Effect Of Special Organic Fertilizer For *Phyllostachys Praecox* On Soil Basic Properties Under Intensive Cultivation Management

Wei ZHANG[1]， Jian-ping WU[2]， Jin-zhong XIE[1*]

(1.Research Institute of Subtropical Forestry, Chinese Academy of Forestry, Fuyang 311400, Zhejiang, China; 2. Hangzhou Jin Hai Agriculture Co., Ltd., Lin'an 311300, Zhejiang, China)

Abstract: The basic soil properties of *Phyllostachys praecox* in the town of Taihuyuan, one of the main shoot producing area of Zhejiang province were analysised to explore the effect of different amount of special organic fertilizer in improving the soil quality of *P. praecox*. The results showed that: compared with compound fertilizer, the special organic fertilizer for *P. praecox* reduced the degree of soil acidification. Soil organic matter content was lower with special organic fertilizer than with compound fertilizer because of slow nutrient release of special organic fertilizer, but the soil organic matter content was increased in later stage than in early stage of covering. At the same time, the hydrolyzed nitrogen, available phosphorus, available potassium content and cation exchange capacity of bamboo soil, especially rapidly-available potassium content in soil increased in later stage of covering with special organic fertilizer.

Key words: special organic fertilizer for *phyllostachys praecox*; soil basic properties

1. Introduction

Phyllostachys praecox is one of the bamboo species used for producing fine edible shoots and is widely distributed in Southern China, with a total of 60,000 ha in Zhejiang Province. Since 1995, mulch technique has been developed (Wan et al., 1995) that allow shoots to emerge in winter season by covering a thick layer of organic material to increase the soil temperature. This technique, together with increased fertilization, resulted in both an earlier harvest and a higher yield than that of traditional practice. (Fang et al., 1994). With this practice being taken for about 20 years, bamboo stands have been degraded, indicating the decline of soil quality (Jing, 1999 and Cao et al., 2004), especially the decline of soil pH that was not observed in traditional bamboo stands (Sun et al., 2010).

Based on soil properties of intensive cultivation bamboo forest, Hangzhou Jin Hai Agriculture Co., Ltd. developed a kind of special organic fertilizer for *P. praecox* (50% cow-dung, 20% hickory Hull, 30%vermiculite) to improve soil quality and reduce consumption of quick-acting fertilizer. This study collected soil from using different doses of special organic fertilizer in degraded bamboo forest in the town of Taihuyuan, one of the main shoot producing area of Zhejiang province and the basic properties of soil were analysised to explore the effect of different amount of special organic fertilizer in improving the quality of soil of *P. praecox* to evaluate the applicability of this special organic fertilizer.

2. Materials and methods

2.1. General situation of sampling sites

Experimental area was located in Taihuyuan town, Linan County (30°14′N and 119°42′E, about 150m above sea level), Zhejiang Province, China. This area has a typically central-subtropical climate. The average annual precipitation is 1430 mm. The annual average temperature is 15.9 □, with the maximum and minimum temperatures 41.7 and -13.3 □, respectively. The annual average sunshine hours and days free of frost are 1939 h and 234 days, respectively. The soil derived from tuff was classified as ferrisols.

In order to gain high yield of bamboo shoots (about 22,500 kg ha^{-1}) and higher income, farmers have fertilized a large amount of quick-acting fertilizer (compound fertilizer ($N:P_2O_5:K_2O$ = 15:15:15) 2250kg·ha^{-1}·a^{-1} and urea 1125kg·ha^{-1}·a^{-1}) in bamboo grove and covered with 15 cm layer rice straw plus 20 cm layer rice husks in December.

2.2 Experimental design

The main experimental plots were initiated in Apr. 2013 with a 8-year-old bamboo grove. Plot size was 5.0m × 10.0m. The experimental design was a split plot design with different fertilizer in a randomized complete-block design (RCBD) with three replications. The experimental plots belong to the same farmer and soil property just the same before our experiment. Fertilization consisted of four treatments (Table 1). The fertilizer rate applied by the farmers conventionally was used as control. The compound fertilizer was applied on May 5, September 5, and December 5, 2002, respectively with 35, 30, and 35% of annual consumption. The urea was applied on May 5, September 5, and December 5, 2002, respectively with 25, 25, and 50% of annual consumption. Special organic fertilizer and slow release fertilizer in treatments 2, 3 and 4 were applied on December 5, 2002 once only. Winter mulch with 15 cm rice straw and 20 cm rice grain hulls was placed upon the surface of soil on December 6, 2013.

Table 1 Fertilizer dosage and composition of different treatments

Treatment No.	dosage of fertilizers
1	compound fertilizer 2250kg·ha^{-1}·a^{-1}+ urea 225kg·ha^{-1}·a^{-1}
2	Special organic fertilizer 60m^3·ha^{-1}·a^{-1}+slow release fertilizer 300kg·ha^{-1}·a^{-1}
3	Special organic fertilizer 90m^3·ha^{-1}·a^{-1}+ slow release fertilizer 450kg·ha^{-1}·a^{-1}
4	Special organic fertilizer 120m^3·hm^{-2}+ slow release fertilizer 600kg·ha^{-1}·a^{-1}

Note: Special organic fertilizer for *P. praecox* were produced by Hangzhou Jin Hai Agriculture Co., Ltd. It mainly contains 50% cow-dung, 20% hickory Hull and 30%vermiculite. Its volume-weight is 0.454 g·cm^{-3}，pH 7.7，Total N 1.55%，Total P 2.96%，Total K 1.24 %；nutrient content of slow release fertilizer is 38%（$N:P_2O_5:K_2O$ = 18：8：12）；nutrient content of compound fertilizer is 45% ($N:P_2O_5:K_2O$ = 15:15:15)

2.3. Sampling of soils

Soil samples (0–15 cm, 15-30 cm depth) were taken on 15 of February, April, May and August 2014. Soil samples of each plot were air-dried and ground to pass through a 2 mm sieve for chemical analysis. Soil sample as a background was also collected (December 1, 2013) before trial being conducted.

2.4. Chemical and biological analyses

Soil hydrolysable N (H-N) was hydrolyzed using 0.1 mol L^{-1} NaOH; available phosphorus (A-P) was determined by the Bray method; available potassium (A-K) was extracted with 1.0 mol L^{-1} CH_3COONH_4; soil pH (soil:H_2O = 1:5) was measured using a pH meter; soil organic matter was measured using $K_2Cr_2O_7$ method; soil cation-exchange capacity was extracted with ammonium acetate and then determination.

3. Results and discussion

2.1 Effect of bamboo special organic fertilizer on soil pH

The 0 ~ 15cm and 15 ~ 30 cm soil pH was 4.94 and 5.13 respectively before covering (Figure 1, Figure 2). While the 0 ~ 15cm and 15 ~ 30 cm soil pH was 4.7 and 4.85 respectively after covering 2 months. After years of coverage, soil of bamboo forest has been significant acidification. This may related with large amount of fertilizer: ammonium (NH^{4+}) fertilizers react in the soil in a process called nitrification to form nitrate (NO^{3-}), and in the process release H^+ ions. Plants grown in acid soils can experience a variety of symptoms including aluminium (Al), hydrogen (H). Aluminium toxicity is the most widespread problem in acid soils. Aluminium is present in all soils, but dissolved Al^{3+} is toxic to plant; Al^{3+} is most soluble at low pH, above pH 5.2 little Al is in soluble form in most soils(Xu et al.,1998;Li et al.,2005).

Soil pH is higher than control after applying different quantity of bamboo special organic fertilizer, especially treatment No.2 (0-15cm soil pH 6.89 in Apr.) and No.3 (0-15cm soil pH 5.96 in Apr.). Soil acidification condition gradually eased up. But 0-15cm soil pH decreased after covering (May). On the one hand may be due to the failure to remove winter mulch after covering, decay caused by fermentation; On the other hand shows that bamboo special organic fertilizer on soil acidification condition improvement had a time limit. And soil pH improvement effect is limited to 15 -30 cm soil, may be due to digging soil incompletely when applying bamboo special organic fertilizer to avoid damage to shoots buds.

2.2 Effect of bamboo special organic fertilizer on soil organic matter

Organic matter is the foundation of soil fertility, it has important significance in improving soil properties. The 0-15cm soil organic matter is lower than control after applying different quantity of bamboo special organic fertilizer (Figure 3, Figure 4). The soil organic matter content of treatment 2 and 3 even much lower than the traditional fertilization methods. But soil organic matter is higher in Apr. than in Feb. of the treatment applying bamboo special organic fertilizer. This may due to nutrient release relatively slow and sustained for a long time of applying bamboo special organic fertilizer than compound fertilizer.

2.3 Effect of bamboo special organic fertilizer on soil hydrolysable N, available phosphorus, available potassium and soil cation-exchange capacity(CEC)

Table 2 Comparison of soil N,P,K and cation exchange capacity (CEC) between different treatment

Sampling time	Treatment No.	hydrolyzable N （mg/kg）		available P （mg/kg）		available K （mg/kg）		CEC (mmol/kg)	
		0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Feb.	1	181	100	240	69.8	312	241	26.0	16.1
	2	107	103	99.4	96.2	197	202	27.9	26.7
	3	121	90.1	104	51.2	261	183	36.3	28.0
	4	223	145	201	197	467	314	42.7	31.2
Apr.	1	156	143	125	59	223	254	26.3	30.2
	2	127	179	130	147	206	251	57.2	31.9

	3	124	119	137	81.9	348	280	54.3	37.9
	4	284	271	214	200	425	343	61.8	49.9

The soil hydrolyzed nitrogen, available phosphorus and available potassium content increased in the Apr. of applying bamboo special organic fertilizer and slow release fertilizer, especially for available potassium content (Table 2). This was because the high content of K of hickory hull in the bamboo special organic fertilizer. But the soil nutrient in treatment of applying bamboo special organic fertilizer and slow release fertilizer is lower than that of single compound fertilizer treatment in the middle of the covering (Feb.).

In soil science, cation-exchange capacity or CEC is the number of exchangeable cations per dry weight that a soil is capable of holding, at a given pH value, and available for exchange with the soil water solution. CEC is used as a measure of soil fertility, nutrient retention capacity, and the capacity to protect groundwater from cation contamination. For many soils, the CEC is dependent upon the pH of the soil. As soil acidity increases (pH decreases), more H^+ ions are attached to the colloids. They have pushed the other cations from the colloids and into the soil water solution. Inversely, when soils become more basic (pH increases), the available cations in solution decreases because there are fewer H^+ ions to push cations into the soil solution from the colloids (CEC increases). Organic materials in soil increase the CEC through an increase in available negative charges. Organic matter CEC is heavily impacted by soil acidity as acidity causes many organic compounds to release ions to the soil solution. The soil CEC was significantly higher in treatment of applying bamboo special organic fertilizer and slow release fertilizer than that of single compound fertilizer trentment. Because this bamboo special organic fertilizer contains a lot of Ca, Mg elements, so the soil buffer capacity increased.

Because in the current intensive management mode, utilization rate of nitrogen was less than 30% (Jiang et al., 2000), a large amount of nitrogen residued in the soil which can lead to soil hydrolysable nitrogen content increased. At the same time, the lower pH value and higher organic matter content also lead to the decomposition of organic matter into hydrolysable nitrogen. After years of continuous covering, available phosphorus content of surface soil rise sharply, mainly due to the intensive management mode by excessive use of P fertilizer. In addition, the high available potassium content will also promote bamboo flowering and hinder absorption of Zn, Fe, Mn and Si elements lead to affecting the normal growth of bamboo plant (Jiang et al., 2000). Potassium is to promote a variety of metabolic reactions, also greatly improve the absorption of N to improve the quality of bamboo shoots. In the treatment No.1(compound fertilizer), we found that the available K content increased with the increase of soil depth, this may due to leaching phenomenon of K in the acidic soil. The treatment of applying bamboo special organic fertilizer and slow release fertilizer significantly improved the surface soil K status. Applying bamboo special organic fertilizer and slow release fertilizer not only reduced the "surplus" problem of soil nutrients but also obviously improved the surface soil nutrient status.

4. Conclusions

We conclude that long-term application of organic mulch and excessive use of compound fertilizer over winter decreased soil pH. Applying bamboo special organic fertilizer and slow release fertilizer improved the soil acidification in a certain extent, not only reduced the "surplus" problem of soil nutrients but also obviously improved soil nutrients sustainability. It is recommended that bamboo special organic fertilizer and slow release fertilizer be developed to alleviate the impacts of winter mulch on the environment.

References

Fang, W.;He, J.C.;Lu, X.K. 1994. Cultivation techniques of early shooting and high yield for *Phyllostachys praecox*. J. Zhejiang For. Coll., 11 (2) , 121–128.

Wan, Z.T.; Fang, W.; He, J.C.1995. Cultivation Techniques of High Yield and Efficient for *Phyllostachys praecox* of Bamboo-Shoot Forest. Agricultural Science and Technology Press, Beijing , China.

Jing, A.W. 1999. A preliminary study on degenerative mechanism of *Phyllostachys praecox* stand planted in a protected site. J. Fujian For. Coll., 19 (1) ,94–96.

Cao, Z.H.; Huang, J.F.; Zhang, C.S.; Li, A.F. 2004. Soil quality evolution after land use change from paddy soil to vegetable land. Environ. Geochem. Health, 97–103

Sun, X., Zhuang, S.Y., Liu G.Q., Li, G.D, Gui, R.Y. 2010. A preliminary study of soil acidification under Lei bamboo plantation with intensive management. Chinese Journal of Soil Science, 41(6), 1339-1343

Li, P., WANG, X. X. 2005.Effects of leaching with low molecular weight organic acids on soil pH and exchangeable aluminum. Soils, 37(6), 669-673

Xu, R.K.; Ji; G.L. 1998. Influence of pH on dissolution of aluminum in acid soils and the distribution of aluminum ion species. Acta Pedologica Sinica, 35(2), 162-171

Jiang, P.K.;Yu Y.W.; Jin A.W.2000. Analysis on nutrients of soil under high yield *Phyllostacys praecox f.prevelnalis* forest. Journal of Bamboo Research, 19(4), 50-53

*Corresponding author. Tel.: +86 571 63346004. E-mail:jzhxie@163.net

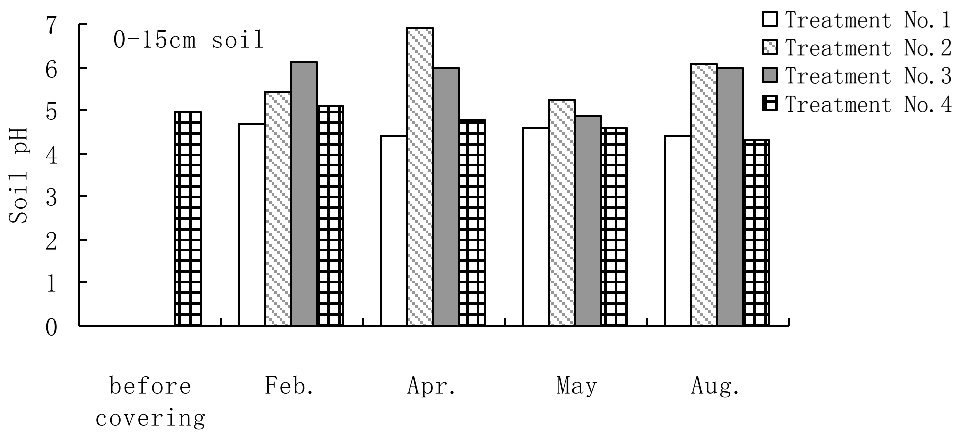

Figure 1 Comparison of 0-15cm soil pH between different treatment

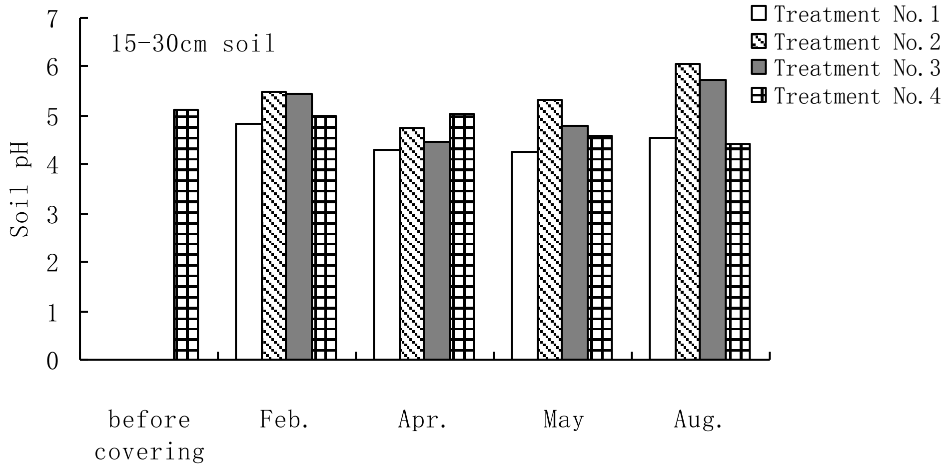

Figure 2 Comparison of 15-30 cm soil pH between different treatment

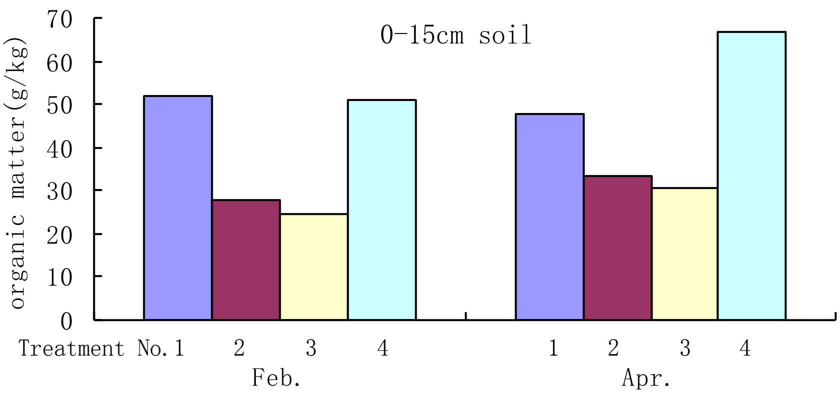

Figure 3 Comparison of 0-15cm soil organic matter between different treatment

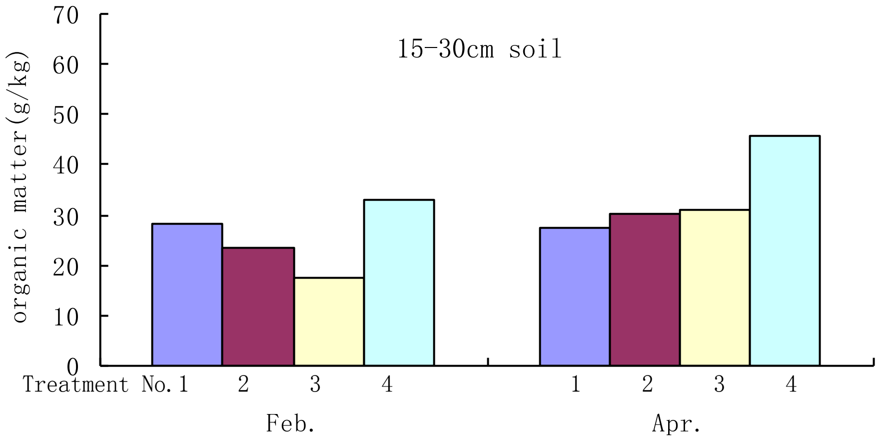

Figure 4 Comparison of 15-30 cm soil organic matter between different treatment