Changes in N, P and K Contents in Eum-orthic Anthrosols at Different Moisture Contents

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Abstract [**Objectives**] This study aimed to provide a basis for the management of nitrogen, phosphorus and potassium nutrients in eum-orthic anthrosols and the fertilization of crops. [**Methods**] Using the indoor culture method, the contents of total nitrogen, available phosphorus and available potassium in eum-orthic anthrosols under three different moisture conditions: long-term drying, long-term logging and alternate drying and logging were analyzed and compared. [**Results**] The total nitrogen content was higher under the moisture condition of long-term drying. The minimum (0.60 g/kg) appeared on day 30, and the maximum (0.74 g/kg) appeared on day 120, increased by 8.8% compared with the minimum. The available phosphorus content was also higher under the moisture condition of long-term drying. The minimum (16.9 mg/kg) appeared on day 60, and the maximum (22.5 mg/kg) appeared on day 120, increased by 33.1% compared to the minimum. The available potassium content showed a downward trend under long-term logging, and was higher than those under the other two moisture conditions. The maximum (150 mg/kg) appeared on day 30, and the minimum (136 mg/kg) appeared on days 75 and 90, reduced by 9.3% compared with the maximum. [**Conclusions**] Water plays a positive role in activating nutrients. Different nutrients have different responses to different moisture conditions.

Key words Eum-orthic anthrosols, Nitrogen, Phosphorus, Potassium, Alternate drying and logging, Long-term drying, Long-term logging

1 Introduction

Soil is the main source of water for plants. The moisture in the soil mainly comes from precipitation and artificial irrigation, and participates in the large water cycle of lithosphere-biosphere-atmosphere-hydrosphere. Soil moisture mainly affects soil aeration, soil microbial activity and soil enzyme activity. When the moisture is excessive, the soil aeration is poor, and the activity of microorganisms and enzymes increases; and when soil moisture is insufficient, soil porosity increases, soil microorganisms decrease, and soil enzyme activity is inhibited. This series of changes will affect the changes in soil nutrient content.

In the context of global climate change, local areas may experience frequent and severe dry and wet processes or severe dry and wet alternates caused by irrigation after a long period of drought. The difference in soil moisture caused by the alternation of drying and logging has an important impact on the activation and transformation of soil nitrogen, phosphorus and potassium. It has obvious advantages over ordinary fertilizers in terms of improving nutrient utilization, and reducing environmental pollution and labor input[1-2]. In this study, the release and activation mechanism of nitrogen, phosphorus and potassium in the soil under different moisture conditions was explored.

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2 Materials and methods

2.1 Test soil The test soil was eum-orthic anthrosols in the central Shaanxi Plain. It was collected from 0 – 20 cm soil layer in field, air-dried indoors and passed through a 2 mm sieve for use.

2.2 Test design The test set up three treatments: long-term drying, long-term logging and alternating drying and logging. For each treatment, three replicates, 30 beakers for each replicate, were arranged. For long-term drying, the test soil was poured into beakers and dried in an oven at 40 ℃. For long-term logging, the test soil was poured into beakers, added water with water surface 2 cm above the soil surface, sealed with plastic wrap, and placed at room temperature (water was added at any time to keep the soil in the beakers in a saturated anaerobic environment, and the indoor temperature was recorded every day). For alternating drying and logging, the soil in the beakers was made logged for half of the time and dry for half of the time. The dry culture was the same as the long-term drying treatment, and the water-submerged culture was the same as the long-term logging treatment. The first 6 times of soil sampling were performed at an interval of 15 d, and the later 4 times of soil sampling were performed at an interval of 30 d. The total culture duration was 210 d.

2.3 Index determination The soil samples collected were naturally air-dried indoors, ground, and passed through 1 mm sieve and 0.149 mm sieve, respectively for content determination of available phosphorus, available potassium and total nitrogen using 0.5 mol/L $NaHCO_3$ extraction-colorimetric method, CH_3COONH_4 extraction-flame photometric method and semi-micro Kjeldahl

method, with reference to *Soil Agrochemical Analysis*[3].

2.4 Data processing Data processing and plotting were performed using Excel 2020.

3 Results and analysis

3.1 Content of total nitrogen in eum-orthic anthrosols under different moisture condition Under the condition of long-term drying, the total nitrogen content of eum-orthic anthrosols showed an overall upward trend. The minimum value (0.60 g/kg) appeared on day 30, and the maximum value (0.74 g/kg) appeared on day 120, an increase of 8.8% from the minimum value. Under the moisture condition of long-term logging, the total nitrogen content did not change much. The minimum value (0.61 g/kg) appeared on day 15, and the maximum value (0.66 g/kg) appeared on day 210, an increase of 8.2% from the minimum value. Under alternating drying and logging condition, the total nitrogen content showed an increasing trend in the first 45 d and reached the maximum (0.69 g/kg) on day 45; and with the extension of culture time, it showed a downward trend and reached the minimum (0.58 g/kg) on day 60, reduced by 15.9% compared with the maximum (Fig. 1). In terms of effect intensity of soil moisture on total nitrogen content, different treatments were in the order as long-term drying > long-term logging > alternating drying and logging. Long-term drying had an important impact on soil nitrogen mineralization[4-5]. The reason may be that long-term drying increased the content of NH_4^+, $-N$, NO_3-N and free amino acids, thereby increasing the total nitrogen content in the soil.

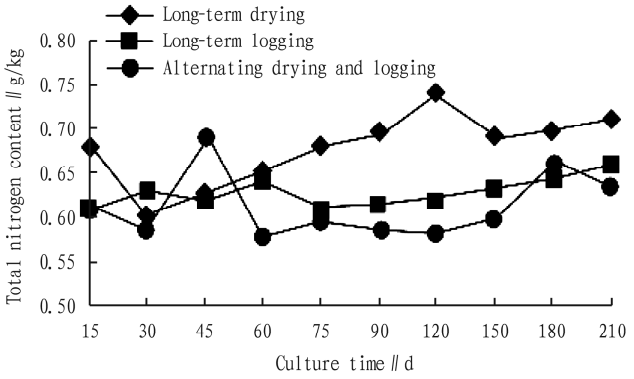

Fig. 1 Content of total nitrogen in eum-orthic anthrosols under different moisture condition

3.2 Content of available phosphorus in eum-orthic anthrosols under different moisture condition Under the moisture condition of long-term drying, the available phosphorus content of eum-orthic anthrosols showed a trend of first decreasing, then increasing and then decreasing. It was lowest (16.9 mg/kg) on day 60 and highest (22.5 mg/kg) on day 120, an increase of 33.1% from the minimum value. Under long-term logging, the available phosphorus content of eum-orthic anthrosols first decreased and then increased. The lowest value (13.6 mg/kg) appeared on day 75, and the highest value appeared at the end of the culture on day 210, which was 17.3 mg/kg, increased by 27.2% from the minimum value. Under the moisture condition of alternating drying and logging, the lowest available phosphorus content (17.3 mg/kg) in eum-orthic anthrosols appeared on day 60, and the highest content (20.9 mg/kg) appeared on day 180, an increase of 20.8% from the minimum value (Fig. 2). In terms of effect intensity of soil moisture on available phosphorus content, the three treatments ranked as long-term drying > alternating drying and logging > long-term logging. Under the condition of alternating drying and logging, phosphorus in the soil will be released, and its chemical form becomes active[6], so the release and absorption of available phosphorus coexist.

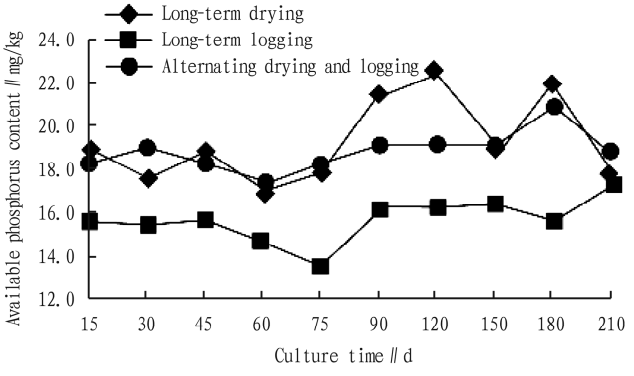

Fig. 2 Content of available phosphorus in eum-orthic anthrosols under different moisture condition

3.3 Content of available potassium in eum-orthic anthrosols under different moisture condition Under the condition of long-term drying, the available potassium content of eum-orthic anthrosols showed an increasing trend. It reached the lowest value (136 mg/kg) on day 15 and the highest value (145 mg/kg) on day 150, an increase of 6.6% over the lowest value. Under long-term logging condition, the available potassium content showed a decreasing trend. The maximum value (150 mg/kg) appeared on day 30, and the minimum value (136 mg/kg) appeared on days 75 and 90. The minimum value was 9.3% smaller than the maximum value. Under the condition of alternating drying and logging, the available potassium content of eum-orthic anthrosols showed an increasing trend. The minimum value (127 mg/kg) appeared on day 15, and the maximum value (143 mg/kg) appeared on day 210. The maximum value was 12.6% greater than the minimum value (Fig. 3). From the perspective of effect intensity of different

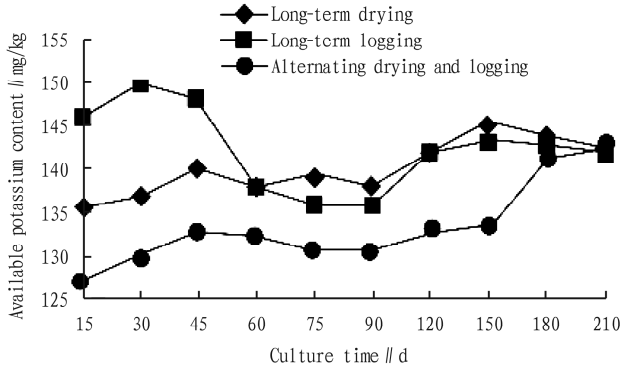

Fig. 3 Content of available potassium in eum-orthic anthrosols under different moisture condition

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moisture content on soil available potassium content, the three treatments were in the order as long-term logging > long-term drying > alternating drying and logging. Under alternating drying and logging condition, potassium ions in the soil were reduced, and relatively more ferrous and manganous ions replaced the potassium ions adsorbed by the soil, resulting in the activation of potassium ions[7], leading to the increase of available potassium content of the soil.

4 Conclusions

Different moisture conditions have different effects on the conversion of nitrogen, phosphorus and potassium. The total nitrogen content showed an upward trend under long-term drying condition, and changed slightly under conditions of long-term logging and alternating drying and logging. In overall, the effect intensity of different moisture conditions on total nitrogen content ranked as long-term drying > long-term logging > alternating drying and logging. The absorption and release of available phosphorus coexisted in the soil under the moisture conditions of long-term drying, long-term logging and alternating drying and logging. In overall, the effect intensity of different moisture conditions on available phosphorus content was in the order as long-term drying > alternating drying and logging > long-term logging. The available potassium content in the soil showed a decreasing trend under the moisture condition of long-term logging, and showed an increasing trend under the moisture conditions of long-term drying and alternating drying and logging. The effect intensity of different moisture contents on soil available potassium content ranked as long-term logging > long-term drying > alternating drying and logging overall.

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