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Seasonal changes in soil labile organic carbon pools within a *Phyllostachys praecox* stand under high rate fertilization and winter mulch in subtropical China

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Abstract

Phyllostachys praecox is a favorite bamboo shoot species that has been widely planted in southern China. High rate of fertilization and heavy winter mulch have been a common practice to gain a good yield and better economic benefit. To get an insight into the effects of fertilization and winter mulch on soil labile organic carbon pools, a trial of different types and rates of fertilizers was conducted from May 2002 to April 2003. Soils in the mixed treatments with both mineral and organic fertilizers (treatments: 1–3) were generally more abundant in soil microbial biomass carbon (MBC) ($P < 0.05$) as compared with treatments of single mineral fertilizer (treatments: 4–6), with MBC for treatments 1 and 2 generally at maximal level and for treatments 4 and 5 at minimal level. The abundance of soil MBC increased with the rate of organic fertilizers applied. Soil MBC content was measured periodically during the year, with the highest in October and December 2002, moderate in August 2002 and February 2003, and the lowest in April 2003. Soil water-soluble organic carbon (WSOC) of all treatments was higher in the August and October, decreased in the December and February, and increased again in the April. It was found that the treatments with mixed mineral and organic fertilizers had much higher WSOC ($P < 0.05$), compared with the pure mineral fertilizer treatments. Soil WSOC increased with the amount of organic fertilizer applied. Winter mulch enhanced soil MBC and WSOC, and the ratios of MBC in the mulch treatments to non-mulched treatments were on average 1.60 and 1.52 in February and April 2003, respectively, while the corresponding ratios of WSOC were on average 1.39 and 1.73 in the February and April, respectively. The high rate of single mineral fertilizer application was not recommended in bamboo management. Both mineral and organic fertilizers would need to be applied for sustaining soil fertility and long-term bamboo production in subtropical China.

Keywords: Microbial biomass carbon; Soil labile organic carbon; *Phyllostachys praecox*; Fertilization; Mulch

1. Introduction

Phyllostachys praecox is an important species of bamboo, mainly for producing edible bamboo shoots, and has been planted in many areas of southern China, with a total of 60,000 ha in Zhejiang Province. A new technique has been developed (Wan et al., 1995) that allows bamboo shoots to emerge in winter season by mulching a thick layer of organic material to elevate the soil temperature. This technique, together with an increased fertilization, results in both an earlier harvest/market for much higher price and a higher yield than that of normal practice. In order to gain high yield of bamboo shoots (about 30,000 kg ha^{-1}) and higher income, farmers have employed this new technique and bamboo stands have been intensively managed with a large amount of fertilizer input and with mulch of 15 cm layer rice straw plus 20 cm layer rice grain hulls in December (Fang et al., 1994). On the other hand, this new practice has also generated some ecological and environmental problems. With this practice being taken for about 10 years, water system has been polluted by excessive amounts of N and P amendments, and bamboo stands have started to degrade, with some bamboos mortality, indicating the decline of soil quality (Jing, 1999; Cao et al., 2004) that was not observed in traditional bamboo stands. It was found that soil nutrients (especially soil N and P) accumulated quickly and enzymatic activities occurred abnormally (Jiang et al., 2000a,b), while both total contents and available concentrations of heavy

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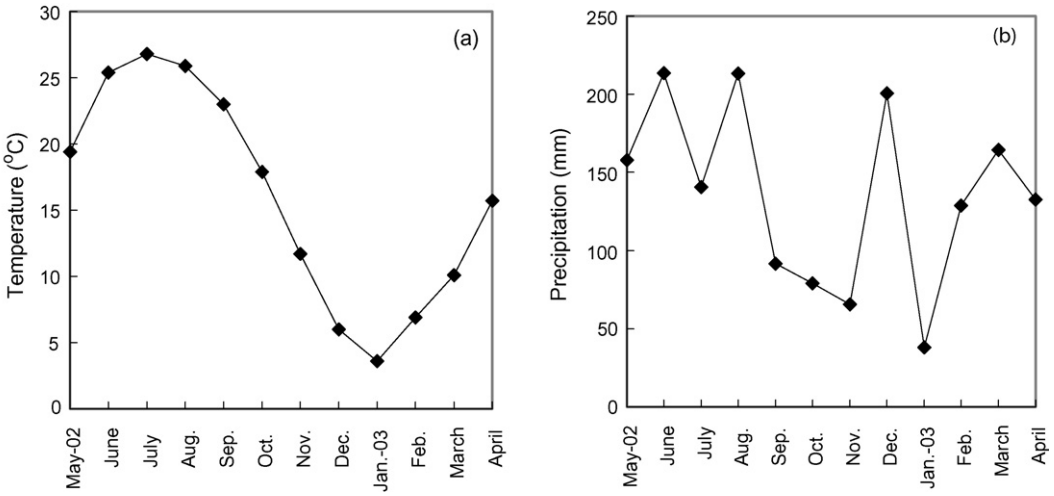

Fig. 1. Air temperature (a) and monthly rainfall (b) during the period of the experiment.

metals such as Zn, Cu and Pb in those soils increased as well (Yang and Xu, 2003). Soil organic matter has been considered as an important factor to ensure a stable ecosystem and sustainable use of land (Doran, 1994; Clapp and Hayes, 1999; Sun et al., 1999; Mathers and Xu, 2003; Chen et al., 2004; Chen and Xu, 2005). Soil labile organic C is a biologically important part of soil organic matter and has been proved as a sensitive indicator of soil quality (Sparling, 1997; Shen and Cao, 1999). However, the information about effects of this new practice on soil labile organic carbon (C) under *P. praecox* bamboo stands is lacking. The objective of this paper was to report the effects of different types and rates of fertilizers on soil labile organic C, and its seasonal changes under *P. praecox* bamboo stands with this new technique.

2. Materials and methods

2.1. Climate of sampling sites and soil properties

Experimental area was located in Linan County (30°14′N and 119°42′E), Zhejiang Province, China. This area has a typically central-subtropical climate. The average annual precipitation is 1420 mm. The annual average temperature is 15.9 °C, with the maximum and minimum temperatures 41.7 and −13.3 °C, respectively. The annual average sunshine hours and days free of frost are 1774 h and 239 days, respectively. The monthly average temperature and monthly accumulated precipitation throughout the period of the experiment are presented in Fig. 1. The soil derived from tuff was classified as Ferrisols with texture: light loam, pH (soil:H_2O = 1:5) 5.1; soil organic C 44.4 g kg^{-1}; total N 1.71 g kg^{-1}, and available P and K 16.9 and 116 mg kg^{-1}, respectively.

2.2. Experimental design

The main experimental plots were initiated in May 2002 with a 6-year-old bamboo grove. Plot size was 5.0 m × 4.0 m. The experimental design was a split plot design with fertilization as main plots and winter mulch as subplots in a randomized complete-block design (RCBD) with three replications. Fertilization consisted of six treatments (Table 1). The fertilizer rate applied by the farmers was similar to one of the treatments that was used as treatment 4 in this study. Urea and compound fertilizer (N:P_2O_5:K_2O = 15:15:15) were used as N, P, and K resources, respectively. The content of nitrogen (N) in 112,500 kg of manure was the same as that in 18,750 kg of rape cake. With 35, 30, and 35% of designed mineral fertilizers applied on May 5, September 5, and December 5, 2002, respectively, while half of organic fertilizers in treatments 1, 2 and 3 were, respectively, applied on May 5, 2002 and December 5, 2002. Winter mulch

Table 1
Fertilizer rate and composition of different treatments

Treatment	Rate of fertilizers (kg ha m^{-2} a^{-1})				N equivalent	Sub-plot
	Mineral fertilizer			Organic fertilizer[a]		
	N	P	K			
1	673	225	225	Manure 112500	2.0	Each plot divided into two parts: 2/3
2	673	225	225	Rape cake 18750	2.0	mulched and another 1/3 non-mulched
3	336.5	112.5	112.5	Manure 56250	1.0	
4	1346	450	450	0	2.0	
5	1009.5	337.5	337.5	0	1.5	
6	673	225	225	0	1.0	

[a] Ingredients of manure: water 73.5%, C 14.2%, N 0.598%, phosphorous (P) 0.091%, and potassium (K) 0.52%; ingredients of rape cake: C 44.08%, N 3.59%, P 1.05%, and K 1.17%.