Effects of Tillage Practices on Soil Fertility in Loess Plateau

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Abstract. In order to determine whether there is a threat to soil nutrient content by long-term no-tillage cultivation in loess plateau, a suitable high-yield and high-efficiency tillage technology system is established. This study was conducted in the Changwu Loess Plateau Agro-ecological Experiment Station of the Northwest A&F University in Changwu County, Shaanxi Province. The experimental field for no-tillage cultivation was selected for three consecutive years. In September 2015, no-tillage and tillage were carried out separately before winter wheat planting. And rotary tillage 3 kinds of farming treatment. After harvesting of winter wheat in 2016, the contents of available phosphorus, available potassium in 0~30 cm soil layer under different tillage methods were analyzed. The results showed that in the 0~30cm soil layer, the contents of available phosphorus and available potassium in soil under three tillage methods decreased along the profile. The contents of available phosphorus and available potassium in 0~10 cm soil layer were significantly higher than that of tillage and rotary tillage (p<0.05). The contents of available phosphorus and available potassium in soil of 10~30cm soil were ploughed tillage > rotary tillage > no-tillage, and there was no significant difference among the three tillage methods in 10-20cm soil layer.

1. Introduction
Soil is the basis for the survival of crops. Different cultivation of soil is an important research content in agricultural production technology system [1, 2]. Choosing a reasonable farming method has a positive effect on soil nutrient fixation, crop growth and yield formation [3-5]. Compared with traditional tillage, conservation tillage techniques such as no-tillage and deep pine have emerged in recent years [6]. A large number of research results at home and abroad have shown that farmland implements conservation soil tillage measures such as no-tillage and less tillage, which can alleviate Wind erosion and water erosion, improve soil physical and chemical properties, and increase crop yield [7, 8]. However, with the extension of the implementation time of conservation tillage, the disadvantages of conservation tillage measures are gradually emerging. For example, long-term less and no-till will...
lead to the accumulation of nutrients in the surface soil, which is not conducive to the uniform distribution of nutrients in the deep soil, thus affecting crop yield [9, 10].

The loess-rid land area is an important grain producing area in the northwestern part of China. It is located in arid and semi-arid areas and belongs to the rain-fed agricultural area. With the rise of conservation tillage research, the experimental field in the study area has been carried out for three years without tillage. In recent years, studies have shown that long-term no-tillage conditions lead to surface nutrient enrichment in farmland soils, low soil nutrients, uneven soil nutrients, and limited crop yields [11]. In order to find out whether long-term no-tillage cultivation in this area threatens soil nutrient content and crop yield, we have treated the soil differently after long-term no-tillage. In this study, the loess and drought-stricken areas were selected. According to the problem of long-term no-tillage, the effects of tillage methods on soil nutrient and yield of long-term no-till winter wheat 0-30cm tillage were analyzed through different soil tillage methods, in order to establish a reasonable round tillage. The system provides a scientific reference.

2. Materials and methods

2.1. Site description

The test area is located in the Changwu Loess Plateau Agro-ecological Experiment Station (35°14′N, 107°40′E) of the Northwest A&F University of Changwu County, Shaanxi Province. The area is a dry farming area with a warm climate. Temperate and semi-humid continental monsoon climate, crops are planted with one year of ripe wheat and corn. The test site is 1200 m above sea level, with an average annual temperature of 9.1 °C, sunshine hours of 2226 h, and an average annual rainfall of 578.5 mm. The test field soil is black loess, the field water holding capacity is 21%~24%, the wilting humidity is 9%~12%, the cultivated soil pH is 8.4, and the bulk density is 1.36g/cm$^3$.

2.2. Experimental layout

In this experiment, the experimental field of no-tillage cultivation was selected for 3 consecutive years. In September 2015, three kinds of tillage treatments were carried out before no sowing, tillage and rotary tillage, and the three treatments were repeated. The experimental treatment methods are shown in Table 1. The amount of fertilizer applied to each treatment was in accordance with the local farmers' management model. The winter wheat variety was selected as “Long Drought 58”, and the seeding amount was 150kg/hm$^2$. It was planted on September 29, 2015 and harvested on June 4, 2016.

| Treatment   | Tillage practices                                                                 |
|-------------|----------------------------------------------------------------------------------|
| No-tillage  | After the wheat is harvested, the straw is removed and the no-till seed drill is used to complete the sowing, fertilizing and repressing operations. |
| Tillage     | After the wheat is harvested, the straw is removed, the fertilizer is applied, the machine is ploughed (cultivation depth 15~20 cm), and the wheat is planted. |
| Rotary tillage | After the wheat is harvested, the straw is removed, the fertilizer is applied, the rotary tiller is rotated (cultivation depth 10 cm), and the wheat is planted. |

2.3. Soil sampling

After the wheat is harvested, three points are taken on the experimental field with soil drills. The depth of the soil is 30 cm, divided into three layers, each layer of 10 cm, that is, 0~10, 1~20, 20~30 cm, and some soil samples are taken (40~ 50g) was placed in an aluminum box to determine the soil moisture content[12], and a portion of the soil sample (350~450g) was placed in a ziplock bag to determine the total nitrogen, available phosphorus and available potassium content of the soil.
2.4. Laboratory measurements
According to the third edition of soil agrochemical analysis edited by Bao Shida, the soil available phosphorus content was determined by 0.5 mol/L NaHCO$_3$ extraction colorimetric method. The soil available potassium content was ammonium acetate.

2.5. Statistical analysis
Mean and standard deviation were used to indicate available phosphorus and available potassium in different tillage methods and different depths. One-way analysis of variance was used to analyze soil organic carbon and total nitrogen in different tillage methods. The effect of available phosphorus, available potassium and winter wheat yield was analyzed by LSD method (P < 0.05). Data processing was performed with Excel2007 and data analysis was performed with Spss20.

3. Results

3.1. Soil available phosphorus contents
As shown in Table 2, the soil available phosphorus content in the 0~30 cm soil layer decreased along the soil profile, and the soil available phosphorus content in the no-tillage soil was significantly different between 0~30 cm soil layer (p < 0.05), there was no significant difference in soil available phosphorus content between 0~30cm soil in plowing tillage (p < 0.05), soil available phosphorus content in rotary soil tillage 0~20cm layer soil and 20~30cm soil layer Significant difference (p < 0.05). Under the different tillage methods, the soil available phosphorus content in the 0~10 cm soil layer showed no-tillage tillage > rotary tillage > tillage tillage, and there was a significant difference between no-tillage tillage and tillage tillage (p<0.05), at 10~20 cm. The soil layer is characterized by tillage tillage > rotary tillage > no-tillage tillage. There is no difference in the 20~30 cm soil layer: tillage tillage > rotary tillage > no-tillage tillage. There was a significant difference (p < 0.05).

Table 2. Soil available phosphorus contents under different tillage practices at different depths (± standard deviation) mg kg$^{-1}$

| soil depths(cm) | No-tillage   | Tillage       | Rotary tillage |
|-----------------|--------------|---------------|----------------|
| 0~10            | 16.8±0.954aA | 14.9±0.751bA  | 15.1±0.814abA  |
| 10~20           | 14.1±0.814aB | 14.6±0.889aA  | 14.2±0.643aA   |
| 20~30           | 11.3±1.153bC | 13.8±0.854aA  | 12.3±1.100abB  |

Values with different lower-case letter within rows are significantly different (p < 0.05) with tillage practices, considering the same depth. Values with different capital letters within columns are significantly different (p < 0.05) with depth, considering the same tillage practices.

3.2. Soil available potassium contents
As shown in Table 3, the soil available potassium content in the 0~30 cm soil layer decreased along the soil profile, and the soil available potassium content in the no-tillage soil was significantly different between 0~30 cm soil layer (p < 0.05), there was no significant difference in the soil available potassium content in the tillage tillage between 0~30cm soil layer (p<0.05), soil available potassium content in rotary soil tillage 0~10cm soil layer available soil and 20~30cm soil The layers showed a significant difference (p < 0.05). Under different tillage methods, soil available potassium content in 0~10 cm soil layer showed no-tillage tillage > rotary tillage > tillage tillage, and soil available potassium content in tillage tillage was not much different from rotary tillage, and soil available potassium under no-tillage tillage The content was significantly different from the two (p<0.05). In the 10~20 cm soil layer, it
showed ploughing tillage > rotary tillage tillage > no-tillage tillage, and there was no significant difference. The performance in the 20–30 cm soil layer was turned over. Tillage > Rotary tillage > no-tillage tillage, and soil available potassium content and no-tillage tillage under tillage tillage, there was significant difference under rotary tillage (p<0.05).

Table 3. Soil available potassium contents under different tillage practices at different depths (± standard deviation) mg kg⁻¹

| soil depths(cm) | No-tillage 142.9±2.511aA | Tillage 134.1±3.934bA | Rotary tillage 135.8±2.589bA |
|-----------------|--------------------------|-----------------------|-----------------------------|
| 0–10            |                          |                       |                             |
| 10–20           | 120.7±6.067ab            | 130.7±4.518ab         | 125.2±8.994ab               |
| 20–30           | 104.2±6.619bC            | 125.8±5.197ab         | 114.2±3.769bB               |

Values with different lower-case letter within rows are significantly different (p < 0.05) with tillage practices, considering the same depth. Values with different capital letters within columns are significantly different (p < 0.05) with depth, considering the same tillage practices.

4. Discussion

The change of tillage mode is mainly the change of tillage depth. The depth of tillage is closely related to soil bulk density, soil porosity, plant roots and soil nutrient contents [13, 14]. In this study, available phosphorus and available potassium in the 0–30 cm soil layer, no-tillage tillage, tillage and rotary tillage were reduced along the profile. This is consistent with Gao Xiaodong's research in the Loess Plateau, that is, the nutrient content decreases with the deepening of the soil layer. This is because the application of surface fertilizer and litter increase the soil surface nutrient content, while the deep soil nutrient mainly depends on the root system. Secretion [15]. In this study, there was significant difference between the 0–10 cm soil layer and the 20–30 cm soil layer in the soil under no-tillage tillage (p<0.05). No-tillage cultivation made the available phosphorus and available potassium accumulate in the 0–10 cm soil of the topsoil. Soil available phosphorus and available potassium content in the 0–30 cm soil layer were not significantly different under tillage. This conclusion is similar to the previous research results, that is, no-tillage can significantly increase the effective phosphorus and available potassium content of 0–10 cm in the soil surface, but the effect on the 10–30 cm soil layer is not obvious [16].

In the present study, the contents of available phosphorus and available potassium in 0–10 cm soil were all tillage > rotary tillage > tillage, soil available phosphorus and available potassium content in tillage and There was no significant difference under rotary tillage, and no-tillage farming was significantly different (p<0.05). Compared with rotary tillage and tillage, no-tillage treatment can reduce the disturbance to the soil surface and increase the soil surface nutrient content [17]. Soil available phosphorus and available potassium content in both 10–20 and 20–30 cm soil layers showed tillage > rotary tillage > no-Tillage, and no-tillage and tillage were significantly different (p<0.05). The analysis can reduce the bottom layer of the plow by the tillage treatment, which is beneficial to the absorption of nutrients in the lower layer of the soil and can improve the availability of available phosphorus in the deep soil, which reduces the available phosphorus and available potassium in the surface soil but increases the nutrient content of the deep soil. This is similar to the results of Zhang Wenchao[16].

5. Conclusion

We found that available phosphorus and available potassium decreased as the soil layer deepened in the 0–30 cm soil layer. 0–10cm soil layer, available phosphorus and available potassium contents under no-tillage is higher than the other two, 10–20cm soil layer, available phosphorus under no-tillage content is reduced, but the contents is increased under rotary tillage. In the 20–30cm soil layer, under soil tillage, the available phosphorus and available potassium were the highest, and no tillage was the least.
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