	9.20	6.03	77.89	124.17
	40—60	9.08	5.50	338.37	132.51

Table 4 Soil microbial population distribution of soil profiles

Soil depth (cm)	Bacteria($\times 10^6$/g)		Fungi ($\times 10^3$/g)		Actinomyces ($\times 10^5$/g)	
	Shallow gully channel	Shallow gully slop	Shallow gully channel	Shallow gully slop	Shallow gully channel	Shallow gully slop
0—10	238.80	91.79	6.99	5.44	8.25	5.15
10—20	93.61	82.06	3.50	2.42	13.84	4.03
20—40	36.64	44.84	1.13	2.43	4.68	1.72
40—60	21.70	37.37	0.79	2.61	1.88	1.61
Average	97.69	64.02	3.10	3.23	7.16	3.13

Table 5 showed three kinds of soil sucrase, urease and neutral phosphatase in shallow gully channel and at shallow gully slope decreased as soil profile increased. Distribution of soil enzyme activity in shallow gully channel and at shallow gully slope was dependent on types of soil enzyme. Soil Neutral phosphatase in the shallow gully channel was higher than that at shallow gully slope. And soil sucrase and urease was not different in shallow gully channel and on shallow gully slope. This reason could be attributed to distribution of soil particle and soil microbial population, which exuded the certain kinds of soil enzymes to soil body (Li, 1990).

3.2.2 Soil organic matter and soil microbial biomass carbon

Table 6 showed that soil organic matter and soil microbial biomass carbon in the shallow gully channel were greater than those on the shallow gully slope. This demonstrated that soil particle movement by water flow not only caused fertile topsoil loss, but also caused reduction of soil fertility and soil microbial activity.

Table 5 Soil enzymatic activities of soil profiles in shallow gully channel and slope

Soil depth (cm)	Sucrase (0.1N $Na_2S_2O_3$ mg/(g • 24h))		Urease (NH_3-N mg/(g • 24h))		Neutral Phosphatase (phenol mg/(g • 24h))	
	Shallow gully channel	Shallow gully slop	Shallow gully channel	Shallow gully slop	Shallow gully channel	Shallow gully slop
0—10	1.620	1.800	0.721	0.712	0.081	0.024
10—20	0.460	0.240	0.244	0.154	0.097	0.057
20—40	0.150	0.170	0	0	0.016	0.000
40—60	0.160	0.170	0	0.033	0.016	0.025
Average	0.598	0.595	0.241	0.225	0.053	0.027

Table 6 Variations of soil organic mater and microbial biomass carbon of soil profiles in shallow gully channel and slope

Soil depth (cm)	Organic mater (g/kg)		Microbial biomass carbon (mg/kg)	
	Shallow gully channel	Shallow gully slop	Shallow gully channel	Shallow gully slop
0—10	17.13	16.21	687.20	440.59
10—20	10.20	6.57	480.72	175.94
20—40	6.53	6.03	310.37	124.17
40—60	5.98	5.50	258.10	132.51
Average	9.96	8.58	434.10	218.30

4 Conclusions

This paper focused to study on variation of soil organic matter, micro-biomass carbon, microbial population and soil enzyme on different slope locations on a hillslope of the Loess Plateau after conversion woodland to cropland. The following results were obtained:

Conversion of woodland to cropland caused an obvious decrease of bacteria, fungi, actinomyces, soil organic matter, soil microbial biomass carbon in topsoil layer as years of deforestation increased, especially at 25 cm soil profile. Soil sucrase, urease and neutral phosphatase distributed differently at different slope locations due to their different behaviors. Effects of soil erosion on soil urease and neutral phosphatase were greater than on soil sucrase.

Hillslope micro-topography of shallow gully channel and shallow gully slope greatly affected soil erosion, deposit and transport processes, especially eroded sediment from shallow gully slope moved to shallow gully, and then was transport by shallow gully concentration flow. Therefore, soil bacteria, fungi and actinomyces, soil organic matter, soil microbial biomass carbon in the shallow gully channel were greater than those on the shallow gully slope. Distribution of soil enzyme activity in shallow gully channel and on shallow gully slope was dependent on types of soil enzyme. Soil neutral phosphatase in the shallow gully channel was higher than that at shallow gully slope. And soil sucrase and urease was not different in shallow gully channel and on shallow gully slope.

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