Preliminary Study on the Effect of Dry-wet Alternation on Soil Nutrient Elements

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Abstract. Dry-wet alternation is one of the main driving factors of soil nutrient cycle. Therefore, it is important to study the effect of dry-wet alternation on soil nutrient activation in order to reduce the amount of fertilizer applied to agricultural land. The effects of long-term drying, long-term flooding and dry-wet alternation on the nutrients of different soils were studied in this paper. The results showed that: (1) The total nitrogen content of feldspathic sandstone was lower than 0.3g/kg after long-term drying, flooding and dry-wet alternation. The total nitrogen content of loess soil tended to increase after drying and wetting alternately, but the change of water flooding treatment was not obvious. (2) There is a process of release and absorption of feldspathic sandstone during long-term drying and alternating wetting and drying. Long-term flooding of available phosphorus is a process of first decreasing, then increasing and then decreasing. During the long-term drying, flooding and dry-wet alternation process, the available phosphorus content of loess soil changed significantly, showing an upward trend. The highest available phosphorus content reached 41.62mg/kg after 5 days of dry-wet alternation culture, which increased by 48.10%. (3) After 15 days of incubation, the available potassium of feldspathic sandstone increased by 40.1% to 101.21mg/kg. Available potassium in loess soil increased gradually under these three conditions, especially in dry-wet alternating conditions, after 15 days, it reached 267.58mg/kg, which increased by 109.34%. The results show that loess soil is very susceptible to environmental conditions, and can be used as one of the materials for nutrient stimulation.

1. Introduction
The alternation of dry and wet is a common natural phenomenon. Due to the lack of rainfall for a long time, long-term rainfall or insufficient rainfall, the phenomenon of alternation of dry and wet occurs frequently [1], which is one of the most extensive forms of abiotic stress experienced by soil [2]. In the process of alternation of dry and wet, the physical change of soil first occurs, which shows the change
of water condition and temperature characteristics; meanwhile, the continuous change of soil under the condition of oxidation and reduction causes the change of chemistry and biology, which shows the change of decomposition and mineralization of soil organic matter, the number and structure of microbial community, etc. [3], and then affects the physical and chemical properties of soil, thus affecting the soil ecosystem The structure and function of the system.

In recent years, some researchers have found that the dry wet alternation process is one of the main factors driving the nutrient cycle of soil ecosystem. The dry wet alternation process can transform the nutrients that are not easy to decompose into the nutrients that are easy to decompose, which is helpful for the mineralization of nutrients and the enhancement of the dissolution in a short time, thus affecting the biogeochemical cycle of soil nutrients [4-5]. Wu found through the study of soil redox process that the alternation of dry and wet affected the activation and transformation of N, P, K by changing redox potential [6]. Ma found that the periodic alternation of dry and wet environment in the Three Gorges Reservoir area affected the release of soil phosphorus, and found that the level of available phosphorus increased when flooding, and decreased when falling dry [4]. Zhan found that the present dry wet alternation process can improve the soil potassium fixation ability [7].

Therefore, it is of great significance to study the transfer and transformation of soil nutrients under the condition of dry wet alternation, and to recognize the change and activation of soil nutrients in the process of dry wet alternation. However, there are few studies on different nutrient base soil and long-term dry and long-term flooded soil. Therefore, Lou soil and feldspathic sandstone are used as base soil in this study to explore the excitation and inhibition of dry wet alternation on soil nutrients, so as to provide basic theoretical support for soil nutrient activation.

2. Materials and methods

2.1. Test design
The experiment was set up in the pretreatment Laboratory of Fuping pilot test base. Three treatments (Table 1) were designed: long-term drying, long-term water flooding and dry wet alternation. Lou soil with high nutrient content and feldspathic sandstone with low nutrient content were used as the test soil, each 30kg, air dried to less than 15% water content, ground and screened for 2mm, each 500g was cultured in a 1 l beaker, and each treatment was set with three repetitions 54 beakers in total.

Under the condition of long-term drying treatment, all soil samples are cultured in the oven at a temperature of 45℃; under the condition of long-term water flooding treatment, all soil samples are cultured at room temperature in the laboratory, the water surface is maintained at 1cm higher than the soil samples, and the temperature is recorded every day; under the condition of alternate dry and wet treatment, all soil samples are dried and watered for half of the cultivation time, dried in the oven, and watered out for real Laboratory inspection. Every 5 days a culture cycle, a total of 15 days 3 cycles.

Table1. Experimental design.

| Serial number | Soil type       | Treatment       | Number |
|---------------|----------------|-----------------|--------|
| 1             | Feldspathic sandstone | Long term drying | G1     |
| 2             | lou soil        | Long term drying | G2     |
| 3             | Feldspathic sandstone | Long term flooding | S1     |
| 4             | lou soil        | Long term flooding | S2     |
| 5             | Feldspathic sandstone | Dry-wet alternation | J1     |
| 6             | lou soil        | Dry-wet alternation | J2     |

2.2. Determination method
Soil samples shall be taken every 5 days for each treatment, 18 samples in total. A small part of the soil samples shall be put into aluminum boxes, and a part of the soil samples shall be put into self sealing bags. The soil sample in the aluminum box is dried in an oven of 105 degrees for 24 hours, and
its moisture content is measured [8]; the soil in the self sealed bag is taken back and dried by natural air, and it is screened by 1mm and 0.149mm respectively. The soil screened by 1mm is used to measure the content of available phosphorus and available potassium in the soil, and the soil screened by 0.149mm is used to measure the content of total nitrogen in the soil. According to the third edition of soil agrochemical analysis edited by Bao [9], the determination method of soil available phosphorus is 0.5mol/l NaHCO$_3$ extraction colorimetry; the determination method of soil available potassium is nh$_4$ac Extraction Flame photometry; the determination method of soil total nitrogen is semi micro Kjeldahl method.

2.3. Data processing
Excel 2007 is used for data processing, SPSS 20 for data analysis and orange 8.0 for drawing.

3. Results and analysis

3.1. Effect of different treatments on soil total nitrogen
Fig.1 shows the change of total nitrogen content of feldspathic sandstone and Lou soil under different treatments. It can be seen from Fig.1 that the total nitrogen content of feldspathic sandstone is relatively low, with a background of only 0.195g/kg. Under the dry treatment, the total nitrogen content shows an upward trend, reaching the highest value on the 15th day of culture; under the water flooded treatment, it shows a downward trend; under the dry wet alternate culture, the content is the highest on the 10th day of culture, but the content drops on the 15th day Low, but above the background value.

The background value of total nitrogen in Lou soil was 0.81g/kg. The content of total nitrogen in Lou soil increased after the alternation of drying and drying. The highest content of total nitrogen was 0.88g/kg in 15 days of culture, and 0.918g/kg in 10 days of culture. Under water flooding treatment, the total nitrogen content decreased, but the change was not obvious.

![Figure 1. Soil total nitrogen content under different treatments (g/kg).](image-url)

3.2. Effect of different treatments on soil available phosphorus
Fig.2 shows the change of available P content of feldspathic sandstone and Lou soil under different treatments. It can be seen from Fig.2 that the background values of available P of feldspathic sandstone and Lou soil are quite different, which are 5.24mg/kg and 28.10mg/kg respectively. During the long-term drying, water flooding and alternation of drying and wetting, the release and absorption process of available phosphorus changes with time. After 5 days of culture, there was a trend of release of long-term drying and alternate drying and wetting. The content of available phosphorus
increased 46.7% to 7.70mg/kg. After 15 days of culture, it decreased to 4.56mg/kg. After 5 days of culture, the available phosphorus increased to 12.05mg/kg, then decreased, while the long-term flooding changed in the opposite direction, showing a trend of first decreasing, then increasing and then decreasing, but always lower than the background value.

During the long-term drying, flooding and alternation of drying and wetting, the content of available phosphorus in Lou soil changed significantly, and showed an upward trend. The content of available phosphorus reached 41.62mg/kg, increased by 48.10%, and then decreased, but still higher than 40mg/kg. After 15 days of culture, the content of available phosphorus reached 39.52mg/kg. Compared with P activation efficiency, long-term drying still increased 10.70% and available P content was 31.47mg/kg 15 days later. It can be seen that the existence of water affects the redox state of soil, thus affecting the release and absorption of P element.

![Figure 2](image)

**Figure 2.** Soil available phosphorus content under different treatments (mg/kg).

3.3. Available potassium of different treatments to soil

Fig. 3 shows the change of quick acting potassium content under different treatments. It can be seen from Fig. 3 that under the long-term dry and dry wet alternation conditions, the soft rock soil mass material shows the trend of first increasing and then decreasing. After 5 days of cultivation, under the dry wet alternation conditions, the change of K element is the largest, the quick acting potassium content is as high as 101.11mg/kg, increasing by 51.46%, and then decreasing gradually. Under the condition of long-term drying, the content of available phosphorus reached 97.76mg/kg after 15 days of culture, and 74.76mg/kg after 15 days of culture. Under the condition of long-term flooding, the content of available potassium was 76.53mg/kg, 96.27mg/kg and 101.21mg/kg for 5 days, 10 days and 15 days respectively.

Under these three conditions, the available potassium of Lou soil increased gradually, especially under the condition of dry wet alternation, after 15 days, it increased to 267.58mg/kg, and under different treatments, the lowest increased by 36.80%, the highest increased by 109.34%.
4. Discussion

4.1. Effect of long-term drying on soil total nitrogen, available phosphorus and available potassium

At present, the global warming has become an indisputable fact, and makes the global drought aggravating. When the soil is under drought and other environmental stresses, a series of physiological and biochemical changes will occur, which will affect the soil nutrient content. Long term drying has an important effect on soil nitrogen mineralization [10-12]. In this study, the total nitrogen content of feldspathic sandstone and Lou soil increases with the increase of drying time, which may be due to the increase of \(\text{NH}_4^+\)-N, \(\text{NO}_3^-\)-N and free amino acid content in the long-term drying, so as to increase the total nitrogen content in the soil. Bai Xiuling et al. Simulated the soil nitrogen content in the growth area of the grayed bolt grass in Poyang Lake Wetland under the dry and wet conditions. Under the constant dry, constant wet and dry alternation conditions without the addition of the fragments of the grayed bolt grass, the soil total nitrogen content changed little [13], which was similar to the results of this study. The content of available P and available K in loessial soil increased with the increase of culture time, which may be related to the different soils selected.

4.2. Effect of long-term flooding on soil total nitrogen, available phosphorus and available potassium

Under the condition of water flooding, the redox environment of water soil interface will change, and the corresponding physical, chemical and biological characteristics will also change [14-15]. The total nitrogen content of Lou soil and feldspathic sandstone decreased under flooding condition. Flooding can lead to the increase of soil nitrogen loss, mainly due to the loss of denitrification and denitrification of nitrogen and nitrate leaching [16-17]. In this study, the decrease of total nitrogen content is mainly caused by the loss of denitrification and denitrification because the soil is cultured in a beaker. Under the condition of long-term flooding, the phosphorus in the soil will be released, and its chemical form will become active [14], so that the content of available phosphorus in the soil will increase. The fixation and release of potassium are affected by many factors. In this study, the content of available potassium in feldspathic sandstone and Lou soil has been increasing during flooding, which may be due to the reduction of potassium, the relatively large amount of ferrous and manganese, the replacement of the absorbed potassium ions, the activation of potassium ions [18], and the increase of the content of available potassium in soil. Li Mengxun et al. Took Beijing cinnamon soil as the research object, and found that the content of soil available potassium was high at constant humidity, which might increase with the increase of the frequency of dry wet alternation. The frequency of four times of dry wet alternation was the critical number of quick potassium recovery [19]. There are similarities and differences with this study, which may be due to different soil properties, different
structures and different responses to corresponding conditions.

4.3. Effect of dry wet alternation on soil total nitrogen, available phosphorus and available potassium

In the alternation of dry and wet, the soil undergoes a cycle from dry to wet, from wet to dry, which causes the change of soil moisture content, and has a profound impact on the transfer and transformation of soil structure, nutrient elements and soil compounds, and then affects the transfer and transformation of nitrogen, phosphorus and potassium. In this study, the content of total N, available P and available K in feldspathic sandstone increased first and then decreased in the process of dry wet alternation, while the content of total N, available P and available K in Lou soil increased in the process of dry wet alternation, which may be related to different soil types, properties and geological conditions [20].

5. Conclusion

Lou soil and feldspathic sandstone have different effects on nutrient activation under different treatments. The results showed that: (1) the activity of total nitrogen was less under different treatments; (2) the effect of dry wet alternation on the activation of available phosphorus in Lou soil was the best, followed by the long-term water flooding; the process of release and absorption of feldspathic sandstone in the long-term drying and dry wet alternation; (3) the change of available potassium in Lou soil under the three treatments was larger, showing an upward trend, especially the dry wet alternation. Compared with Lou soil, the change of available potassium in feldspathic sandstone is smaller, but also increased. The two materials showed that Lou soil had a more active response to the environment, and could be used as the materials of nutrient activation to continue the research for a long time, in order to obtain a stable activation effect.

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