Leaching of Dissolved Organic Carbon (DOC) as Affected by Plant Residue Composition and Soil pH

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Abstract Leaching column experiment was conducted in the laboratory to investigate the influence of soil pH and plant residue incorporation on dissolved organic carbon (DOC) output. The results indicated that the pH in leachate was greatly increased when plant residues were incorporated into soils with very low pH (pH 3.0 and pH 3.5), but it was not the case in the soil with pH 6.5. At the end of leaching experiment, cumulative DOC output ranged from 260 to 457 mg C kg^{-1} soil in the control columns, and the highest amount was found in the soil with pH 6.5. Plant residue incorporation significantly increased cumulative DOC output by 471–948 mg C kg^{-1} soil at rice straw treatment and by 2,268–4,068 mg C kg^{-1} soil at Chinese milk vetch (CMV) treatment as compared to the corresponding control. Our results suggest that soil pH and the composition of plant residues are the key factors for determining DOC output during plant residue decomposition.

Keywords Dissolved organic carbon • Soil pH • Plant residue • Leaching

Introduction

Soil dissolved organic carbon (DOC) is an essential part of soil organic carbon pool and plays an extremely important role in soil microbial activity, mineral weathering, transport of nutrients, and many other biochemical processes. Leaching of DOC is also a critical process in the carbon cycle, which could result in the loss of soil organic carbon. The production and leaching of DOC are affected by soil properties (e.g., texture, microbes, pH) and vegetation, as well as environmental factors (e.g., temperature, precipitation). Soil pH is a key factor affecting soil

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microbial activity, association/dissociation of organic compounds, and partitioning of soil organic matter, which may ultimately affect the production and leaching of DOC (You et al. 1999; Andersson et al. 2000; Andersson and Nilsson 2001). The objective of this study was to investigate the influence of soil pH and plant residue incorporation on content of dissolved organic carbon (DOC) in soil.

Materials and Methods

Soil used in this study was collected in Longyou County, Zhejiang Province, with an original pH of 4.4 (H_2O, 1:2.5), and then air-dried and ground to pass 2-mm sieve. Soil pH gradient was artificially achieved with the method of direct current (DC), as described by Li et al. (1994). Finally, soils with pH gradient of 3.0, 3.5, 5.2, and 6.5 were obtained. Rice straw and Chinese milk vetch (CMV) was selected for incorporation in this study, both oven dried and ground to pass 1-mm sieve.

Leaching columns were constructed using polymethylmethacrylate (PMMA) cylinders (30 cm in length, 5 cm in inner diameter). Each cylinder was filled with 200-g air-dried soil. Rice straw and CMV were added at a rate of 1.5%, respectively. Soils without addition of the plant residue were used as controls. Each treatment was replicated three times. 100 mL simulated rainfall solution was applied to each column each time. The total volume of simulated rainfall solution applied during the entire leaching period was approximately 60% of the annual precipitation for the study area.

The pH in leachate was measured within 1 day after collecting. DOC was analyzed on a Multi N/C 3100 analyzer (Germany).

Results and Discussion

The pH in soil leachate, especially for soils with very low pH, was greatly increased after incorporation of plant residues and was significantly higher under CMV addition than under rice straw addition (Fig. 1A, B), but this phenomenon weakened with the increase of soil pH (Fig. 1C, D). For the soil with pH 6.5, the pH in leachate fluctuated little no matter whether plant residues were added, and there was almost no difference between CMV and rice straw treatment and control.

As shown in Fig. 2, plant residue incorporation significantly increased the content of DOC. DOC in leachate was significantly greater in soils amended with CMV than with rice straw, which largely resulted from faster decomposition of CMV with a lower C to N ratio than rice straw. In addition, it was found that the total leaching flux of DOC increased with the increase of soil pH. Throughout the entire leaching period, the cumulative DOC output ranged from 260 to 457 mg C kg^{-1} soil in the control columns, and the highest amounts were found in the soil with pH 6.5. Plant residue incorporation significantly increased

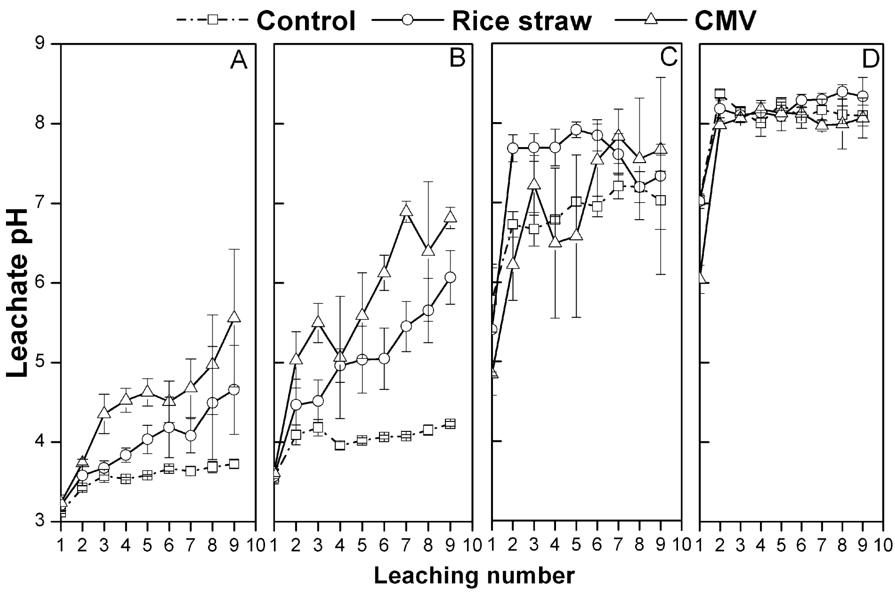

Fig. 1 The variation of pH in leachate during the leaching experiment. *A*, *B*, *C*, and *D* were represented as soil pH 3.0, 3.5, 5.2, and 6.5, respectively. *Error bars* represent ±SD ($n = 3$)

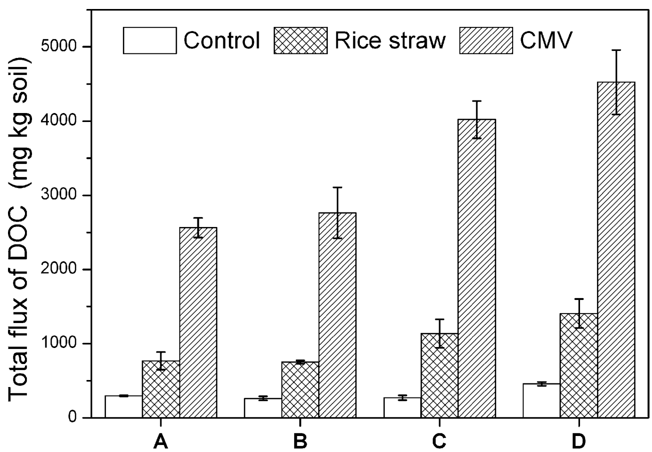

Fig. 2 Total leaching flux of DOC as influenced by plant residue incorporation and soil pH. *A*, *B*, *C*, and *D* were represented as soil pH 3.0, 3.5, 5.2, and 6.5, respectively. *Error bars* represent ±SD ($n = 3$)

cumulative DOC output by 471–948 mg C kg^{-1} soil at rice straw treatment and by 2,268–4,068 mg C kg^{-1} soil at CMV treatment as compared to the corresponding control, and the maximum difference for both rice straw and CMV treatment occurred in the soil with pH 6.5.

Our results showed that both composition of plant residues and soil pH affect the content of DOC in leachate. Since the plants are not grown in the leaching experiment, the results in this study need to be further confirmed under field conditions.

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References

Andersson, S., and S.I. Nilsson. 2001. Influence of pH and temperature on microbial activity, substrate availability of soil-solution bacteria and leaching of dissolved organic carbon in a mor humus. *Soil Biology and Biochemistry* 33: 1181–1191.

Andersson, S., S.I. Nilsson, and P. Saetre. 2000. Leaching of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) in mor humus as affected by temperature and pH. *Soil Biology and Biochemistry* 32: 1–10.

Li, C.L., H.S. Li, Y.J. Sun, et al. 1994. A simulation study for acidifying soil by current. *Chinese Journal of Soil Science* 25(4): 166–169, (in Chinese).

You, S.J., Y.J. Yin, and E.A. Herbert. 1999. Partitioning of organic matter in soils: effects of pH and water soil ratio. *Science of the Total Environment* 227: 155–160.