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Influence of long-term fertilization on soil physicochemical properties in a brown soil

Dongdong Li^{1,2}, Peiyu Luo^{1,2,*}, Xiaori Han^{1,2}, Jinfeng Yang^{1,2}

¹College of Land and Environment, Shenyang Agricultural University, Shenyang 110866, Liaoning, China

²National Engineering Laboratory for Efficient Utilization of Soil and Fertilizer Resources, Shenyang 110866, Liaoning, China

*Corresponding author e-mail: ibtyoufe@163.com

Abstract. This study aims to explore the influence on soil physicochemical properties under a 38-y long-term fertilization in a brown soil. Soil samples (0-20 cm) were taken from the six treatments of the long-term fertilization trial in October 2016: no fertilizer (CK), N₁ (mineral nitrogen fertilizer), N₁P (mineral nitrogen and phosphate fertilizer), N₁PK (mineral nitrogen, phosphate and potassic fertilizer), pig manure (M₂), M₂N₁P (pig manure, mineral nitrogen and phosphate fertilizer). The results showed that the long-term application of chemical fertilizers reduced soil pH value, while the application of organic fertilizers increased pH value. Fertilization significantly increased the content of AHN, TN and SOM. Compared with the CK treatment and chemical fertilizer treatments, organic fertilizer treatments significantly increased the content of AP and TP. The content of AK and TK were no significant difference in different treatment.

1. Introduction

Soil is a natural body with biological activity, and the level of soil fertility is the basic condition to determine soil productivity. Since 1980s, amount of chemical fertilizers increased rapidly, while the amount of organic fertilizers decreased gradually. The application of chemical fertilizers became the most important measure of increasing grain yields. The utilization of chemical fertilizers not only increases crop yields, but also changes soil physicochemical properties. In recent years, scholars have done a great deal of research work on fertilizer efficiency and the effects on soil physicochemical properties by long-term fertilization. Yadav [1] believed that the long-term utilization of chemical fertilizers can still maintain soil productivity, while Doran [2] and Aref [3] argued that it is not conducive to sustainable and healthy development of soil fertility. This study explored the effects on physicochemical properties under a 38-y long-term fertilization in a brown soil, and was to provide basis for scientific fertilization and the agricultural production of sustainable development.



2. Materials and methods

2.1. Experimental site and investigation design

The study was conducted in the semi-humid region of Shenhe district, Shenyang (40°48'N and 123°33'E) of Liaoning Province, China. The field experiment was conducted in a well-drained field under a rotation of maize-maize-soybean. The crop growing season started in April and ended in September. In this study, a randomized block design was adopted in the experimental field and six treatments with four replicates each were chosen as follows: no fertilizer (CK), N₁ (mineral nitrogen fertilizer), N₁P (mineral nitrogen and phosphate fertilizer), N₁PK (mineral nitrogen, phosphate and potassic fertilizer), pig manure (M₂), M₂N₁P (pig manure, mineral nitrogen and phosphate fertilizer). The mineral fertilizers were applied in the form of urea, calcium superphosphate and potassium sulphate. Basic chemical properties of experimental soil in 1979 and the application rates of fertilizer are described by Luo et al [4].

Soil samples were taken from 0-20 cm soil in maize harvest stage.

2.2. Soil physicochemical property analysis

Soil pH was determined with a glass electrode using a soil/water ratio of 1:2.5. Soil organic matter (SOM) and total nitrogen (TN) were determined by dichromate oxidization method and semi-micro Kjeldahl apparatus, respectively^[5]. Total soil phosphorus (TP) and potassium (TK) were digested by HF-HClO₄ [6] and determined by molybdenum-blue colorimetry and flame photometry, respectively. Available phosphorus (AP) and potassium (AK) in the soil were extracted by sodium bicarbonate [7] and ammonium acetate [8] respectively. Alkali-hydrolyzable nitrogen (AHN) in the soil was determined as described by Xiong et al [9].

2.3. Statistical analysis

The charts were made by Microsoft Office Excel 2010 and Variance Analysis adopt SPSS 19.00.

3. Results and discussion

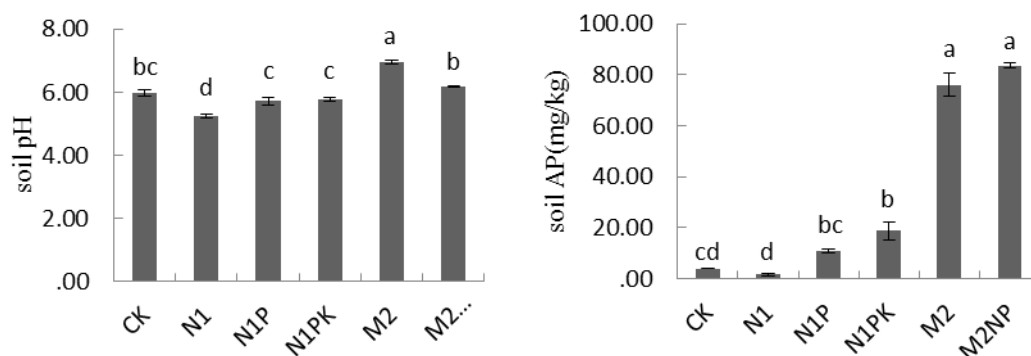


Fig.1 The pH of different fertilization treatments **Fig.2** The AP of different fertilization treatments

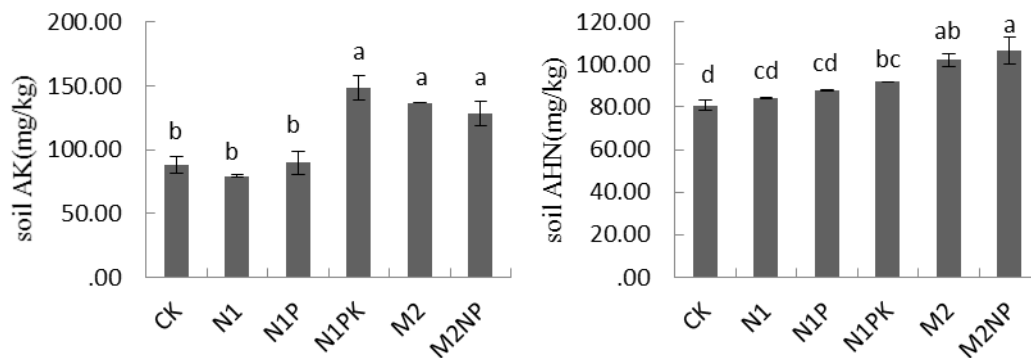


Fig.3 The AK of different fertilization treatments **Fig.4** The AHN of different fertilization treatments

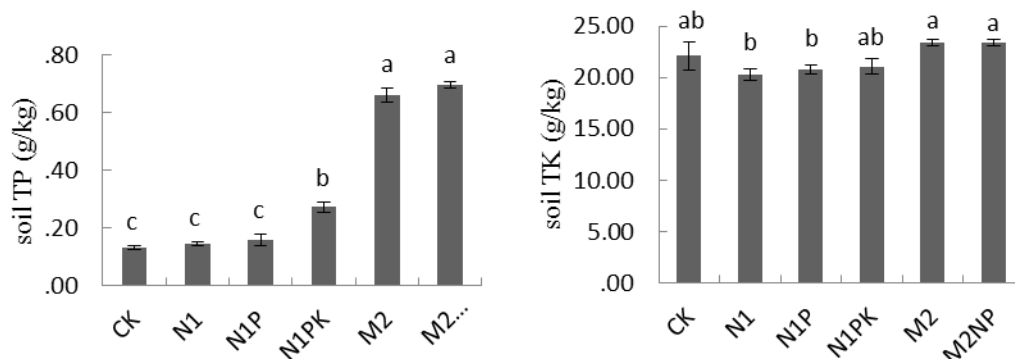


Fig.5 The TP of different fertilization treatments **Fig.6** The TK of different fertilization treatments

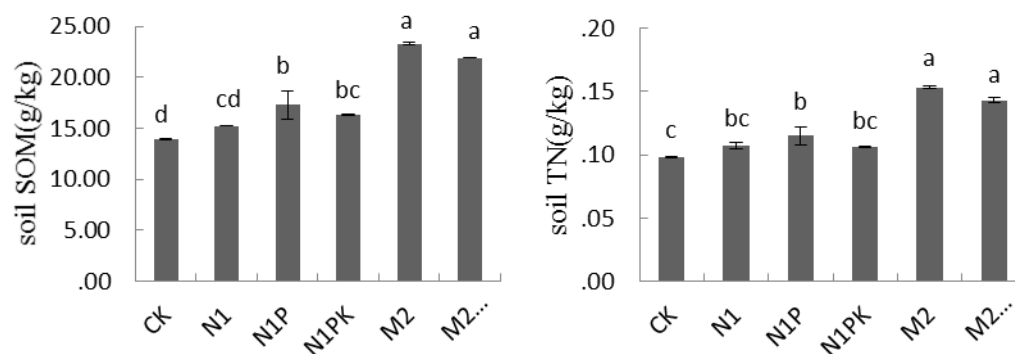


Fig.7 The SOM of different fertilization treatments **Fig.8** The TN of different fertilization treatments

The soil physicochemical properties in different fertilization treatments were shown in Fig.1-8. Long-term fertilization resulted in significant differences in most soil physicochemical properties. Soil pH ranged from 5.24 to 6.95 in different fertilization treatments, it was lowest in the N₁ treatment and highest in the M₂ treatment (Fig.1). Compared with organic fertilizer treatments, chemical fertilizer treatments showed a significant lower in pH value. The long-term application of chemical fertilizers reduced soil pH value, might be explained by the use of acidifying mineral fertilizers and thus increased soil acidity. Conversely, enrichment of cations increases the soil pH with the application of organic fertilizers [10, 11].

Fertilization significantly increased the content of AHN, TN and SOM (Fig.4, Fig.7 and Fig.8). The increase of soil nitrogen may be due to atmospheric nitrogen deposition, but more likely the nitrogen fixation from rhizobium during soybean planting stage. The increase of soil organic matter by

fertilization may be due to more root exudates of crop and stubble in the fertilized area compared with CK treatment, thus increasing the content of soil organic matter. In addition, the organic matter content was higher in organic fertilizer treatments than in chemical fertilizer treatments. On one hand, this could be caused by the higher amount of organic C and microbial biomass C added by organic manures, and on the other hand, increased above and below ground C input resulted in long-term nutrient accumulation [12, 13].

Compared with the CK treatment and chemical fertilizer treatments, organic fertilizer treatments significantly increased the content of AP and TP (Fig.2 and Fig.5). The content was the highest (83.60mg/kg and 0.70g/kg) in M₂NP treatment, while that of CK treatment was the lowest (4.11mg/kg and 0.13g/kg) respectively. The result indicated that the application of organic fertilizer with inorganic fertilizer is helpful to increase the content of AP and TP.

The content of AK and TK were no significant difference in different treatments (Fig.3 and Fig.6). The application of N fertilizer and the combined application of N and P fertilizers reduced the content of AK, while the combined application of N, P and K fertilizers could alleviate the trend. However, this trend was not obvious.

4. Conclusion

This study has demonstrated that after 38-y long-term fertilization, there is significantly different in the soil physicochemical properties. The long-term application of chemical fertilizers reduced soil pH value, while the application of organic fertilizers increased pH value. Fertilization significantly increased the content of AHN, TN and SOM. Compared with the CK treatment and chemical fertilizer treatments, organic fertilizer treatments significantly increased the content of AP and TP. The content of AK and TK were no significant difference in different treatments.

Acknowledgments

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