

## Experimental Study on Amelioration of Aeolian Sandy Soil with Soil Conditioners (Postprint)

**Authors:** Xi Yinqiao, Zhao Ying, Dong Zhengwu, Li Shengyu, Zhao Ying

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### Abstract

To evaluate the effects of multiple soil amendments (sodium carboxymethyl cellulose, phosphogypsum, and biochar) on the physicochemical properties of aeolian sandy soil and plant growth, cotton pot experiments were conducted with mixtures of amendments and aeolian sandy soil at different ratios. Changes in soil physicochemical properties and plant growth status were measured and analyzed, and an evaluation system for amendment effects was constructed by combining principal component analysis (PCA) with weighted summation to identify the optimal amendment and its application rate. The results showed that: compared with the control, bulk density and pH of aeolian sandy soil decreased, while porosity, organic matter, total nitrogen, total phosphorus, available phosphorus, and available potassium increased, with total potassium content remaining relatively unchanged; simultaneously, cotton plant height, base stem diameter, and biomass all increased substantially. Calculations using the comprehensive evaluation equation revealed that the comprehensive scores of amendment treatments under high irrigation amount were significantly higher than those under low irrigation amount. Under high irrigation amount, the biochar treatment achieved the highest comprehensive score, followed by phosphogypsum treatment, while sodium carboxymethyl cellulose treatment had the lowest score. The ranking of comprehensive scores was: CG3> CG2> CG1> BG3> BG2> AG3> BG1> AG2> AG1, among which the treatment with biochar applied at 45 g kg<sup>-1</sup> showed the best improvement effect with a score of 4.69.

### Full Text

#### Arid Zone Research (ChinaXiv Partner Journal)

**Authors:** XI Yin-qiao<sup>1,2</sup>, ZHAO Ying<sup>1</sup>, DONG Zheng-wu<sup>1</sup>, LI Sheng-yu<sup>1</sup>

**Affiliations:**

<sup>1</sup> Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences,

Urumqi 830011, Xinjiang, China

<sup>2</sup> University of Chinese Academy of Sciences, Beijing 100049, China

## 1.2 Experimental Design

The experiment employed a completely randomized design with three types of soil conditioners—sodium carboxymethyl cellulose (CMC), phosphogypsum, and biochar—each applied at three concentration levels. CMC was applied at rates of 0.5, 2.0, and 3.5 g · kg<sup>-1</sup>; phosphogypsum at 5, 15, and 25 g · kg<sup>-1</sup>; and biochar at 15, 30, and 45 g · kg<sup>-1</sup>. Two irrigation regimes (high and low) were implemented, with each treatment replicated three times. The soil bulk density was measured using a 100 cm<sup>3</sup> cutting ring, and soil samples were air-dried for physicochemical analysis. The experimental site experienced an average annual temperature of 9.2°C, with maximum and minimum temperatures of 26°C and -14°C, respectively.

## J 2 Statistical Analysis

Data were organized using Excel and analyzed with IBM SPSS Statistics 19.0. One-way ANOVA and Duncan's multiple range test were used to determine significant differences among treatments at the 0.05 probability level. Pearson correlation analysis was performed to examine relationships between variables. Figures were generated using OriginPro 2016.

## 2 Results and Analysis

### 2.1 Principal Component Analysis of Soil Conditioner Effects

Principal component analysis (PCA) was conducted on 12 measured indicators to evaluate the comprehensive effects of soil conditioners on Aeolian sandy soil properties and cotton growth. The analysis yielded three principal components with eigenvalues greater than 1, explaining 85.3% of the total variance.

The factor score equations for the principal components were:

$$F = 0.09X_1 - 0.11X_2 + 0.53X_3 + 0.32X_4 + 0.28X_5 - 0.46X_6 + 0.48X_7 + 0.14X_8 - 0.09X_9 - 0.19X_{10} - 0.10X_{11} - 0.02X_{12} \quad (2)$$

$$F = +0.21X_1 - 0.20X_2 + 0.14X_3 - 0.17X_4 - 0.13X_5 - 0.12X_6 + 0.04X_7 + 0.06X_8 - 0.41X_9 + 0.43X_{10} + 0.56X_{11} + 0.41X_{12} \quad (3)$$

The comprehensive evaluation equation was calculated as:

$$F = 0.603F_1 + 0.213F_2 + 0.184F_3 \quad (4)$$

The comprehensive scores under high irrigation were significantly higher than those under low irrigation. The treatment effects ranked as follows: CG3 > CG2 > CG1 > BG3 > BG2 > AG3 > BG1 > AG2 > AG1. The highest comprehensive score (4.69) was achieved with biochar applied at 45 g · kg<sup>-1</sup> under

high irrigation conditions, indicating this as the optimal treatment for improving Aeolian sandy soil.

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**Abstract:** This study synthetically evaluated the effects of three kinds of soil conditioner (sodium carboxymethyl cellulose, phosphogypsum and biochar) on the physiochemical properties of Aeolian sandy soil and cotton plant growth. A pot experiment was carried out under different ratios of soil conditioner additions, and 12 indexes were determined. The methods of principal component analysis (PCA) and mathematical calculation of weighted summation were used to establish the comprehensive evaluation equation for the improvement effect by calculating the comprehensive scores so as to select the best ratio of soil conditioner. The results showed that all three kinds of soil conditioner could be used to decrease the soil bulk density and pH value, increase the soil porosity and contents of organic matter, total nitrogen, total phosphorus, available phosphorus and available potassium, and slightly change the total potassium content. Moreover, the plant height, basal stem and biomass of cotton were increased substantially. Based on the comprehensive evaluation equation, the comprehensive score under high irrigation was significantly higher than that under low irrigation, and the comprehensive score was in an order of CG3 > CG2 > CG1 > BG3 > BG2 > AG3 > BG1 > AG2 > AG1. The improvement effect of applying biochar for  $45 \text{ g} \cdot \text{kg}^{-1}$  under high irrigation was the best, and its score was the highest (4.69).

**Keywords:** Aeolian sandy soil; soil conditioner; principal component analysis; pot experiment; cotton

*Note: Figure translations are in progress. See original paper for figures.*

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