Long-term effects of tillage and residue management on the soil microbial community structure in the Loess Plateau

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Introduction

The severe soil erosion present in the Loess Plateau of western China has resulted from a combination of highly erodible soil, variable rainfall and intensive cultivation (Shi and Shao 2000). Conservation agriculture practices, including no till, crop residue retention and crop rotation, have been found to increase crop yield, improve water use efficiency, reduce energy inputs and improve soil fertility (Bukert *et al.* 2000; Rahman *et al.* 2008). The soil microbial community function and structure play key roles in the decomposition of organic matter, nutrient cycling and altering the availability of nutrients to plants, which has been shown to change under conservation agriculture (González-Chávez *et al.* 2010). The aims of our research are to quantify impacts of tillage and crop residue management on soil microbial community structural diversity on the Loess Plateau by PLFA techniques.

Methods

Site description

A long-term field experiment was carried out at Qingyang Loess Plateau field station of Lanzhou University, located in the Gansu, China (35°39′N, 107°51′E). The area receives an annual precipitation from 480 mm to 660 mm, 60% of which falls from July to September. The dominant soil type is a sandy loam of low fertility.

Experimental design

A trial rotation of maize (*Zea mays*), winter wheat (*Triticum aestivum*) and soybean (*Glycine max*) commenced in 2001 with four tillage treatments: conventional tillage (t); conventional tillage with previous residue retention (ts); No till (nt), and no till with previous residue retention (nts). A randomized block design was employed with 4 replicates per treatment for a total of 16 plots.

Soil sampling and analysis

At soybean anthesis in 2010, five plants in each plot were randomly selected. Soil which adhered to the root hairs after repeated gentle shaking of the whole root system was collected as rhizosphere soil. Phospholipid fatty acids (PLFA) extraction was conducted for each sample following the modified procedure of Bligh and Dyer (Bossio *et al.* 1998).

Results

Total PLFAs, Bacterial PLFAs, Fungal PLFAs and the ratio of fungal to bacterial PLFAs (F/B) were significantly affected by residue retention, however tillage and interaction effects were not (Table 1). Concentrations of Total PLFAs, Bacterial PLFAs and Fungal PLFAs of rhizosphere microorganisms was significantly (P<0.01) greater in soils with crop residue retention than those with residues removed, increasing 19.2%, 22.4% and 31.2%, respectively. The ratio of F/B is a sensitive indicator of different tillage management practices and was higher under ts treatment than under other treatments (Table 1).

The PLFA data patterns from all plots were measured by principal components analysis (PCA). Principal components PC1 and PC2 accounted for 50.5% and 13.0% of the total variation in PLFA, respectively. The two residues retention treatments (ts and nts) were distributed on the positive axis of PC1, compared to the residue removal treatments (t and nt) on negative axis, which clearly divides PLFA patterns of the microbial community under the two residues treatments (Fig. 1). The score coefficients of the PC1 showed significant differences between all treatments (P<0.001), indicating that residue retention significantly changed the soil microbial community structure diversity compared to residue removal treatments.

Table 1. Effect of tillage and residue treatments on total phospholipid fatty acids (PLFAs), fungal and bacterial PLFAs, and the ratio of fungal to bacterial PLFAs (F/B) at soybean anthesis.

Treatment	Total PLFAs (nmol/g)	Bacterial PLFAs (nmol/g)	Fungal PLFAs (nmol/g)	F/B
t	26.89	15.85	1.61	0.10
ts	33.21	20.22	2.26	0.11
nt	29.84	17.60	1.76	0.10
nts	34.41	20.72	2.16	0.10
LSD(P=0.05)	3.00	1.65	0.25	0.01
Tillage Effect	*ns*	*ns*	*ns*	*ns*
Residue Effect	***	***	***	**
Tillage×Residue	*ns*	*ns*	*ns*	*ns*

t, conventional tillage; ts, conventional tillage with previous residue retention; nt, No till; nts, no till with previous residue retention; *ns,* not significant (P>0.05); ** Significance level: $P \leq 0.01$; *** Significance level: $P \leq 0.001$.

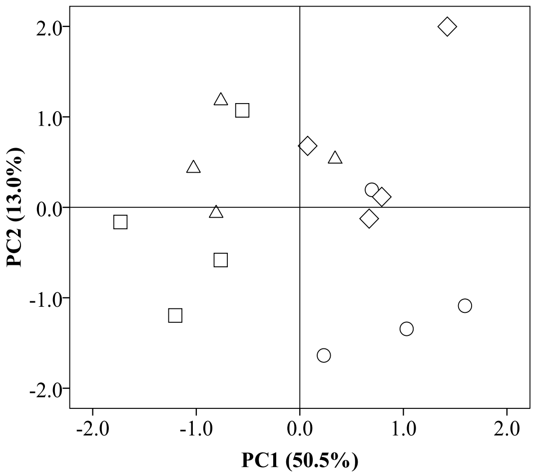

Figure 1. Principal component analysis (PCA) of phospholipid fatty acids (PLFAs) for tillage and residue treatments in soybean anthesis. □ = t treatments; ○ = ts treatments; △ = nt treatments; ◇ = nts treatments.

Discussion

Crop residue can provide necessary substrates for microorganism growth and induce soil microbial community composition and structure changes. Crop residue returned to the land can also increase soil aggregation and soil organic carbon (SOC) content (Unger 1997). The F/B in ts treatment was highest, which suggests residue retention can overcome the negative effect of conventional tillage on the soil microbial community.

Conclusion

This study focused on the long-term effects of tillage and residue retention on the structural diversity of the soil Microbial community in the Loess Plateau. It clearly demonstrates that retention of crop residues can significantly improve soil microbe structural diversity and increase total microorganism, bacterial and fungal biomass in soybean rhizosphere soil. Residue retention is the most beneficial soil management practice for contributing to sustainable agriculture on the Loess Plateau when compared to conventional tillage systems.

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References

Bossio DA, Scow KM, Gunapala N, Graham KJ (1998) Determinants of soil microbial communities: effects of agricultural management, season, and soil type on phospholipid fatty acid profiles. *Microbial Ecology* **36**, 1-12.

Buerkert A, Bationo A, Dosso K (2000) Mechanism of residue mulch-induced cereal growth increases in West Africa. *Soil Science Society of America Journal* **64**, 346-358.

González-Chávez MA, Aitkenhead-Peterson JA, Gentry TJ, Zuberer D, Hons F, Loeppert R (2010) Soil microbial community, C, N, and P responses to long-term tillage and crop rotation. *Soil and Tillage Research* **106**, 285-293.

Rahman MH, Okubo A, Sugiyama S, Mayland HF (2008) Physical, chemical and microbiological properties of an Andisol as related to land use and tillage practice. *Soil and Tillage Research* **101**, 10-19.

Shi H, Shao MG (2000) Soil and water loss from the Loess Plateau in China. *Journal of Arid Environments* **45**, 9-20.

Unger PW (1997) Aggregate and organic carbon concentration interrelationships of a Torrertic Paleustoll. *Soil and Tillage Research* **42**, 95–113.