Study on the adsorption and desorption characteristics of Phosphorus in Ryegrass and natural grasses in sloping land of Rainy Area of West China

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Abstract. In this study, runoff plot test was carried out in Rainy Area of West China to study the adsorption and analytical characteristics of phosphorus on ryegrass (Lolium perenne L.) and natural grass soil planted on different slopes. The results showed that the content of available phosphorus and total p in ryegrass was higher than that in natural grassland. Langmuir equation can well fit the adsorption of phosphorus on soil, and the maximum adsorption capacity and adsorption coefficient are 434.76mg/kg and 0.57, respectively, which all appear in ryegrass field. The secondary kinetic equation can well fit the adsorption dynamic characteristics of phosphorus. The equilibrium adsorption capacity and adsorption rate are between 44.64~49.06 mg/kg and 0.0258~0.0466 kg/(mg·h), and the maximum value is in ryegrass field. The phosphorus analysis rate of the soil in the study area was 30.93~34.41%, which showed that the natural grassland was > ryegrass. At the same adsorption amount, the soil phosphorus content was > ryegrass. The results showed that the soil phosphorus fixation effect of ryegrass was good. The rational planting of ryegrass on the slope of yuping district in west China can effectively reduce the pollution of phosphorus from non-point sources.

1. Introduction
A long-term process of land under the action of human activities is called land use [1]. The specific conditions of human use of land are reflected by land use patterns, and the different ways of land use have a significant impact on soil phosphorus content. Phosphorus is one of the three essential nutrients in plants, and it has an extremely important impact on the overall growth and development of crops. It is an important indicator for evaluating soil. Improper use of phosphorus will bring point-source pollution and non-point source pollution to the environment [2]. Due to the development of agriculture, the application rate of phosphate fertilizer increased, and under the action of atmospheric precipitation, surface runoff and soil erosion entered the nearby water bodies, forming non-point source pollution [3]. A large number of studies have shown that excessive phosphorus content in water can cause eutrophication of water bodies and cause environmental pollution [4-8]. Therefore, the non-point source pollution of phosphorus is one of the key issues of concern today, but the current research pays more attention to the phosphorus content in the water, but rarely involves the loss of phosphorus in the soil and its impact on the water environment.

The Rainy Area of West China is the transitional zone between the Sichuan Basin and the western
Sichuan Plateau [9]. Yucheng District, Ya’an City, Sichuan Province is located in the center of the Yuping District of Huaxi City. It is rainy all year round, and the erosion of rainwater causes soil erosion. A large amount of phosphorus in the soil will enter the water pollution basin [10]. In this study, a runoff plot experiment was conducted in the Yuping District of western China to study the adsorption characteristics and regularity of phosphorus adsorption in ryegrass and natural grass soils, in order to provide a reference for the treatment of phosphorus pollution in slope soils in the rain-screen area of western China.

2. Materials and Methods

2.1 Study area overview

The location of the test area is 103°42′00″ east longitude and 29°11′00″ north latitude. It is located in the runoff field on the north slope of Yucheng District, Ya’an City (FC5121517150) [11]. There are five observational plots in the test area, with 5° and 15° slopes. Among them, there are 2 5° slopes on the same slope. Each community is 5m wide and 20.08m long. The surrounding walls are 0.12m wide and 0.6m high. There are 3 15° slopes on the same slope. The cells are 5m wide and 20.71m long, and the four surrounding walls are 0.12m wide and 0.6m high. In April 2016, all the soil in the experimental plot was ploughed, all weeds were removed, and a plot of ryegrass (Lolium perenne L.) was planted in a 5° and 15° slope plot with a seeding density of 2.5 g/m², another community allows natural grass growth. Natural grass are mainly Artemisia stelleriana (Artemisia sieversiana Ehrhart ex Willd.), malan (Kalimeris indica (L.) Sch.-the BJP.), groundsels (Senecio scadens Buch.-Ham.Ex D.D on), silk MAO (Imperata koenigii (Retz.) Beauv.), snake blackberry (Duchesnea indica (Andr.)Focke), wild cotton (Anemone vitifolia bch-ham.) The physical and chemical properties of soil in the test plot are shown in the following table:

| Number | Land use pattern | pH   | Organic matter (g/kg) | Effective phosphorus (mg/kg) | Total phosphorus % | Calcium carbonate (g/kg) | Active iron oxide (g/kg) | Activated aluminium oxide (g/kg) |
|--------|-----------------|------|----------------------|-----------------------------|-------------------|-------------------------|-------------------------|---------------------------------|
| L-1    | 5°ryegrass      | 6.83 | 31.1                 | 7.2                         | 0.054             | 115.84                  | 1.69                    | 1.01                            |
| L-2    | 5°Natural grass | 6.42 | 55.1                 | 4.5                         | 0.039             | 106.1                   | 1.47                    | 1.21                            |
| L-3    | 15°ryegrass     | 6.96 | 23.7                 | 6.6                         | 0.053             | 127.06                  | 1.52                    | 1.34                            |
| L-4    | 15°Natural grass| 6.95 | 22.1                 | 3.1                         | 0.037             | 122.28                  | 1.64                    | 1.60                            |

2.2 Sample collection and processing

In April 2017, using the five-point sampling method, take 0-20 cm surface soil in each corner and center of each plot, mix it as a sample, collect 2 kg of soil sample by quadruple method, and record the land use mode, each sample Repeat three times for a total of 15 soil samples. Each soil sample was divided into two equal parts and used for air adsorption, grinding and sieving treatment in soil for adsorption analysis of soil phosphorus.

2.3 Experiment design

Phosphorus adsorption was analyzed by colorimetric analysis of the concentration of phosphorus in the solution, and the amount of phosphorus adsorbed by the soil was calculated by subtraction method, repeated three times [12], and the phosphorus analysis was carried out by centrifugation with cacl; and then filtered with a 0.45 um filter [13], adsorption power. The experimental experiment calculates the amount of phosphorus adsorbed by soil by subtractive method [14].

2.4 Data processing and analysis

Data analysis was performed using Excel 2010, MATLAB2014, and SPSS20; Origin 8.5 was plotted.
3. Results and analysis

3.1. Adsorption characteristics of phosphorus by ryegrass and natural grasses

3.1.1 Soil isothermal adsorption curves of ryegrass and natural grasses

It can be seen from Fig. 1 that the adsorption amount of phosphorus to ryegrass and natural grass soil in the experimental area increases with the increase of equilibrium concentration. When the equilibrium concentration reaches 10 mg/L, the growth rate slows down and then reaches the adsorption equilibrium. Therefore, the isothermal adsorption curve is divided into two stages: the equilibrium concentration is lower than 10 mg/L, which is called the chemisorption stage, mainly because the adsorption point on the soil surface is combined with phosphorus ions; the equilibrium concentration is greater than 10 mg/L. The amount of adsorption decreases with the increase of the equilibrium concentration, and gradually reaches equilibrium, which is called the physical adsorption stage. When the equilibrium concentration is a fixed value. The relationship between the phosphorus adsorption capacity of 5° slope soil was: natural grass>ryegrass; the relationship of phosphorus adsorption on 15° slope soil was: ryegrass>natural grass.

![Fig 1. Soil isothermal adsorption curve for ryegrass and natural grass](image)

3.1.2 Adsorption kinetics of phosphorus

The data showed that with the extension of adsorption time, the adsorption amount of phosphorus on the soil increased gradually, but when the adsorption amount reached a certain level, the adsorption amount basically did not change with the increase of time, that is, reached saturation. Phosphorus adsorption rate can directly reflect the speed of phosphorus adsorption per unit time. Described in table 2 of perennial ryegrass and natural grass soil phosphorus adsorption rate between (0~24 h): because of the initial concentration, the largest high phosphorus content in solution, the adsorption rate is mostly at the beginning of one hour, and increased with time, concentration of solution decreases, the adsorption rate decreased gradually, until equilibrium is reached. 5° slope positions at the same time the adsorption rate is as relationship: natural grass>ryegrass.15° slope adsorption rate size relations are: natural grass>ryegrass, maximum adsorption rate is a natural born grass 99.71 mg/h.

| Table 2. Phosphorus adsorption rate table |
|-------------------------------------------|
| Time (h) | 5° ryegrass | 5° Natural grass | 15° ryegrass | 15° Natural grass |
| 0.1      | 133.45      | 99.71            | 99.71        | 84.24             |
| 0.25     | 78.69       | 66.88            | 65.19        | 60.13             |
| 0.5      | 53.68       | 47.78            | 45.53        | 39.62             |
| 1        | 32.32       | 26.28            | 29.79        | 26.28             |
| 2        | 19.89       | 15.95            | 17.5         | 15.6              |
3.2 Analytical characteristics of phosphorus in ryegrass and natural grass soils
The resolution is the ratio of the resolution to the adsorption. The higher the resolution, the more phosphorus is released into the environment, and vice versa. The figure 2 shows that the study area soil resolution between 30.93~34.41%, the maximum value appeared in 15° natural grassland, the minimum value in 5° of ryegrass. Ryegrass and natural grass soil resolution within 5°,15° slope relations are characterized by natural grass>ryegrass.

Phosphorus removed from the soil by solution is called fixed phosphorus. As can be seen from Figure 2, the soil phosphorus fixation is between 182.11 and 214.89 mg/kg. The relationship between the fixed soils of the two plants at 5° was ryegrass>natural grass, and the relationship between soil average phosphorus fixation was: ryegrass>natural grass.

3.3 The relationship between adsorption and analytical quantities of soil
The amount of soil resolution increases with the increase of adsorption capacity. The soil phosphorus content of natural grasses at 5° slope was the largest (57.38mg/kg). In general, when the soil adsorption capacity is the same, the relationship between the soil resolution of the 5° slope is: natural grass>ryegrass, in which the ryegrass land use method has a linear relationship between the soil resolution and the adsorption amount, natural grass The amount of soil adsorption and the amount of analysis are power relations. The maximum amount of phosphorus in natural grasses at 15° slope was 56.42 mg/kg. At the same adsorption amount, the relationship between soil resolution was: natural grass>ryegrass, and the amount of soil adsorption and analysis of natural grasses The quantity is in a power relationship; the soil adsorption capacity of ryegrass has a linear relationship with the analytical amount.

4. Discuss
The available phosphorus content of ryegrass and natural grasses in the same slope of the study area is ryegrass>natural grassland, which is due to the presence of a large number of phosphate-dissolving bacteria in the rhizosphere of ryegrass [15]. The difficult to use organic phosphorus, apatite, and calcium phosphate are converted into available forms, resulting in higher levels of organic phosphorus in ryegrass grassland than natural grassland.

Different plant species have different effects on soil phosphorus fixation ability. In this study, the soil phosphorus adsorption analytical characteristics of the soil were found to be stronger in the soil of ryegrass. Xin Guorong [16] showed that in rice paddy field with agricultural non-point source pollution, the land showed stronger ability to fix phosphorus, which could reduce the loss of phosphorus in the
soil. Shi Jing studied the effect of mixed sowing grass belt on controlling soil phosphorus loss in the slope farmland around Yunlong Reservoir in Kunming, and found that the mixed straw belt had better control effect on phosphorus loss than natural vegetation. Therefore, in the next stage, we can further study the ability of soil to fix phosphorus in the soil mixed with ryegrass and other grasses, and to find a better combination of plant species with better phosphorus fixation.

Different slopes on slopes also have an effect on soil phosphorus fixation capacity. Soil phosphorus loss with surface run off is one of the causes of soil non-point source pollution. Zhang Jiaqi showed that the slope affects the soil nutrient loss on the slope. The amount of nutrient loss in the range of 5°~15° slopes increases with the increase of slope, and reaches the critical slope within the range of 15°~25°. This study is similar to Zhang Jiaqi and other studies. The slope of the test slope is 5° and 15°. The analytical characteristics of soil phosphorus adsorption under different slopes of the same plant species are different. In the case of planting the same kind of plants, the amount of phosphorus adsorption on the soil showed a slope of >15° on a slope of 5°; the analytical amount of phosphorus on the soil showed a slope of <15° on a slope of 5°. That is, the soil phosphorus fixation capacity is 5° slope >15° slope, and the 15° slope soil phosphorus loss is more.

In summary, the effect of soil phosphorus fixation in rye grassland is better. It is suggested that planting ryegrass on the slope of Rainy Area of West China can reduce the pollution of phosphorus source.

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