Effect of long-term fertilization on organic matter, total nitrogen and microbe characteristic of black soil

Dan Wei [A], Xingzhu Ma[A], Shuang Wang[B] and Baoku Zhou[A]

[A]Institute of Soil Fertilizer and Environment Resources, Heilongjiang Academy of Agricultural Sciences, Harbin, China, Email wd2087@163.com, maxingzhu@163.com
[B]Harbin Institute of Technology, Harbin, China.

Abstract
The changes in black soil organic matter, total nitrogen and microbe characteristics were studied for a long-term fertilization experiment which has been on-going for 27 years. Results showed that the treatment of organic manure plus chemical fertilizer increased the content of soil organic matter and total nitrogen, while the no fertilizer treatment had the lowest contents. Soil pH declined under long-term chemical fertilizer and the addition of organic manure decreased pH slowly as well. The addition of chemical fertilizer increased the number of cellulose utilizing bacteria. The number of N utilizing microbes increased significantly under the addition of organic manure plus chemical fertilizer with the number of ammonifying bacteria being most affected.

Key Words
Long-term experiment, black soil, organic matter, microbe characteristic.

Introduction
Black soil has many characteristics, such as deep depth of humus, incompact texture, higher natural fertility, higher content of clay and so on. The black soil area in northeast of China, as one of three big black soil area in world, was the important production base of commodity grain in China. Soil fertility properties had changed after reclamation, the soil natural fertility had a descending trend in great areas, soil nutrient and microorganism properties etc. also had changed (Chen *et al.* 1984; Huang *et al.* 2005; Li *et al.* 2006; Wang *et al.* 2008). Long-term fixed experiment at important sites and measures to understand each factor and their interaction effect in farm ecosystems and the productivity of land, was useful to illuminate trends. Some mechanisms of soil fertility and the interaction effects among factors could only be recognized rightly after 10 years (Xu *et al.* 2006; Wu *et al.* 2008). This the long-term fixed experiment on black soil to study soil organic matter, total nitrogen and microbe characteristics under long-term different fertilization, tried to reveal the evolution rule of soil fertility and microorganism characteristics, to provide a basis for improving fertility and the quality of black soil.

Methods
Location and treatments
Soil samples were collected from a long-term experiment station in April, 2005. This station was established in 1979, since its establishment, this station adopted crop rotation: wheat-soybean-corn, the basic soil chemical properties are in Table 1. We selected four treatments and amounts of fertilizer are listed in Table 2. Soybean was planted in 2005. Soil samples were divided into two parts, one part air-dry for soil nutrient measurement, the other part kept cold for microbe analysis.

Methods
1) Nutrient: organic matter and total nitrogen were measured by Vario Elementar, Germany; soil pH was measured in a 1:5 soil to water solution using a glass electrode (Lu 1991).
2) Microorganisms: the numbers of ammonifying bacteria, aerobic bacteria for cellulose decomposition, aerobic nitrogen-fixing bacteria were measured by a diluted flat method. Nitrobacteria, denitrifying bacteria, anaerobic bacteria of cellulose decomposition, anaerobic nitrogen-fixing bacteria were analyzed by a MPN method (Lab of Microorganism 1985).

Table 1. The basic soil chemical properties (0-20cm).

O.M (g/kg)	Total N (g/kg)	Total P (g/kg)	Total K (g/kg)	pH
26.7	1.47	1.07	25.16	7.22

Table 2. The treatments and fertilizer application rates.

Treatment	Fertilizer application rates		
	Soybean stubble	Corn stubble	Wheat stubble
CK	0	0	0
NPK	N 75 kg/ha, $P_2O_5$150 kg/ha, K_2O 75 kg/ha	N 150 kg/ha, P_2O_5 75 kg/ha, K_2O 75 kg/ha	
M	N 75 kg/ha (manure: about 18600 kg/ha) every three years	0	0
MNPK	N 75 kg/ha, $P_2O_5$150 kg/ha, K_2O 75 kg/ha+ N 75 kg/ha	N 150 kg/ha, P_2O_5 75 kg/ha, K_2O 75 kg/ha	

(Note: nitrogen fertilizer-urea, phosphorus fertilizer-superphosphate and monoammonia phosphorate, potassium fertilizer-potassium sulphate).

Results

Soil organic matter and total nitrogen were the important indexes of soil fertility (Mäder *et al.* 2002). Results (Figure 1) showed that different long-term fertilizations had significant effects on soil organic matter content, the content followed: M>MNPK>NPK>CK. Long-term no fertilizer decreased the content of soil nitrogen and fertilization increased the soil nutrient content, especially the organic manure plus chemical fertilizer (MNPK). The pH had effects on status, transformation and availability of soil nutrients. Long-term chemical fertilization (NPK) decreased the pH value. Compared to chemical fertilizer organic manure (M) treatment the value of pH decreased slowly, which would avoid aggravating soil acidification.

The bacteria of cellulose decomposition took major part in utilizing microbe C (Zhang *et al.* 2001), after incubation, the cellulose decomposition was mostly by fungi in this study (Figure 2). The results also found that fertilization increased the numbers of bacteria of cellulose decomposition and numbers of fungi of cellulose decomposition in four treatments (CK, M, NPK, MNPK) were 1.64, 2.76, 4.66 and 1.91×104 g-1 dry soil respectively. The amounts of aerobic bacteria and anaerobic bacteria under NPK treatment were higher than for other treatments.

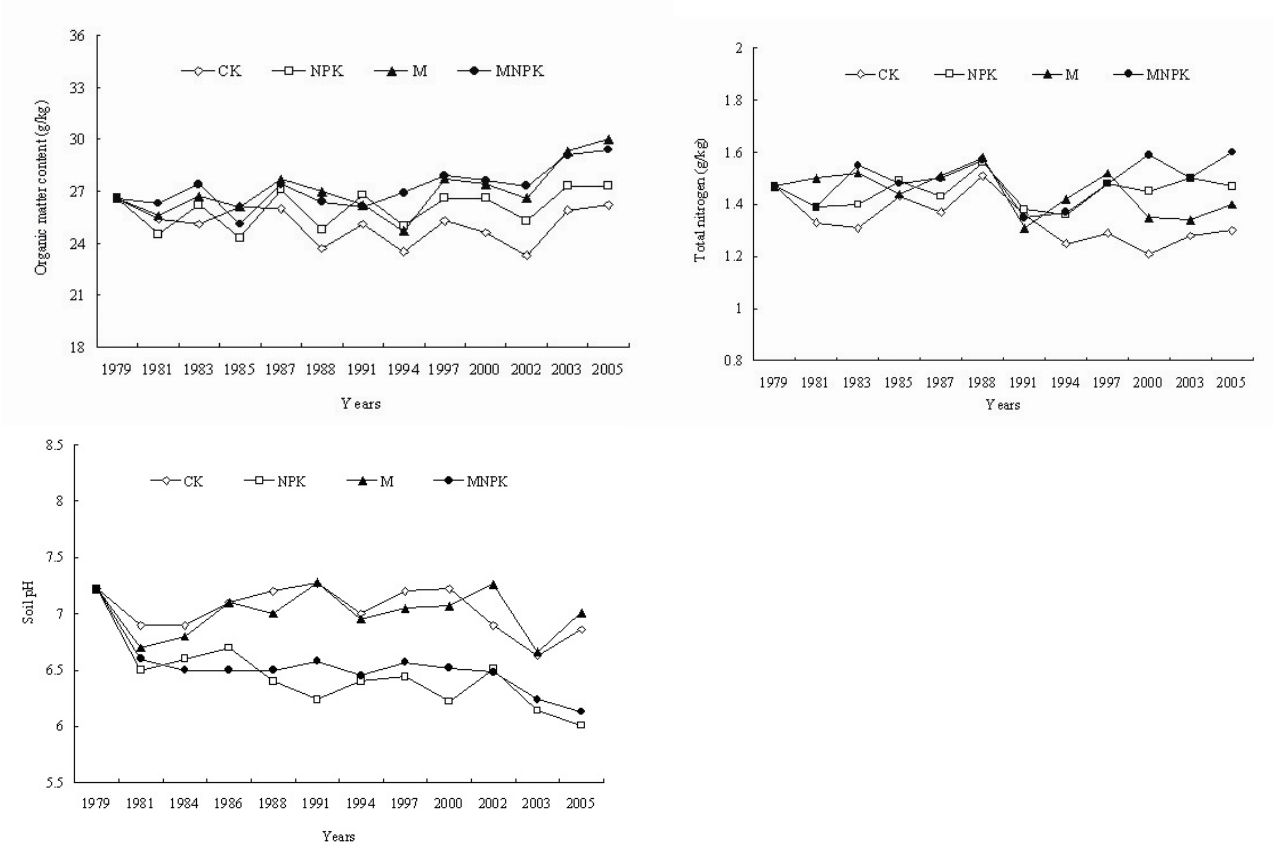

Figure 1. Changes of organic matter and total nitrogen content, pH value in black soil under different long-term fertilizations (1979-2005).

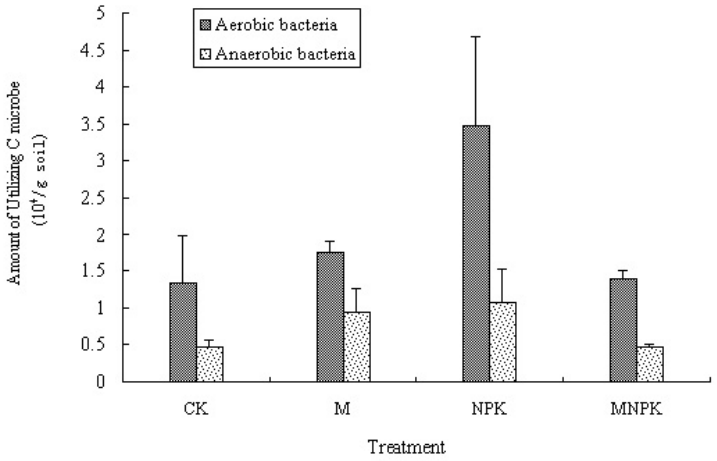

Figure 2. Number of C utilizing microbes in black soil under different long-term fertilizations.

Results (Figure 3) show that in N utilizing microbes, the numbers followed: ammonifying bacteria>nitrogen-fixing bacteria>denitrifying bacteria>nitrobacteria, the MNPK treatment had the most ammonifying bacteria, nitrogen-fixing bacteria and denitrifying bacteria, which accounted for 54.79%, 7.74% and 4.25% of total number of bacteria, the number of nitrobacteria was most for the NPK treatment, accounting for 1.82% of the total number of bacteria. The MNPK treatment increased the number of N utilizing microbes significantly more than the NPK treatment.

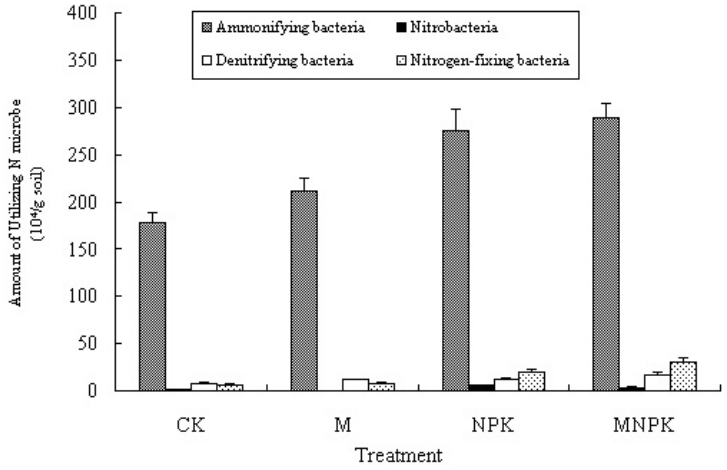

Figure 3. Number of N utilizing microbes in black soil under different long-term fertilizations.

Conclusion

1. Long-term organic manure plus chemical fertilizer treatment increased contents of soil organic matter and total nitrogen, which was very important for improving soil fertility. The pH value declined under long-term chemical fertilizer treatment, whereas organic manure treatment could slow down soil acidification.
2. The number of ammonifying bacteria was largest for N utilizing microbes, it accounted for 55% of the total number of bacteria, the number of nitrobacteria was the least. MNPK treatment increased the number of N utilizing microbes significantly. The bacteria for cellulose decomposition took a major part in utilizing microbes C; NPK treatment had the most number of these bacteria.

References

Chen EF, Zhou LK, Wu GY(1984) Study on the Essence of soil fertility II. Black soil. *Acta Pedologica Sinica* **21**, 229-237.

Huan J, Zhang HL, Fu WY, Ma B, Li X, Wang AW (2005) Analysis of the Changing Characteristics of the Soil Fertilities in the Black Soil Area of Northeast China. *Chinese Journal of Soil Science* **36**, 659-663.

Wang XB, Wu YY, Deng L (2008) Approaches to Black Soil Degeneration in Northeast China. *Resources and Industries***10**, 81-83.

Li FP, Li JY, Xu ZX (2006) The Status Quo of Black Soil Degradation and Water and Soil Loss in Northeast China. *Research of Soil and Water Conservation* **13**, 50-54.

Xu MG, Liang GQ, Zhang FD (2006) 'Changes of Soil Fertility in China'. (China Agricultural Science and Technology Press Publishing: Beijing).
Wu CY, Chen Y, Yang SM, Wang JY (2008) Evolution of soil fertility in a long-term fertilizer experiment. *Acta Agriculturae Zhejiangensis* **20**, 353-357.
Lu RK (1991) 'Analysis Methods of Soil Agricultural Chemistry'. (China Agriculture Press Publishing: Beijing).
Lab of Microorganism, Institute of Soil Science, Chinese Academy of Sciences (1985) 'Study methods of soil microorganism'. (Science Press Publishing: Beijing).
Mäder P, Bach AF, Dubois D (2002) Soil fertility and biodiversity in organic farming. *Science* **293**, 1694-1697.
Zhang CB, Jin ZX, Li JM (2001) Diversity of bacterial physiological groups and microbial flora in the soil of eight forest types of Tiantai Mountain, Zhejiang. *Chinese Biodiversity* **9,** 385-388.