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# EFFECTS OF HUMIC ACID ON CHLOROPHYLL CONTENT AND ROOT LENGTH OF RYEGRASS (*LOLIUM MULTIFLORUM* LAM.)

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*Keywords:* Potassium humate, Potassium fulvic acid, Raw soil, Soil maturity

**Abstract**

Use of humic acid has great significance to improve soil quality and crop yield in loess hilly and gully areas. In the present study, potassium humate (PH) and potassium fulvic acid (PFA) were used as soil amendments in gully the control project area of Yan'an City, Shaanxi Province. A pot culture experiment was conducted to evaluate the influence of two types of humic acid (PH and PFA) on the growth characteristics of ryegrass in the loess hilly and gully area. Results showed that application of potassium humate and potassium fulvic acid considerably increased the chlorophyll synthesis as well as root length of ryegrass. When the proportion of PH and PFA was the same, the effect of PFA was to be found better than that of PFH. When the proportion of potassium humate was 15g/kg soil, the leaf chlorophyll content and root length attained the maximum, and the soil maturity effect was the best.

## Introduction

Humic acid is a kind of macromolecular organic matter formed by microbial decomposition and transformation of animal and plant remains and complex geochemical processes (Fu 2016). Humic acid is widely used in industry, agriculture, environmental protection, etc. With the in-depth study of humic acid, the use of humic acid products will be more extensive. Humic acid fertilizer is a new type of multifunctional organic fertilizer, which is mainly made of peat, weathered coal or lignite. The application of humic acid in fertilizer field is becoming more and more perfect (Sun and Su 2009, Cheng *et al.* 2011). Humic acid is widely used as an important green, organic and environmental fertilizer. It can be divided into primary humic acid according to its formation and source, also known as natural humic acid; humic acid generated by natural weathering or artificial oxidation of regenerated humic acid is called regenerated humic acid; synthetic humic acid synthetic humic acid, also known as artificial humic acid. The beneficial effect of humic acids on soil was first reflected in enhancing soil fertility (Lian 2015, Zhao and Zhang 2015, He 2016, Yao 2016). Owing to have a fairly high content of organic matter, it can increase the soil organic matter content and can reduce the fixation of soluble phosphorus in soil and improve the utilization rate of phosphorus fertilizer. Humic acid can also form complexes with some trace elements existing in insoluble salts, so that water is easily absorbed by crops and promote plant growth (Niu *et al.* 2008, Lin *et al.* 2013, Liu *et al.* 2017). Humic acid can also help improve soil structure, including formation of aggregate structure, which is conducive to the regulation of water, gas and heat in soil (Xu 2009, Yang *et al.* 2013). Concerning plants, humic acid can promote seed germination root growth, crop growth, and improve crop quality (DiDonato and Hatcher 2017).

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In view of the problems such as poor soil structure, low water and fertilizer retention capacity and poor soil after land consolidation in the loess hilly and gully region. The persent study had used two types of humic acid fertilizers to investigate its effects on quick maturing of raw soil and the growth of ryegrass through a pot experiment.

## Materials and Methods

Baota area is a hilly and gully region of the loess plateau in northern Shaanxi, which is part of the Ordos platform of the North China Platform (Fig. 1). The strata are dominated by Mesozoic and Cenozoic. The paleotopography formed by the Mesozoic and Cenozoic late Tertiary red soil layers is the basis for the formation of modern landforms. After the strong uplift of the crust in the Middle Pleistocene, the ancient loess plateau of more than 900 ~ 1500 meters was formed. After long-term water erosion and other external erosion, it developed into today's loess hilly gully landform. It is characterized by broken ground, dense ravines and deep mountains.

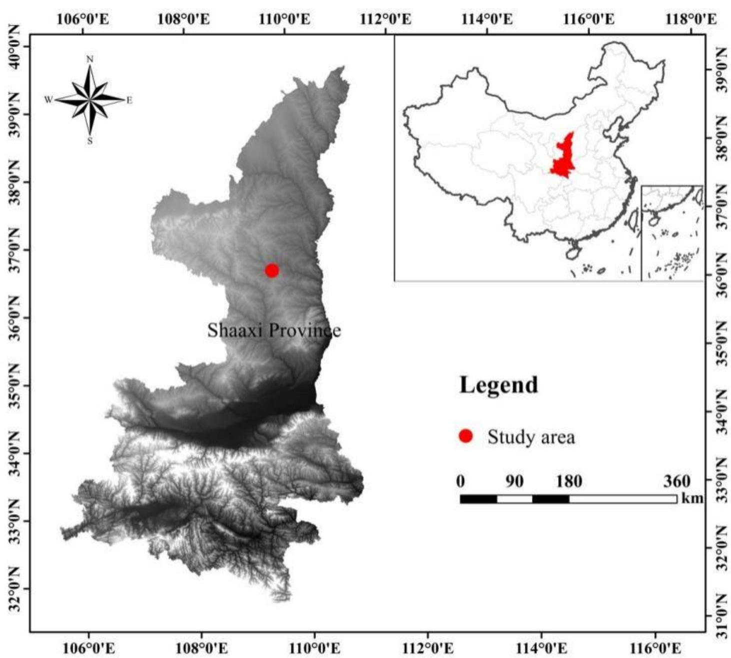


Fig.1. Schematic diagram of the geographical location of the study area.

The terrain of Baota area is high in the northeast and southeast, and uplifts in the middle. It is a hilly valley with two circular tilts to the east. The whole region belongs to the hilly-gully region of the Loess Plateau. The macro-geomorphology is mainly loess plateau and hilly. According to its geomorphological elements and topographic characteristics, the whole region can be divided into three types: the northern hilly-gully region, the southern hilly-gully region and the southeast residual plateau region.

Baota district is located in the inland, the terrain is high, the climate is dry and changeable, uneven heat and cold, semi-arid continental monsoon climate. According to the data of meteorological stations in Baota District of Yan'an City from 1951 to 2005, the average annual precipitation is 562.1mm, the maximum is 871.2mm, and the minimum is 330mm. Dry season and wet (rainy) season are distinct, and the annual distribution of precipitation is very uneven, mostly concentrated in June, July, August and September, which account for 60-80% of the annual precipitation.

The whole Baota area is located in the loess plateau, the surface loess is widely distributed, the loess lithology is loose and weak, and the upper multi-level tributaries are developed. The main rivers are the Yanhe River and Fenchuan River. The Yanhe River is the largest river in the study area, with a total length of 286.9 km and a basin area of 7725 $km^2$. The water level changes with the rainy season and fluctuates violently, which is prone to flood disasters.

The soil in Baota district mainly includes yellow cotton soil, black loessial soil and red soil. Among them, the area of yellow cotton soil is the largest, accounting for 63.9% of the total soil area in the region. It is the main cultivated and eroded subject in the basin. Due to the easy dispersion of the parent material, soil erosion is prominent. Channel soil organic matter content is about 13.66g/kg, the soil texture is mostly silt loam and soil pH is >8.5.

Yangjuangou watershed is located in the transition zone of forest and grassland. The natural vegetation in the watershed is seriously damaged. At present, the secondary vegetation formed by artificial planting and the primary vegetation of natural recovery are mainly composed of 31-year-old plantation and 33-year-old abandoned grassland in the study area. According to the remote sensing images of Yangjuangou watershed in 2006 and 2011, the most dramatic changes are: grassland into shrub land, the area of 27.680 $hm^2$, accounting for 30.35% of the total grassland in 2006; the volume of grassland converted into arbor forest land was 30.927 $hm^2$, accounting for 33.91% of the total grassland in 2006. The slope farmland converted to terrace, about 10.999 $hm^2$, accounting for 43.54% of the total slope farmland in 2006. This was due to the increase of soil erosion control measures in the basin during this period, the land use structure is adjusted, making the proportion of arbor forest and shrub land in the basin increased, throughout the whole small watershed. Because of afforestation, terrace converted to arbor forest land and shrub land trend is bigger, especially in the east and west of the basin is more obvious, most of the grassland is converted to arbor forest land, shrub land and slope farmland.

Potassium humate and potassium fulvic acid were added to soil in the pot at the rates of 5, 10, 15, 20 and 25g/kg. Seeds of ryegrass was sown in each pot. Each treatment was repeated three times. There were three blank treatments CK1, CK2, CK3 and three NPK treatments NPK1, NPK2, NPK3 (Table 1).

**Table 1. Pot design scheme.**

| Test number | Label | Proportion of PH and PFA (g/kg) | Potassium humate (g) | Potassium Fulvic Acid (g) |
|---|---|---|---|---|
| 1 | CK | 0 | 0 | 0 |
| 2 | NPK | 0 | 0 | 0 |
| 3 | PH1 | 5 | 25 | 0 |
| 4 | PH2 | 10 | 50 | 0 |
| 5 | PH3 | 15 | 75 | 0 |
| 6 | PH4 | 20 | 100 | 0 |
| 7 | PH5 | 25 | 125 | 0 |
| 8 | PFA1 | 5 | 0 | 25 |
| 9 | PFA2 | 10 | 0 | 50 |
| 10 | PFA3 | 15 | 0 | 75 |
| 11 | PFA4 | 20 | 0 | 100 |
| 12 | PFA5 | 25 | 0 | 125 |

**Results and Discussion**

Chlorophyll is the main photosynthetic pigment in plant leaves, and its content is an important index to evaluate the physiological status of plants. High chlorophyll content indicates that plants have strong photosynthesis, which can ensure normal life activities of plants, and synthesize sufficient energy to provide material basis for their growth and development. In the present study, the chlorophyll contents of ryegrass leaves at 15, 30 and 45d under different treatments were measured to compare the effects of different potassium humate and potassium fulvic acid additions on the growth of perennial ryegrass (Fig. 2).

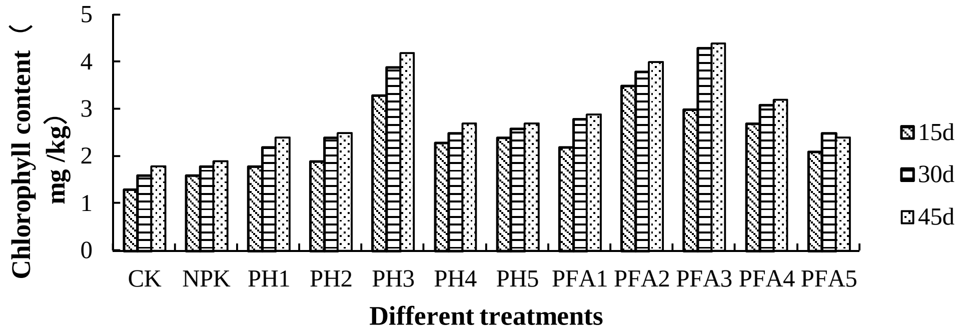


Fig. 2. Effects of humic acids (PH and PFA) on chlorophyll content of ryegrass.

It is appcent from Fig.2 that with the increase of measurement time, the chlorophyll values of different treatment groups showed an increasing trend. The increment was maximum at 15-30 d and minimum at 30-45 d. With the increase of the proportion of potassium humate and potassium fulvic acid, the difference of chlorophyll value of ryegrass was not significant at the same determination time, but with the increase of the proportion of potassium humate and potassium fulvic acid, the change of chlorophyll value increased first and then decreased. When the application ratio was 15g/kg, the chlorophyll content of ryegrass in different treatment groups reached the maximum. In the 15 day period, PH3 and PFA3 treatments increased by 2.0 and 1.7 mg/kg compared with CK in the control group; in the 30 day period, PH3 and PFA3 treatments increased by 2.3 and 2.7 compared with CK in the control group; at 45 d, PH3 and PFA3 treatments increased by 2.4 and 2.6 compared with CK in the control group. The results showed that the application of potassium humate and potassium fulvic acid could promote the synthesis of ryegrass chlorophyll in raw soil and alleviate the inhibition of ryegrass growth in raw soil. When the application ratio was the same, the effect of potassium fulvic acid was better than that of potassium humate.

Figure 3 showed the results of root length changes of ryegrass under different ratios of potassium humate and potassium fulvic acid. It was observed that the root length of ryegrass treated with different proportions of potassium humate and potassium fulvic acid was greater than that of the treatment group without PH and PFA, and with the increase of the proportion, the root length of each treatment group showed a trend of increasing first and then decreasing. When the ratio of PH and PFA was 15g/kg, the root length of each treatment group reached the maximum. Compared with the control group (6.1cm), the root length of ryegrass increased to 8.1-10.1cm, showing an increase of 49.8 and 33.0%. Results showed that the application of PH and PFA could increase the root length of ryegrass, and the effect of PFA was better than that of PH under the same application ratio. The root length of ryegrass in soil under different treatments was significantly increased than that of the control group (without potassium humate and potassium fulvic acid).

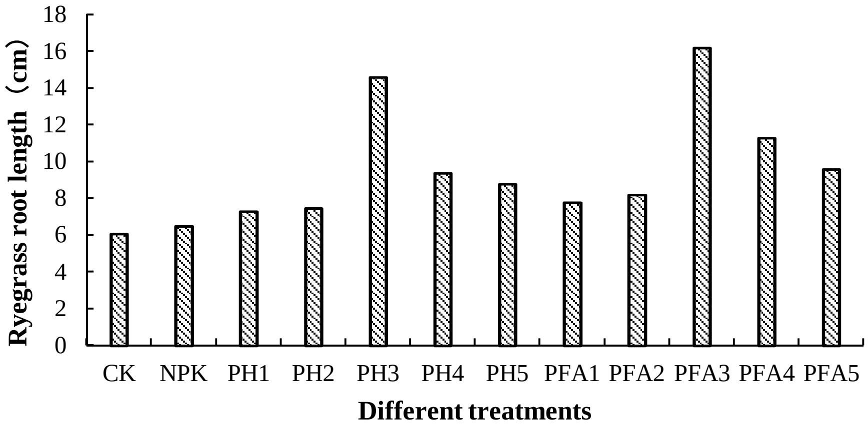


Fig. 3. Effects of humic acids (PH and PFA) on root length of ryegrass.

In the present study, PH and PFA were used as soil amendments in the raw soil of the gully control project area in Yangquangou small watershed, Yan'an City, Shaanxi Province. Different proportions of potassium humate and potassium fulvic acid were applied. Through pot experiment and indoor analysis, and through the combination of pot experiment and theoretical analysis, the influence of humic acid on the growth characteristics of ryegrass under different treatments was analyzed, and the optimal ratio of humic acid for rapid maturation of raw soil in loess hilly and gully region was obtained. Results showed that the application of potassium humate and potassium fulvic acid had increased the chlorophyll synthesis of ryegrass in raw soil, and the root length of ryegrass was greater than that of the treatment without PH and PFA. When the proportion of potassium humate was the same, the effect of potassium humate was better than that of potassium humate. When the proportion of potassium humate was 15g/kg, the chlorophyll content and root length reached the maximum, and the soil maturing effect was the best.

Potassium humate and potassium fulvic acid fertilizers could be used as soil amendments which would benefit the soil quality as well crop growth. Application of these two humic acids significantly influenced the chlorophyll synthesis and root length of ryegrass. The proportion of potassium humate at 15g/kg was found better showing the maxinmun leaf chlorophyll content and root length of ryegrass.

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