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EFFECTS OF HILLSIDE FIELDS MANAGING PATTERNS ON THE VEGETATION AND SOIL ENVIRONMENT IN THE LOESS PLATEAU, CHINA

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Abstract

The present study was aimed to assess the effects of different hillside fields managing systems (slope-separated terrace (SST), large terraced field (LTF), large fish-scale pit (LFP)) on the vegetation and soil environment. The results showed that after 10-years development of hillside fields engineering management could effectively enhance the rainfall acceptance ability of the hillside fields and improve soil microbial community diversity. The plantation with stronger roots and high water consumption improved the development of dry soil layer on the basis of the management in the slope fields. Meanwhile, SST was the best managing mode, whose soil moisture was significantly higher than others in the order of SST > LTF > LFP > control. The projected area of plant canopy and vegetation coverage in SST increased by 21.1 and 1.1% than LTF, 26.4 and 13.5% than LFP and 37.4%, 43% than control, respectively on the base of same plantations. Furthermore, Biolog analysis revealed that average well color development (AWCD), functional diversity indices of microbial communities, and the relative substrate utilization of carbon sources were the highest in SST, as well as whose economic and ecological benefits were obvious.

Introduction

The first sub-region of the Loess Plateau, China is located in the south sand area along the Great Wall, in the vast area of north hilly area of the Loess, which is the most serious soil erosion region in Loess Plateau (Zhang *et al.* 2007, Fu *et al.* 2011, Bianchi *et al.* 2015). The steep slope in this area accounts for about 70% of the total area. The soil is loose and easy to be eroded. It has a special water environment and erosion process. It is ecologically fragile and soil erosion is serious. Therefore, many workers have carried out more in-depth studies about this hoping to find remediation measures. Consequently, Fu *et al.* (2009) reported the rainfall runoff of hillside fields in the Loess Plateau and pointed out that the slope length and the rainfall were the main factors of Loess Plateau hillside fields sediment yield, vegetation cover could significantly reduce the erosion process. Furthermore, Gao *et al.* (2017) studied that the erosion reduction of hillside fields vegetation in the region, artificial arbor tree species location allocation programs and evaluation criteria, provided the basis for reducing the erosion and improving the soil environment. Jiao *et al.* (2012) suggested that the enhancing hillside fields vegetation coverage by planting vegetation is one of the effective measures to reduce soil erosion and prevent further deterioration of the ecological environment.

Previous studies have shown that hillside fields management engineering and forest-grass combination could effectively improve the erosion resistance of hillside fields (Belen *et al.* 2016, Bell *et al.* 2016, Bararunyeretse *et al.* 2017). It was also pointed out that different vegetation types have different water consumption ways and their performances and vegetation are important factors

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affecting soil moisture change (Ladygina and Hediund 2010). In another study conducted by Cheng *et al.* (2017) explored the simple combination of forest and grass and did not pay attention to reasonable hillside fields management engineering. Other study also showed that the main effect of plants on the soil environment was to change the characteristics of soil microbial communities, and the effects of different restoration vegetation on soil microbes were also different (Jia *et al.* 2017). Therefore, the study of vegetation, soil environmental effects and the relationship between microbes can better understand the improved situation of vegetation restoration on soil environmental effects. Sheng *et al.* (2017) considered only the impact of *Robinia pseudoacacia* on soil environment, but did not consider a reasonable hillside fields management engineering. In the present study the managing patterns, vegetation restoration effect and soil moisture change were studied with a view to investigate the effects of soil environmental factors. The functional diversity of soil microbial communities was studied by using Biolog-Eco microplate culture method, with a view to provide a theoretical basis for the restoration of hillside fields vegetation in the region and the improvement of soil environment.

Materials and Methods

The experiment was carried out in between 2004 and 2016 in the test base of the Loess Plateau Control Institute of Quanjiagou Village of Mizhi County, Shaanxi province. The area of hillside fields is 15 hm^2 with a slope of 20 to 25. Slope direction is south west, and elevation is 1000 m to 1100 m, which is typical of the Loess Plateau and gully landform. It belongs to a semi-arid warm temperate climate and vegetation regionalization is warm temperate forest steppe zone. The annual mean temperature is 8.8°C and the absolute maximum temperature is 38°C, the absolute minimum temperature is –35°C, and the accumulated temperature of this area more than 10 is 3281.0°C, sunshine duration is 2372.7 h/a. The frost-free period is 160 d, with annual mean rainfall of 400 mm, more concentrated in the 7, 8, 9 for three months. In the form of rainstorm, the three months of rainfall accounted for 70% of the annual precipitation. The dryness is 1.14. The soil in the test area of loessial soil, soil profile development is not clear uniform and of good permeability. Most of the hillside fields vegetation is dysplasia, severe erosion, coverage of about 20%.

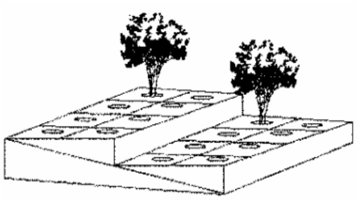

Fig. 1. Large terraced field Measuring methods.

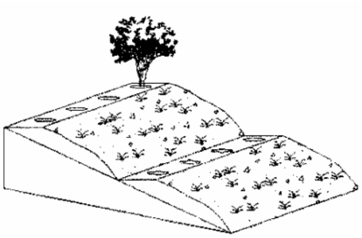

Fig. 2. Slope-separated terrace.

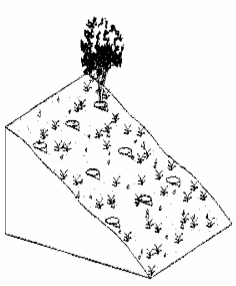

Fig. 3. Large fish-scale pit.

In the test area, 20 - 25° hillside fields of a piece, an area of 5 hm^2 were selecting. Setting three treatments in the winter of 2004: large terraced field (LTF), slope-separated terrace (SST), large fish-scale pit (LFP) (Figs 1-3). The same forest, grass and intercropping patterns were set-up in each treatment. LTF was consisted of terraces with 2 m - 3 m width, whose length varied by landscape. Within LTF, the ridges were built by 1 m × 2 m or 2 m × 2 m to prevent the formation and flow of runoff; SST was composed of terraces with 1 - 1.5 m width and 2 m - 3 m natural slopes, within terraces of SST, the horizontal ridges were built every 1 - 1.5 m to prevent lateral flow of runoff; LFP was planting pit excavated by 1 m diameter based on the slope directly. In the spring of 2005, trees and grass species were planted in each treatment area according to experimental design. The tested tree was *Robinia pseudoacacia*, which was main species in the Loess Plateau for returning farmland to forest. For all treatments, trees were planted according to the spacing of 2 m × 2 m, simultaneously intercropping with *Medicago sativa* and *Agropyron cristatum* in every treatment, respectively. There was 200 m^2 area of every treatment. The all entire treatments were performed in triplicates, and setting wasteland locust as control.

Randomly sampling method was used to study the intensity of topsoil water loss caused by original vegetation destruction after hillside-fields managing. 100 m^2 was chosen randomly in each treatment site. The relationship between water loss and distance of terrace side slope was studied by selecting a measuring point every 20 cm from the ridge inside in every treatment area. Ten trees were randomly selected to measure the vertical projection area and vegetation coverage in each treatment. The vegetation coverage with quadrat ruler was used for determination.

The water content in different soil layers was measured by time domain reflectometer (TDR) after the rainy season in November every year from 2014, and the growth of plants basically stops (Mamidi *et al*. 2015).

Soil samples were taken from the plough layer (0 - 40 cm depth) using a soil auger of 5 cm diameter using plum sampling method. After carefully removing the surface organic materials and fine roots, the sample was frozen at –20°C for the determination of soil microbial community function using Biolog method (Kumar *et al*. 2017). The fresh soil (5 g dry-weight equivalent) were weighed into a 150 ml erlenmeyer flask containing 45 ml 0.85% NaCl sterile solution (m/v) and shaken on a shaker at 150 r/min for 30 min. The microbial suspension was diluted by using 10-folds method to a concentration of 10^{-3}. Then the microbial suspension was inoculated into a Biolog ECO-microplate with 150 µl per well on a sterile bench. The microplates were incubated for 240 hrs in a 25°C incubator and read with a Dias microplate reader at wavelengths of 590 nm after every 24 hrs.

The average well color development (AWCD) of the solution absorbance value in the Biolog-Eco microplate hole is calculated as:

$$\text{AWCD} = \sum (C_i - R)/ n$$

where C_i is the absorbance of each well and R is the absorbance of the control, n is the number of wells, the value of the Biolog-Eco plate is 31, the $C_i - R$ is less than zero, in the record as zero, namely: $C_i - R \geq 0$.

Simpson index (D) $D = 1 - \sum P_i^2$

Shannon index (H) $H = - \sum P_i \times (\ln P_i)$

McIntosh index (E) $E = H / \ln S$

where $P_i = (C_i - R) / \sum (C_i - R)$, which is the ratio of the difference between the absorbance of one carbon source-involved well and control well to the sum of total differences of 31 substrates. where S indicated the carbon source number (absorbance ≥ 0.25) of Biolog Eco-microplate (Lipiec and Frac 2016).

The statistical analyses were performed using Excel 2010 and the all graphs were made by using SPSS 21.0.

Results and Discussion

Due to the different managing patterns of hillside fields, the processing capacity of intercepting rainfall was quite different. In order to quantitatively study the ability of each treatment model to accept rainfall, the soil moisture of each soil was randomly measured by time domain reflectometer (TDR) on the 5th day after. The results are presented in Table 1.

Table 1. Effects of different treatments on the absorbance ability of rainwater in soil after 10 years.

Treatment		Rainfall in the middle of\ Sept. 2014			Rainfall in the middle of Sept. 2015			Rainfall in the middle of SepT. 2016		
		0-50 cm	50-100 cm	100-150 cm	0-50 cm	50-100 cm	100-150 cm	0-50 cm	50-100 cm	100-150 cm
		Soil layer	Soil layer	Soil layer	Soil layer	Soil layer	Soil layer	Soil layer	Soil layer	Soil layer
I . LTF	R.P+M.S	7.5	6.6	6.2	7.5	6.4	5.8	7.3	5.8	5.7
	R.P+A.C	7.4	6.5	6.4	7.7	6.5	6.1	7.5	6.3	6.0
II.SST	R.P+M.S	7.5	6.6	6.1	7.4	6.3	6.1	7.3	6.1	5.9
	R.P+A.C	7.2	6.4	6.5	7.6	6.6	6.3	7.6	6.5	6.3
III.LFP	R.P+M.S	6.4	6.2	5.9	6.7	5.9	6.1	6.7	5.9	6.0
	R.P+A.C	6.5	6.4	6.3	7.0	6.3	6.2	6.8	6.3	6.2
CK	B.R.P	6.3	6.1	5.8	6.4	5.9	5.9	6.3	6.1	5.8

R.P: *Robinia pseudoacacia*; M.S: *Medicago sativa*, A.C: *Agropyron cristatum*, B.R.P: Barren hillside fields *Robinia pseudoacacia*.

Table 1 shows the results of the disposable rainfall of 52, 69 and 59 mm from 2014 to 2016, respectively. LTF and SST had the best effect. The precipitation in September 2014 was 52 mm, 5 days after rain, 0 - 50cm soil moisture was 19.5, 17.5, 19.5 and 14.3% higher as compared to the control. Subsequently, the 50 -100 cm soil moisture was improved by 8.2, 6.6, 8.2 and 4.9%, respectively compared with the control. LFP in 0 - 50 cm soil layer increased only by 1.6, 3.2%. LFP in 50 -100 cm layer increased only by 1.6 and 4.8% as compared to the control. There was no significant difference in the ability of receiving rainfall between the LTF and SST, and reached a significant level compared with the LFP, compared with the control, to achieve a very significant level. In September, 2015 and September 2016 rain of the results was found to be consistent with the above results indicating that hillside fields engineering management was conducive to accept rainfall, promote infiltration, and the effect was obvious after 10 years. The ability to accept the rainfall was in the order: LTF ≥ SST > LFP > control.

In order to study the utilization of vegetation to soil moisture, after the plant growth stopped in November each year, random points were taken in each treatment area. The soil moisture content in different soil layers was determined by time domain reflectometer (TDR), and the results are presented in Table 2.

It can be seen that after the experiment, the water content of each treated soil decreased year by year, which indicated that the rapid restoration of vegetation on the hillside fields gradually increased the demand for soil moisture, and the natural rainfall was far from being supplemented in time. But the comparison showed that the soil moisture content in 2015 was higher than that in 2014 (Table 1) and that there was a strong rainfall process in early September 2015. In addition, the vegetation of the control hillside fields is scarce and the utilization rate is low, from the long-term trend, there is also a trend of decreasing soil water content. The results explored that the artificial vegetation in the Loess Plateau grows at the expense of drawing excess soil moisture (Alburn *et al*. 2015, Teravest and Thierfelder 2015). After several years, the "dry layer" of soil moisture is formed, which restricts the growth of vegetation, this finding is consistent with the results reported by Bunting *et al*. (2016).

From different forest-grass configuration mode, the soil water content of *Robinia pseudoacacia* and *Medicago sativa* combination was the fastest decline in different treatments, which was due to the serious water absorption of *Medicago sativa*. Planted the 12th year, the soil water content of SST (*Robinia pseudoacacia* + *Medicago sativa*) had reached the effect close in respect with control. Each soil layer moisture content of the combination of *Robinia pseudoacacia* and *Agropyron cristatum* was 12.9, 8.4 and 9.7% higher than the control, respectively. The annual rainfall in the area is 350 - 420 mm and the loss is serious, the soil moisture of allocation mode of *Robinia pseudoacacia* and *Medicago sativa* drew more than rainfall supplement. Resulting in soil water deficit, and gradually form a "dry layer", so the area should avoid planting strong root grass, tree species. But also corresponding reduced the density of planting, so as to effectively slow down the soil "dry layer" development speed (Rutgers *et al*. 2016).

Table 2. Effects of different treatments on soil moisture content of different layers after 10 years (%).

Treatment		0-50 cm Soil layer				50-100 cm Soil layer				100-150 cm Soil layer			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
I . LTF	R.P+M.S	6.79	6.74	6.56	5.92	6.74	6.44	6.14	5.85	6.40	6.34	6.03	5.44
	R.P+A.C	6.92	6.88	6.77	6.47	6.59	6.57	6.48	6.39	6.39	6.41	6.26	6.06
II.SST	R.P+M.S	6.95	6.78	6.51	5.82	6.81	6.40	6.21	5.71	6.30	6.02	5.80	5.40
	R.P+A.C	6.98	6.90	6.61	6.40	6.65	6.13	6.14	6.05	6.09	6.08	5.96	5.76
III. LFP	R.P+M.S	6.48	6.31	6.14	5.66	6..24	6.09	5.86	5.55	6.05	5.76	4.54	4.95
	R.P+A.C	6.60	6.33	5.96	6.04	6.25	6.06	5.92	5.64	6.10	6.01	5.37	5.55
CK	B.R.P	5.94	6.09	5.76	5.67	5.94	5.69	5.58	5.58	6.07	5.66	6.02	5.25

R.P: *Robinia pseudoacacia*; M.S: *Medicago sativa*, A.C: *Agropyron cristatum*, B.R.P: Barren hillside fields *Robinia pseudoacacia*.

Due to the difference of soil water content, the grass growth and vegetation coverage of hillside fields are affected. A comparative analysis is made on the growth of forest-grass and the vegetation coverage in each treatment year, as shown in Table 3. It can be seen that after 10 years of treatment, the shadow area of canopy and vegetation coverage of SST were higher than the same cropping pattern in other treatments, respectively. Compared with the LTF, it was increased by 21.1 and 1.1 %, 26.4 and 13.5% higher than LFP, 37.4 and 43% higher than the control.

Table 3. Effects of different treatments for 10 years on sapling growth and vegetation coverage.

Treatment		Shadow area of canopy (m^2)				Coverage of vegetation (%)			
		2013	2014	2015	2016	2013	2014	2015	2016
I. LTF	R.P+ M.S	1.11	1.40	1.63	2.46	41.20	42.20	42.50	46.40
	R.P +A.C	1.19	1.70	1.90	2.61	42.50	42.80	43.90	46.52
II.SST	R.P+ M.S	1.21	1.51	1.60	2.87	42.90	43.30	45.50	46.90
	R.P +A.C	1.25	1.58	1.95	3.16	44.70	46.50	46.70	46.82
III.LFP	R.P+ M.S	1.07	1.50	1.55	2.27	42.50	40.50	40.50	41.31
	R.P +A.C	1.18	1.61	1.75	2.70	41.40	42.50	42.30	42.32
CK	B.R.P	1.01	1.14	1.60	2.30	36.30	32.80	32.50	32.80

R.P: *Robinia pseudoacacia*; M.S: *Medicago sativa*, A.C: *Agropyron cristatum*, B.R.P: Barren hillside fields *Robinia pseudoacacia*.

It is apparent from Fig. 4 that the AWCD value with the extension of incubation time, the amount of carbon source used by the soil microbial communities of each treatments increased gradually. The AWCD of the soil microbial community of each treatment methods increased rapidly in 24 - 96 hrs and then continued slowly to rise until the incubation time ends. The rapid increase in the value of the AWCD indicates that the microorganisms enter the exponential growth phase and the carbon source is heavily utilized. It can be seen that there is a difference in the AWCD values of the soil microbial community during the whole culture process. The AWCD of the LTF and SST field increased rapidly, and the processing of the LFP was slower. In a word, the order of the ability of soil microbes of different treatments to utilize a single carbon source is: SST > LTF > LFP, indicating that the soil microbial community of SST has the highest metabolic rate and the strongest activity. Furthermore, LTF and LFP were observed at second. The soil microbial metabolism of control is slowest and showed the weakest activity.

The results of Biolog-ECO microplate culture 96 h for microbial metabolic diversity analysis are presented in Table 4. In the different treatment of soil microbial community metabolic diversity there was a big difference. The Shannon index (H) and McIntosh index (E) of the SST managing pattern are significantly higher than those of LTF and LFP ($P < 0.05$). While the soil microbial species richness and dominance were the lowest in the LTF, the soil microbial community had the lowest degree of uniformity.

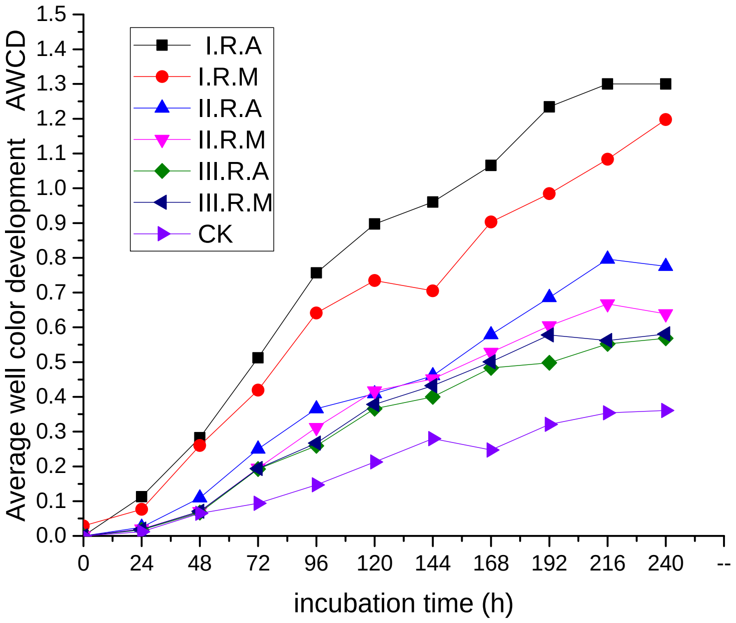

Fig. 4. Changes of soil AWCD in different treatment with incubation times.
I.R.A: Slope-separated terrace (*Robinia pseudoacacia* + *Agropyron cristatum*), I.R.M: Slope-separated terrace (*Robinia pseudoacacia* + *Medicago sativa*), II.R.A: Large terraced field (*Robinia pseudoacacia* + *Agropyron cristatum*), II.R.M: Large terraced field (*Robinia pseudoacacia* + *Medicago sativa*), III.R.A: Large fish-scale pit (*Robinia pseudoacacia* + *Agropyron cristatum*), III.R.M: Large fish-scale pit (*Robinia pseudoacacia* + *Medicago sativa*), CK: Barren hillside fields *Robinia pseudoacacia*.

The 31 carbon sources of the Biolog-Eco plates used in this study were classified into six classes, including carbohydrate, amino acids, carboxylic acids, polymers, phenolics and amines. It can be seen from Table 4, the soil microbes of different treatments have significant differences in the utilization of 6 carbon sources. The managing pattern of SST (*Robinia pseudoacacia* + *Agropyron cristatum*) on soil microbial carbohydrates, amino acids and carboxylic acids carbon source utilization rate was the highest. The managing pattern of SST (*Robinia pseudoacacia* + *Medicago sativa*) was second. The managing pattern of LFP (*Robinia pseudoacacia* + *Medicago sativa*) on the utilization of carbohydrates, the managing pattern of LTF(*Robinia pseudoacacia* + *Agropyron cristatum*) on the utilization of amino acids was only below the above two kinds of treatment. Other treatments had relatively low utilization rates for six types of carbon sources, but all were higher than those of abandoned land.

Table 4. Functional diversity index of soil microbial communities under different treatments.

Treatment	Shannon (H)	Simpson (D)	McIntosh (E)
SST(R.P+A.C)	2.96 ± 0.02a	0.94 ± 0.07a	1.19 ± 0.02b
SST(R.P+M.S)	2.65 ± 0.06b	0.91 ± 0.01b	1.17 ± 0.04a
LTF(R.P+A.C)	2.34 ± 0.06c	0.91 ± 0.01b	1.11 ± 0.03cd
LTF(R.P+M.S)	2.31 ± 0.04d	0.83 ± 0.01c	1.07 ± 0.03cd
LFP(R.P+A.C)	2.33 ± 0.05bc	0.91 ± 0.01b	1.07 ± 0.04bc
LFP (R.P+ M.S)	2.26 ± 0.05bc	0.90 ± 0.01b	1.02 ± 0.04bc
CK	2.16 ± 0.04c	0.90 ± 0.01b	0.99 ± 0.01d

Means in column followed by the different letters were significantly different at 0.05 level. R.P: *Robinia pseudoacacia*, M.S: *Medicago sativa*, A.C: *Agropyron cristatum* CK: Barren hillside fields *Robinia pseudoacacia*.

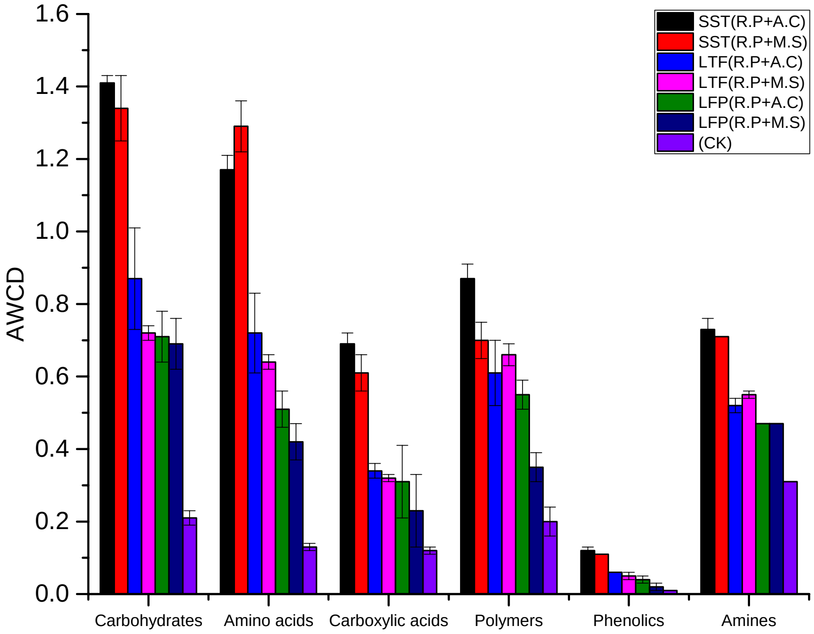

Fig. 5. Utilization of 6 types of carbon sources by soil microorganisms under different treatments. R.P: *Robinia pseudoacacia*, M.S: *Medicago sativa*, A.C: *Agropyron cristatum*, CK: Barren hillside fields *Robinia pseudoacacia*.

Rainfall is the only way to add soil moisture to the steep slope of the first sub-area of the Loess Plateau. Soil water content is affected by both precipitation and natural evaporation. It is also affected by vegetation water consumption, and in the growing season with the vegetation growth conditions and constantly changing. This change has a direct impact on the growth of surface plants and soil microbial population growth. From the above results, it may be concluded that the managing pattern of hillside fields in the Loess Plateau, the managing pattern of SST and LTF can effectively absorb compulsory precipitation, forcibly infiltration and reduce the evaporation of soil moisture. Compared with the study of Jia *et al.* (2017) who reported the effectively reduce soil desiccation and increase soil moisture content. Soil moisture content in the 0 -100 cm soil layer of SST and LTF was all increased, there was no significant difference in the receive rainfall capacity between the two groups. SST compared with the LFP reaches a significant level, compared with the control reached extremely significant level, and 10 years after the treatment effect is significant. In comparison with the study of Zhang *et al.* (2007) who found that 10 years after the treatment of LTF soil moisture content had increased significantly than the treatment after 4 years. And even the higher in the year of 2014 and 2015 as compared with SST. SST on the basis of this, made reasonable allocation of forest-grass. It can obviously increase the growth of forest and grass, and improve the vegetation coverage. Such as *Robinia pseudoacacia* and *Agropyron cristatum* combination after planting 12 years, shadow area of canopy reached 3.16 m^2, the coverage of vegetation reached 46.82%. Furthermore, this was documented by 21.1 and 1.1% higher than that of the LTF, respectively. Moreover, it was noted 26.4 and 13.5% higher than that of the LFP. The improvement was 37.4 and 43% higher than that of the control. It can be promoted and applied.

The soil microbial carbon source average color changes as a results of soil microbial community metabolism activity of different managing patterns is different, but both significantly increased compared with the control. This is because of the community structure of different types of vegetation on soil microbe and soil for different types of carbon sources (Zhai *et al.* 2016), Also, plantation rhizosphere released a large amount of carbon sources, and decomposition of litter in the plantation increased the contents of soil organic matter, C, N, P and other micro nutrients, which in turn affected the distribution and metabolic activity of soil microbial communities. AWCD is an important indicator of soil microbial metabolic activity, ie, an important indicator of the ability of a single carbon source, to a certain extent, reflecting the number and structure of microbial populations in the soil. The AWCD of the treated soil in the SST and the LTF increased rapidly, and the treatment of the LFP was slower. The results showed that the soil microbial community of SST had the highest metabolic rate and the strongest activity in all treatments, while the LTF and LFP were the second. The community diversity index can be used to characterize the extent of carbon source utilization in soil microbial communities. The Shannon index (H), Simpson index (D) and McIntosh index (E) were used to describe the soil microbial species richness, dominance and measure community species evenness. The Shannon index (H) and McIntosh index (E) of the SST were significantly higher than those of the LTF and the LFP managing pattern. The enrichment and dominance of soil microbial species were the lowest in the LTF. Compared with the study of Xiao *et al.* (2016), it is found that the soil microorganism community activity of reasonable hillside fields managing pattern is higher than pure planting *Robinia pseudoacacia*. This is because the rational hillside fields managing patterns effectively enriches the moisture in the soil, thereby promoting the development of plant rhizosphere and providing a more favorable growth environment for the microbial community. And the utilization of carbon sources was studied. Soil microorganisms have the highest utilization rate of carbohydrates, amino acids and carboxylic acid carbon sources in the SST (*Robinia pseudoacacia* + *Agropyron cristatum*) managing pattern, the managing pattern of SST (*Robinia pseudoacacia*+ *Medicago sativa*) was second. The reasons for this difference might be related to the physiological characteristics of plants, photosynthetic products and root exudates and so on. PCA analysis showed that the utilization characteristics of soil microbial carbon sources in different treatments were different, and the major contributors to the principal component separation were carbohydrates, amino acids and carboxylic acids. Pengthamkeerati *et al.* (2011) also found that glucose and amino acids are the main carbon sources for soil microbial metabolism such as bacteria and fungi. Different types of vegetation lead to changes in plant community structure, and plant species have an impact on microbial diversity and soil carbon distribution.

In this study, Biolog analysis method was used to analyze the characteristics of soil microbial community in different hillside fields managing patterns in the Loess Plateau. However, the Biolog analysis method mainly focused on the culturable bacterial groups, which could not be detected for uncultured microorganisms with special functions. Although Biolog analysis method has some defects, it is still a fast and effective method to study the metabolic function of soil microorganisms. Due to the complexity of soil microorganisms and the inability of the vast majority of microorganisms in the soil to culture, it is still necessary to carry out studies on the functional groups of soil microbial communities in combination with other detection methods.

The results showed that the managing pattern of the SST (*Robinia pseudoacacia* + *Agropyron cristatum*) could reduce the formation of soil dry layer and enhance the natural regeneration ability of vegetation. And the functional diversity of the soil microbial community, the metabolic diversity index and the utilization of soil microbes were significantly improved. Overall, the above-mentioned SST (*Robinia pseudoacacia* + *Agropyron cristatum*) was the best pattern for the hillside fields management of the Loess Plateau.

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