Effects of oil pollution stress on the growth status of ryegrass

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Abstract. Recently the area of oil-polluted soil in Northern Shaanxi is increasing rapidly, which seriously affects the health and safety of local people. This experiment studied the effects of different concentrations of oil pollution on the growth status of ryegrass under natural conditions, to provide some evidence for the plant selection of oil-contaminated soil remediation in the study area. The test showed that oil pollution inhibits the normal growth of ryegrass, leading to the decrease of germination rate and plant height and delay of germination time. The higher the oil pollution concentration, the more obvious the growth difference of ryegrass. In the early stage of growth, ryegrass grew rapidly, while slowly in middle and late stage. The result showed that ryegrass can be better adapted to the oil-polluted soil in mild and moderate concentrations, which can be used as a suitable repair plant.

1. Introduction
Recently the area of oil-polluted soil in Northern Shaanxi is continuously expanding [1-4]. As a kind of environmentally-friendly and economic soil repair technology, phytoremediation has great market potential [5-6]. It mainly uses the interactions between plants, microbes and environment, such as direct absorption, releasing of secretions and enzyme, stimulating the root zone microbial activities and strengthening the biological conversions, to remove the oil pollutants from the soil [7-9]. This paper studied the effects of different concentrations of oil pollution on the growth status of ryegrass under natural conditions, to provide some evidence for the plant selection of oil-contaminated soil remediation in the study area.

2. Materials and Methods
2.1. Test materials
The tested soil was selected from topsoil of Fuxian county, Yanan. Supplied plant was ryegrass, bought from forage workstation in Gunquan county, Yanan. And the selected crude oil derived from Moping
17 well of oil production plant in Fuxian. The hydrocarbon content of the crude oil was higher and the maturity was high [10-12].

The pot experiment set up four different concentration treatment groups, namely 0g/kg, 10g/kg, 20g/kg, 30g/kg respectively and each treatment group repeated 3 times. The trial began in mid-April. The stones and weeds were removed from the original soil sample and the soil was sieved by 2mm. Then weighed the crude oil samples accurately and mixed them with corresponding potted soil.

Because the soil sample itself contains a certain amount of petroleum hydrocarbon, and artificial configuration of oil concentration could not stand for the accurate content of the oil pollutants in the soil, therefore the background values of oil pollutants need to be determined. The critical value of oil-contaminated soil and clean soil is 500mg/kg (0.05%) [13]. The content of oil pollutants in the original soil was 0.019%, which can be considered as clean soil. While the other soil samples added the crude oil all exceeded the standard, and the concentration gradient distribution was shown in Fig.1. The oil-contaminated soil in this test was divided into 4 levels, namely < 0.05% for non-pollution (H0), 0.05%~0.5% for mild-pollution (H1), 0.5%~1.0% for moderate pollution (H2), and > 1.0% for severe pollution (H3).

![Fig.1. The content of oil pollutants in the original soil and treated soil](image)

2.2. Pot experiment
The satiated and evenly sized ryegrass seeds were selected beforehand and were planted with 50 grains in each experiment pot, and the sowing depth was about 2 cm. All the experimental pots were covered with plastic films and the ventilation holes were reserved, cultivated under natural conditions. Watering and clearing the weeds regularly and protecting them from the rainstorm and strong sunlight every day.

2.3. Indicators measuring
The germination ability of the species under oil pollution stress is a prerequisite for phytoremediation [14-15]. In this test, the germination time of ryegrass was recorded under different crude oil concentrations, also the plant heights in the early (50 days), medium (100 days) and late (150 days) stage of growth.

3. Experimental results and analysis

3.1. Germination rate and time
The germination rate is the percentage of germinated plants accounted for the total plants. During germination, the number of germinated seeds was counted daily. Ryegrass began to sprout for 6-8 days
under these 4 concentration gradients. The increase in the concentration of crude oil resulted in the sprout delay of ryegrass (Table1). Due to the small changes in concentration gradients, the mild and moderate pollution had no significant effects on the germination time, while the severe ones not.

| Sample code | Germination time (d) | Germination rate (%) |
|-------------|----------------------|----------------------|
| HYA0        | 6                    | 74                   |
| HYA1        | 6                    | 64                   |
| HYA2        | 7                    | 39                   |
| HYA3        | 8                    | 33                   |

The germination rate of ryegrass was negatively correlated with oil pollution concentration. Table1 showed that the germination rates of ryegrass under clear soil and mild pollution were higher than that of moderate and severe pollution. It can be inferred that the ryegrass has poor adaptability under severe oil pollution.

3.2. Plant height of ryegrass under different growth stages

The ryegrass is a kind of gramineous plants, with a fibrous root system. The roots have larger surface area and can secrete more rhizosphere secretions, providing a wider space for microorganisms [16-17]. The strong root system made great contributions on repairing PAHs, phenyls and pyrene, benzopyrene etc [18-19]. However, the root length could not be measured accurately; the paper only measured the plant heights of ryegrass under different growth stages. According to the experimental design and local weather changes, the plant height was measured at 50/100/150 days (Fig.2).

Fig.2 showed that oil pollution obviously inhibited the normal growth of ryegrass. In the early stage, ryegrass grew fastest. The average plant heights of H1, H2, H3 accounted for 86.2%, 50.0% and 34.5% of H0 respectively. In the middle stage, the average plant heights of H1, H2, H3 accounted for 91.9%, 67.5% and 59.4% of H0 respectively. And in the end of growth, ryegrass grew slowest, the average plant...
heights of H1, H2, H3 accounted for 95.3%, 76.7% and 61.6% of H0 respectively. The higher the concentration of oil pollution, the more obvious the inhibition effect on the plant.

4. Conclusion and Suggestion
This experiment studied the effects of different concentrations of oil pollution on the growth status of ryegrass under natural conditions, to provide some evidence for the plant selection of oil-contaminated soil remediation in the study area. Test showed that the oil pollution inhibits the normal growth of ryegrass, leading to the decrease of germination rate and plant height and delay of germination time. The higher the oil pollution concentration, the more obvious the growth differences of ryegrass. In the early stage of growth, ryegrass grew rapidly, while slowly in middle and late stage. The result showed that ryegrass can be better adapted to the oil-polluted soil in mild and moderate concentrations, which can be used as a suitable repair plant.

In future study, the field experiments can be selected, which is closer to the plant restoration under natural conditions. Meanwhile, strengthening the research on the mechanism of phytoremediation and bioremediation technology, to construct an efficient plant-microbial repair system of oil-contaminated soil [20].

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