Influence of Yuetian soil conditioner on output, heavy metal concentration and soil improvement of rice

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Abstract. A field experiment was conducted to test the influences of several doses of Yuetian brand soil conditioner on dry matter output and heavy metal concentration of rice, and the influence of basic physical and chemical properties of soil. The outcomes indicated that the dry matter output of rice was increased by 1.29%~23.42% by using different dosage of Yuetian brand soil conditioner compared with no soil conditioner treatment (treatment 1). The effect of Treatment 5 (1875kg/ha) was better on enhancing dry matter output of rice. And they could reduce Cd and Pb concentration of rice by 17.32%~60.17% and 11.47%~64.68%, respectively. Treatment 5 and 6 had a better effect on reducing heavy metal concentration in rice, and could increase the pH of the soil by 4.7%~37.2% and decrease the exchangeable acid (latent acid) by 3.5%~55.9% , the concentrations of soil effective Cd and Pb were reduced by 9.28%~49.48% and 8.34%~24.40% , respectively.

1. Introduction

Under the double influences of the natural conditions of regional high temperature and rainy weather and the man-made factors of high intensity exploitation and utilization of farmland, in particular, driven by the large amount of chemical fertilizers used by farmers in pursuit of high output and by the increasing damage of acid rain in recent years, the trouble of soil acidification of cultivated land in Red-soil Region of Southern China has become increasingly serious [1,2]. Soil acidification caused soil compaction, the decrease of biological availability of nutrient elements such as nitrogen and phosphorus, and the increase of metal ions such as aluminum, iron, manganese and toxic and harmful heavy metal elements in soil [3,4].

Yuetian soil conditioner is a kind of natural mineral raw material rich in calcium, magnesium, silicon, molybdenum and other mineral elements. After industrial activation treatment, it is grinded and processed into micron level powder. Because of its huge contact surface area of soil, it can be fully mixed with the soil evenly, so that the effective nutrient utilization rate can reach the maximum, and timely supplement the medium and small amount of soil which is easy to be lacked elements (such as calcium, magnesium, silicon, molybdenum, etc.). There are a few reports on the experiment of Yuetian soil conditioner in acidified farmland. For example, Ye Yuzhen's research outcomes indicated that the use of Yuetian brand soil conditioner 1200 kg/ha on acid farmland could effectively improve the emergence rate of Chinese yam, promote vine growth, enhance its commerciality, and increase its output and nutritional quality [5]; For another, Wu Lingyun's research outcomes indicated that the application of Yuetian brand soil conditioner 2250 kg/ha could enhance the pH value of the cultivated
soil by 18.4%, significantly improve the agronomic characteristics of cauliflower, and significantly reduce the incidence of cauliflower root swelling, which also had a certain promoting effect on the output of cauliflower[6]. It can be seen that Yuetian brand soil conditioners used in acid soil of our province has shown a good effect of increasing production and improving soil. However, there are few reports about Yuetian brand soil conditioners used on other crops.

As a result, the influences of several dosages of Yuetian brand soil conditioner on rice output, heavy metal concentration and soil properties were studied.

2. Materials and methods

The test was assigned in the betel nut and rice planting base of Songlin village, Hetian Town, Changting County, Fujian Province. Six treatments were designed with different dosage of Yuetian brand soil conditioners, for examples: T1, Control; T2, 750 kg/ha; T3, 1125 kg/ha; T4, 1500 kg/ha; T5, 1875 kg/ha; T6, 2250 kg/ha. Each treatment was repeated 3 times, and the area of each trial plot was 20m².

The test products (main technical indexes are CaO ≥20%, MgO ≥10%, SiO2 ≥12%, pH 10–12) were produced and supplied by Guangdong Wanshan soil remediation Technology Co., Ltd. The soil conditioner products of each treatment were combined with soil preparation and mixed with base fertilizer. On July 8, 2019, soil conditioner was applied in combination with site preparation. The soil conditioner was fully mixed with topsoil. The test crop variety was rice, the variety was Zhongzheyou No. 8, rice seedlings were raised on May 25 and planted on July 9, and Rice and soil samples were collected and measured on September 30.

The soil and plant samples were analyzed and determined with references[7].

3. Outcomes and analysis

3.1. Influences of different dosages of Yuetian brand soil conditioner on dry matter output of rice

Outcomes (Fig. 1) indicated that the output of dry matter of rice was increased to some extent by using some doses of Yuetian brand soil conditioner, compared with CK (T1), the dry matter output of rice increased from 1.29% to 23.42%, and T5 (1875kg/ha) had a better effect than others on dry matter output of rice.

The linear regression equation between the amount of Yuetan brand soil conditioner (x) and the dry matter output of rice (Y) was fitted, and the outcomes indicated that the amount of quadratic equation

\[ y = -29.066x^2 + 485.44x + 4763.1 \quad (R^2 = 0.9215*) \]

could be fitted well (Figure 1).

![Figure 1. Influences of several dosages of Yuetian brand soil conditioner on dry matter output of rice](image-url)
3.2. Influences of several dosages of Yuetian brand soil conditioner on heavy metal concentration of rice

Outcomes (table 1) indicated that the concentrations of Cd and Pb in rice were reduced by 17.32%–60.17% and 11.47%–64.68% respectively by using several doses of Yuetian brand soil conditioner, T5 and T6 had better influences on reducing Cd and Pb concentrations of rice.

Table 1. Influences of several dosages of Yuetian brand soil conditioner on heavy metal concentrations in rice

| Treatment  | Cd   | Pb   |
|------------|------|------|
|            | Concentration (mg/kg) | Increasing rate (%) | Concentration (mg/kg) | Increasing rate (%) |
| Treatment 1| 0.231 Aa | \   | 0.218 Aa | \   |
| Treatment 2| 0.191 ABb | -17.32 | 0.193 Aa | -11.47 |
| Treatment 3| 0.182 ABb | -21.21 | 0.155 Ab | -28.90 |
| Treatment 4| 0.135 Bc | -41.56 | 0.105 Bc | -51.83 |
| Treatment 5| 0.101 Bd | -56.28 | 0.081 Bd | -62.84 |
| Treatment 6| 0.092 Bd | -60.17 | 0.077 Bd | -64.68 |

3.3. Influences of several dosages of Yuetian brand soil conditioner on soil pH and exchangeable acid concentration

Outcomes (table 2) indicated that the pH of the soil after rice harvest could be increased by 4.7%–37.2% by using several doses of Yuetian brand products. And all of them might decrease the exchangeable acid (latent acid) in the soil by 3.5%–55.9%. Inside them, T6 had a better effect than others on the increasing soil pH value and decreasing exchangeable acid concentration.

Table 2. Influences of several dosages of Yuetian brand soil conditioner on soil pH and exchangeable acid concentration

| Treatment  | pH Value | Increasing rate (%) | Exchangeable acid | Increasing rate (%) |
|------------|----------|---------------------|-------------------|---------------------|
|            |          |                     | (mmol/L)          |                     |
| Treatment 1| 4.3Bc    | \                   | 4.33 Aa           | \                   |
| Treatment 2| 4.5Bbc   | 4.7                 | 4.18 Aa           | -3.5               |
| Treatment 3| 4.9Bb    | 14.0                | 3.93 ABab         | 9.2                 |
| Treatment 4| 5.2ABa   | 20.9                | 3.46 ABb          | -20.1               |
| Treatment 5| 5.5ABa   | 27.9                | 2.92 Be           | -32.6               |
| Treatment 6| 5.9Aa    | 37.2                | 1.91 Cd           | -55.9               |

3.4. Influences of several dosages of Yuetian brand product on the concentration of effective heavy metals in soil

Table 3. Influences of using several dosages of Yuetian brand product on soil effective heavy metal concentration

| Treatment  | Available Cd | Available Pb |
|------------|--------------|--------------|
|            | Concentration (mg/kg) | Increasing rate (%) | Concentration (mg/kg) | Increasing rate (%) |
| Treatment 1| 0.097 Aa     | \               | 1.967 a               | \                   |
| Treatment 2| 0.088 Aa     | -9.28          | 1.803 a               | -8.34               |
| Treatment 3| 0.077 Ab     | -20.62         | 1.712 ab              | -12.96              |
| Treatment 4| 0.061 ABC    | -37.11         | 1.634 bc              | -16.93              |
| Treatment 5| 0.055 Bcd    | -43.30         | 1.501 c               | -23.69              |
| Treatment 6| 0.049 Bd     | -49.48         | 1.487 c               | -24.40              |
Outcomes (table 3) indicated that the concentrations of available heavy metals Cd and Pb decreased by 9.28%~49.48% and 8.34%~24.40% respectively after applying different doses of Yuetian brand soil conditioner.

4. Conclusion

The outcomes indicated that the dry matter output of rice was increased by 1.29%~23.42% with different dosage of Yuetian brand soil conditioner compared with no soil conditioner treatment (treatment 1). Treatment 5 (1875kg/ha) had a better effect than other treatments on increasing dry matter output of rice. And they could reduce Cd and Pb concentration of rice by 17.32%~60.17% and 11.47%~64.68% respectively, treatment 5 and 6 had better influences on reducing heavy metal concentration in rice, increasing soil pH by 4.7%~37.2% and decreasing exchangeable acid by 3.5%~55.9%, the concentrations of soil effective heavy metal Cd and Pb in soil were reduced by 9.28%~49.48% and 8.34%~24.40%, respectively. On the whole, the effect of applying Yuetian brand soil conditioner (1875~2250 kg/ha) on rice output, heavy metal concentration of rice and soil acidification improvement is relatively better under the experimental conditions. It is suggested that the use of Yuetian brand product in acid paddy field in red soil area should be popularized.

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